

材料情報のための共通データフォーマット

-Material Ontology (Ver. 1.1)-

2008年3月29日 芦野俊宏

2008年2月25日 岡 伸人

1. 共通フォーマットの構造

Material Ontology は、材料分野における諸概念やそれらの関係性を整理したオントロジーを、W3C によるオントロジー記述言語の標準である OWL によって記述したものである。このフォーマットは"材料情報に関するテンプレート"、"核となるオントロジー"、"周辺のオントロジー"から構成される。

A) 材料情報: MaterialInformation オントロジー

- 核となるオントロジーによって記述される個々の材料情報を連結し、材料データのレコードとする

B) 中核オントロジー: Substance オントロジー、Property オントロジー、Environment オントロジー、Process オントロジー

- 材料を含む物質を表す Substance に対して、ある環境(Environment)の下で、加工・測定などを含む何らかの Process を作用させることで特性(Property) が得られる、という観点から、これらを独立した概念のネットワークとしてオントロジーを構築している。これに対して、Environment を Process に依存するものとしてまとめ、Structure を Substance と独立したものとして定義する考え方もあるが、ここでは、実用材料においては Structure は材料の分類に密接に関連するものとして Substance に含めた

C) 周辺オントロジー: UnitDimension オントロジー、PhysicalConstant オントロジー

- これらは科学技術情報に関連する他の分野においても用いられるものとして独立して定義している

これらのオントロジーは相互に参照しあい、材料データを記述することができる。下記のデータをサンプルに、共通フォーマットへデータを入力する。

- 一般名称: Aluminum
- 材料組成: Al
- 材料特性名: Thermal Conductivity
- 材料特性値: 297
- 材料特性値の単位系: SI 単位

そしてデータを入力した共通フォーマットは次のようになる。

```
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF
```

```

xmlns:xsd="http://www.w3.org/2001/XMLSchema#" .....(1)
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" .....(2)
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#" .....(3)
xmlns:owl="http://www.w3.org/2002/07/owl#" .....(4)
xmlns:matinfo="http://codata.jp/OML-MaterialInformation.owl#" .....(5)
xmlns:substance="http://codata.jp/OML-Substance.owl#" .....(6)
xmlns:property="http://codata.jp/OML-Property.owl#" .....(7)
xml:base="http://codata.jp/AIST_UO2_.owl">
<owl:Ontology>
    <owl:imports rdf:resource="http://codata.jp/OML-MaterialInformation.owl"/> ... (8)
</owl:Ontology>

<matinfo:MaterialProperty rdf:ID="MaterialProperty1"> .....(9)
    <matinfo:Specimen> .....(10)
        <matinfo:EngineeringMaterial rdf:ID="EngineeringMaterial"> .....(11)
            <matinfo:CommonName> .....(12)
                Aluminum
            </matinfo:CommonName> .....(13)
            <matinfo:ChemicalComposition>
                <substance:Al rdf:ID="Al"/> .....(14)
            </matinfo:ChemicalComposition>
        </matinfo:EngineeringMaterial>
    </matinfo:Specimen>
    <matinfo:Property> .....(15)
        <property:ThermalConductivity rdf:ID="ThermalConductivity1"> .....(16)
            <property:UnitSystem rdf:resource="http://codata.jp/OML-
            UnitDimension.owl#SI"/> .....(17)
            <property:Value
            rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
                .....(18)
                297</property:Value>
            </property:ThermalConductivity>
        </matinfo:Property>
    </matinfo:MaterialProperty>
</rdf:RDF>

```

(1)から(4)の宣言は **Semantic Web** の規格により与えられた名前空間に属する要素型や属性名を、こ

の共通フォーマット中で利用するために必要とされる。さらに(5)から(7)の宣言により、Material Ontology で定義した OWL Class (以下、クラス)や OWL Property (以下、プロパティ)を利用することができる。

- (1) XML Schema¹の名前空間を宣言し、接頭辞を **xsd** とする。
- (2) RDF (Resource Description Framework)²の名前空間を宣言し、接頭辞を **rdf** とする。
- (3) RDFS(RDF Schema)³の名前空間を宣言し、接頭辞を **rdfs** とする。
- (4) OWL(Web Ontology)の名前空間を宣言し、接頭辞を **owl** とする。
- (5) MaterialInformation オントロジー(テンプレート)の名前空間を宣言し、接頭辞を **matinfo** とする。
- (6) Substance オントロジーの名前空間を宣言し、接頭辞を **substance** とする。
- (7) Property オントロジーの名前空間を宣言し、接頭辞を **property** とする。

また(8)の宣言により、目的語として示されたオントロジー(材料情報に関するテンプレートとしての MaterialInformation オントロジー)のグラフを取り込んで、主語オントロジーのグラフに加えることができる。

(9)以下はデータの記述となる。

MaterialInformation のサブクラスで MaterialProperty クラスのインスタンスとしてデータを与えて材料特性を記述する。この MaterialInformation オントロジーに関する詳細は 3.3.1 項に示す。rdf:ID として指定されている文字列 MaterialProperty1 はこのインスタンスに与えられたインスタンス名である。

(10)で MaterialInformation クラスの Specimen プロパティを用いて、測定試料に関する情報を入力する。オブジェクトプロパティ(owl:ObjectProperty)であり、(11)にあるように工学材料に関する情報入力フォーマットである EngineeringMaterial クラス(2.1 節)のインスタンスを値として持つ。(12)の CommonName プロパティはデータタイププロパティ(owl:DatatypeProperty)であり、材料の一般名称を文字データとして入力する。(13)の ChemicalComposition プロパティはオブジェクトプロパティであり、材料の化学組成を入力するために、(14)においてアルミニウムを定義した Substance オントロジーの ElementalSubstance クラスの AI インスタンスを値として持つ(2.2 節)。

(15)は Property プロパティ(オブジェクトプロパティ)で材料特性に関する情報を入力した例である。(16)では Property オントロジーの ThermalConductivity クラスを参照し、熱伝導率データの単位と値をそれぞれ(17)(18)に入力する。UnitSystem プロパティ(オブジェクトプロパティ)は、周辺オントロジーの一つである UnitDimension オントロジーの UnitSystem クラスを参照するここでは<property:UnitSystem rdf:resource= "http://codata.jp/OML-UnitDimension.owl#SI">として、インスタンスを作成することなく、Unit Dimension オントロジー: Unit System クラスのサブクラスである SI_units クラスの"SI"という Unit Dimension オントロジー内で既に定義されているインスタンスを(17)で参照している。

¹ C. M. Sperberg-McQueen and Henry Thompson, XML Schema W3C Recommendation on 2 May 2001. Retrieved 22 February 2008 from the World Wide Web: <http://www.w3.org/XML/Schema>

² Ivan Herman, Ralph Swick and Dan Brickley, Resource Description Framework (RDF), 2004. Retrieved 22 February 2008 from the World Wide Web: <http://www.w3.org/RDF/>

³ Dan Brickley, R.V. Guha and Brian McBride, RDF Vocabulary Description Language 1.0: RDF Schema W3C Recommendation on 10 February 2004. Retrieved 22 February 2008 from the World Wide Web: <http://www.w3.org/TR/rdf-schema/>

Property オントロジーの Value プロパティはデータタイププロパティであり、指定されたデータ型の値を与える。ここでは物性値を表す浮動小数点の数値である。ベクトルやテンソルを表現する場合には数値の並びを与え、Dimensions プロパティを用いて別途配列の次元を指定する。なお Property オントロジーや UnitDimension オントロジーに関する詳細な情報は各々3.2.2 項、3.3.1 項において、クラス参照についての情報は 2.7 節において述べる。

2. 共通フォーマットにおけるオントロジー間の関係性

Material Ontology で定義される各々のオントロジーは相互に参照しあい、材料に関するデータを記述することができる。本章ではオントロジー間の関係について述べる。

図 1 に MaterialInformation オントロジーと、Substance オントロジーとの関係を示す。

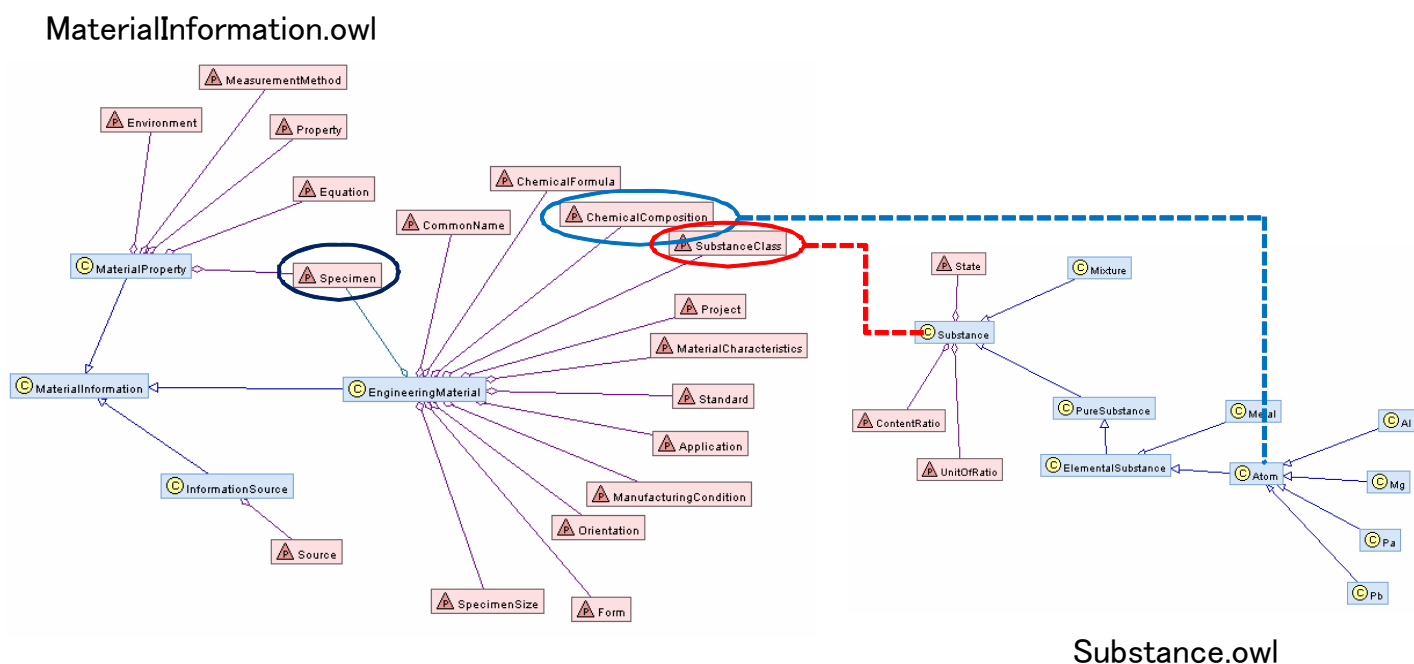


図 1. MaterialInformation オントロジーと Substance オントロジーとの関係性

◎: クラス, △: プロパティ

2.1. Specimen プロパティ (図 1)

Specimen プロパティはオブジェクトプロパティであり、MaterialInformation オントロジーの MaterialProperty クラスを定義域とし、同オントロジーの EngineeringMaterial クラスを値域とする。EngineeringMaterial クラスを参照することで個別の測定試料から、特定の規格の材料、といった多様な材料に関する情報を記述することが可能である。

2.2. ChemicalComposition プロパティ (図 1)

ChemicalComposition プロパティはオブジェクトプロパティであり、EngineeringMaterial クラスを定義域とし、Substance オントロジーの Atom クラスを値域とする。元素の定義である Atom クラスを参照することで、工学材料の組成に関する情報を記述する。

2.3. SubstanceClass プロパティ (図 1)

SubstanceClass プロパティはオブジェクトプロパティであり、EngineeringMaterial クラスを定義域とし、Substance オントロジーの Substance クラスを値域とする。材料の分類を記述したオントロジーである Substance クラスを参照し、データを記述する対象の材料を表す。

図 2 に MaterialInformation、Property、UnitDimension の三つのオントロジーの関係を示す。

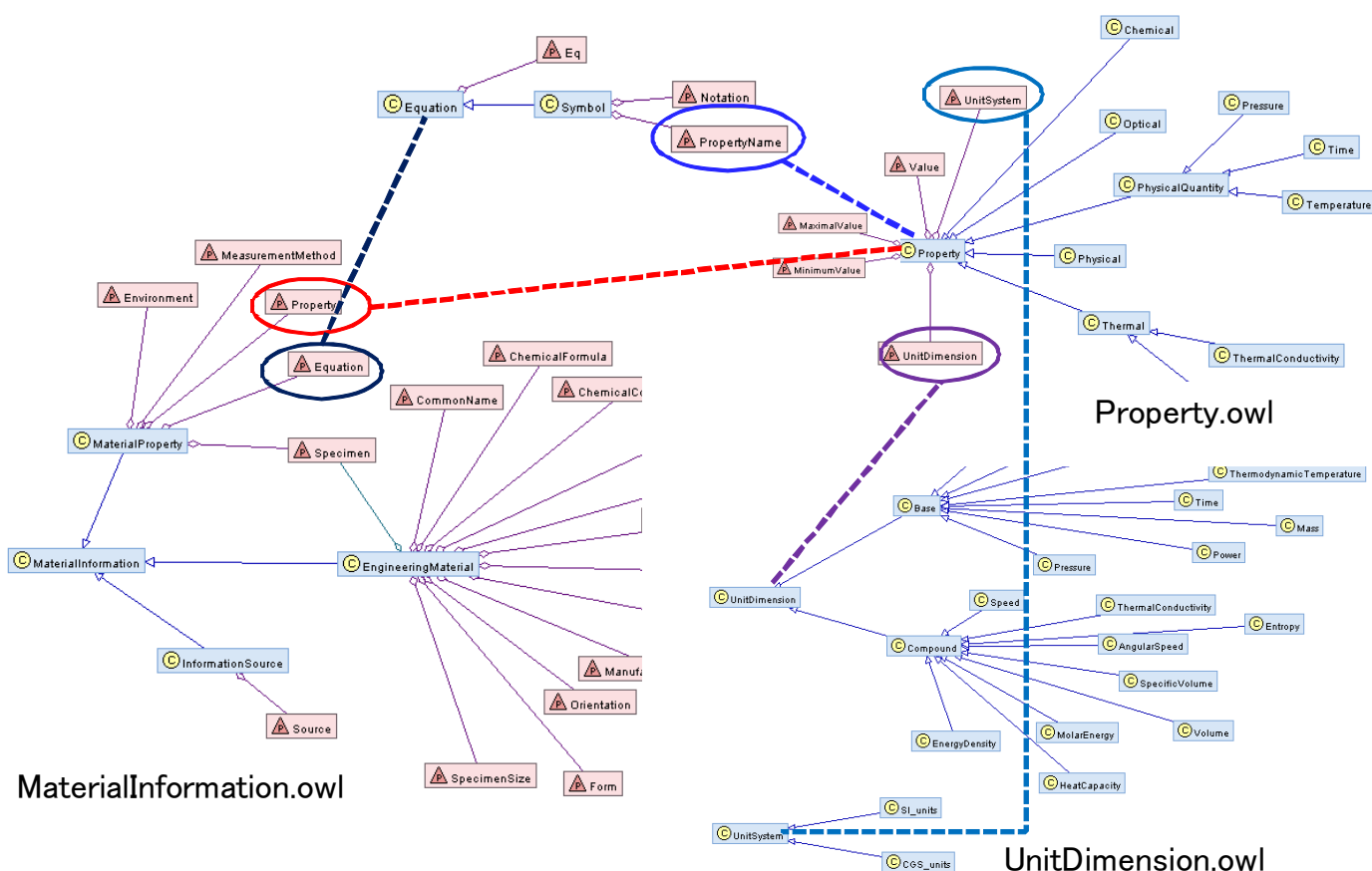


図 2. MaterialInformation、Property、Unit Dimension 各オントロジー間の関係

◎: クラス, △: プロパティ

2.4. Property (図 2)

Property プロパティはオブジェクトプロパティであり、MaterialInformation オントロジーの MaterialProperty クラスを定義域とし、Property オントロジーの Property クラスを値域とする。材料特性

に関するオントロジーである **Property** クラスを参照することで、材料特性に関する情報を記述する。

2.5. Equation (図 2)

Equation プロパティはオブジェクトプロパティであり、**MaterialInformation** オントロジーの **MaterialProperty** クラスを定義域とし、**Property** オントロジーの **Equation** クラスを値域とする。**Equation** クラスは材料特性の評価式に関する情報を記述する。

2.6. PropertyName (図 2)

PropertyName プロパティはオブジェクトプロパティであり、**Property** オントロジーの **Symbol** クラス (**Equation** クラスのサブクラス)を定義域とし、同オントロジーの **Property** クラスを値域とする。評価式において利用されるシンボルと材料特性名との対応を記述する。

2.7. UnitSystem (図 2)

UnitSystem プロパティはオブジェクトプロパティであり、**Property** オントロジーの **Property** クラスを定義域とし、**UnitDimension** オントロジーの **UnitSystem** クラスを値域とする。物性値の単位に関する情報を記述する。

2.8. UnitDimension (図 2)

UnitDimension プロパティはオブジェクトプロパティであり、**Property** オントロジーの **Property** クラスを定義域とし、**UnitDimension** オントロジーの **UnitDimension** クラスを値域とする。物性値の次元を記述する。

3. **Material Ontology** を構成するオントロジー

Material Ontology を構成するオントロジーの各々について、以下に説明する。

3.1 材料データ

3.3.1 **MaterialInformation** オントロジー

MaterialInformation オントロジーは、“**MaterialInformatio**”、“**MaterialProperty**”、“**EngineeringMaterial**”、“**InformationSource**”という 4 個のクラスと、18 個のプロパティから構成され、。これは、**MaterialInformation** クラスを最上位に、そのサブクラスとして **MaterialProperty** クラス、**EngineeringMaterial** クラス、**InformationSource** クラスを持つ。中核オントロジーによって表現される材料に関連する概念を相互に連結し、材料に関するひとまとまりのデータを表現する。**MaterialInformation** の構造を図 3 に、表 1 には **MaterialInformation** オントロジーにおいて定義されているプロパティの一覧を示す。

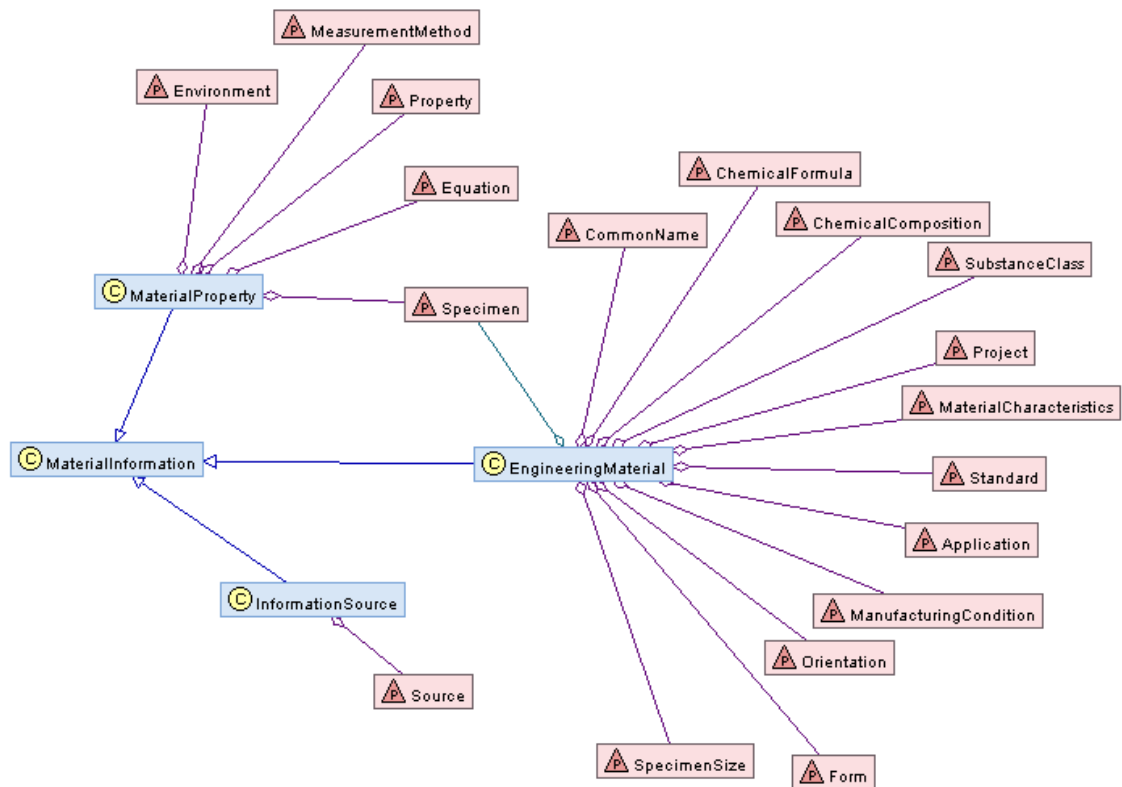


図 3. MaterialInformation オントロジーの構成要素と要素間の関係

◎: クラス、△: プロパティ

MaterialInformation クラスのサブクラスの一つ MaterialProperty クラスは、Environment、MeasurementMethod、Property、Equation、Specimen というプロパティを持つ。

Environment プロパティでは、材料特性の測定環境について記述する。これは Environment オントロジーの Environment クラスを値域とするオブジェクトプロパティである。同様に、MeasurementMethod、Property、Equation、Specimen は、それぞれ Process オントロジー: MeasurementMethod クラス、Property オントロジー: Property クラス、Property オントロジー: Equation クラス、EngineeringMaterial クラスを値域とするオブジェクトプロパティである。

EngineeringMaterial クラスのプロパティのうち、CommonName、ChemicalFormula、MaterialCharacteristics、Standard、Orientation、Form、SpecimenSize、Projec、Application は、String 型による文字列データを値域とするデータタイププロパティである。これに対して ChemicalComposition、SubstanceClass、ManufacturingCondition は、それぞれ Substance オントロジーの Atom と Substance クラス、Process オントロジーの ManufacturingProcess を値域とするオブジェクトプロパティである。

InformationSource クラスのプロパティは文字列を値域として持つ Source のみである。

表 1. MaterialInformation オントロジーのプロパティ一覧

プロパティ名	プロパティの種類	定義域	値域	意味
Environment	オブジェクト	MaterialProperty	Environment オントロジー: Environment	材料特性の 測定環境
MeasurementMethod	オブジェクト		Process オントロジー: MeasurementMethod	材料特性の 測定条件
Property	オブジェクト		Property オントロジー: Property	材料特性値
Equation	オブジェクト		Property オントロジー: Equation	材料特性式
Specimen	オブジェクト		EngineeringMaterial	材料特性の 測定試料
CommonName	データタイプ	EngineeringMaterial	文字列データ	材料の 一般名称
ChemicalFormula	データタイプ		文字列データ	材料の化学式
ChemicalComposition	オブジェクト		Substance オントロジー: Atom	材料の化学組成
SubstanceClass	オブジェクト		Substance オントロジー: Substance	物質の分類
ManufacturingCondition	オブジェクト		Process オントロジー: ManufacturingProcess	材料製造条件
MaterialCharacteristics	データタイプ		文字列データ	材料の特徴
Standard	データタイプ		文字列データ	材料標準規格
Orientation	データタイプ		文字列データ	幾何学的配置
Form	データタイプ		文字列データ	外形
SpecimenSize	データタイプ		文字列データ	試料の寸法
Project	データタイプ		文字列データ	製造プロジェクト
Application	データタイプ		文字列データ	適用分野
Source	データタイプ		InformationSource	文字列データ

3.2 中核オントロジー

3.3.1 Substance (材料に関するオントロジー)

Substance オントロジーは、上位オントロジーの一つである SUMO (Suggested Upper Merged Ontology)を参考に構築され、PureSubstance や Mixture、ElementalSubstance などの 323 個のクラスと、5 個のプロパティから構成された材料に関するオントロジーである。Substance クラスはサブクラスとして純粋な物資に対応する PureSubstance クラスと混合物に対応する Mixture クラスを持つ。さらにそれらのクラスは各々サブクラスとして ElementalSubstance クラスなどを持つ。クラス同士の関係を図 4 に示す。また ElementalSubstance、FerrousAlloy、Non-FerrousAlloy クラスはそれぞれ図 5、図 6、図 7 に示すサブクラスを持つ。



図 4. Substance オントロジーの構成要素(クラスのみ)と要素間の関係

ElementalSubstance クラスはそのサブクラスとして Metal、Atom クラスを持つ。Atom クラスはサブクラスとして He などの元素を意味するクラスを持つ (図 5)。Atom クラスは、ContentRatio、MaximumContentRatio、MinimumContentRatio、State、UnitOfRatio プロパティを持ち、材料の化学組成に関する情報を記述する。ContentRatio (元素の含有比率について記述)、MaximumContentRatio (元素の最大含有比率について記述)、MinimumContentRatio (元素の最少含有比率について記述) は String 型による文字列データを値域とするデータタイププロパティである。また UnitOfRatio プロパティ(含有比率で

用いた単位について記述)、**State** プロパティ(物質の状態について記述)は、それぞれ"Wt%、at%、mol%、volume%","Gas、Solid、Liquid"という文字列データを値域とするデータタイププロパティである。表 2 に Atom クラスが持つプロパティの一覧を記す。

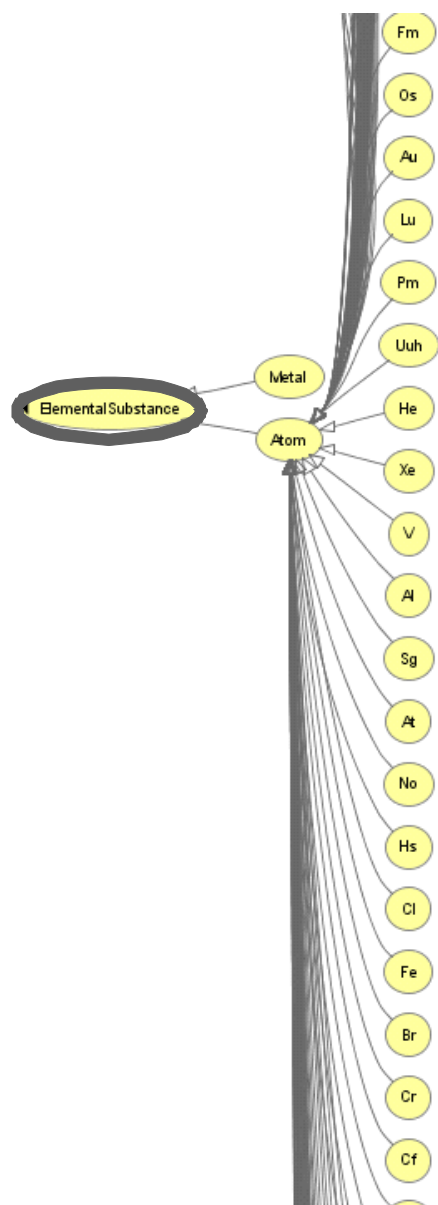


図 5. Substance オントロジー: ElementalSubstance クラスの構成要素(クラスのみ)と要素間の関係

表 2. Substance オントロジー: Atom クラスのプロパティ一覧

プロパティ名	プロパティの種類	定義域	値域	意味
ContentRatio	データタイプ	Atom	文字列データ	元素の含有比率
MaximumContentRatio	データタイプ		文字列データ	元素の最大含有比率
MinimumContentRatio	データタイプ		文字列データ	元素の最少含有比率
UnitOfRatio	データタイプ		Wt%、at%、mol%、 volume%から選択	含有比率で用いた単位

State	データタイプ		Gas、Solid、Liquid かどうか選択	物質の状態
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FerrousAlloy クラスには、ASTMSteel、CarbonSteel など鉄合金を意味するサブクラスを持つ。この構造は鉄系の合金の分類を記述するものである(図 6)。

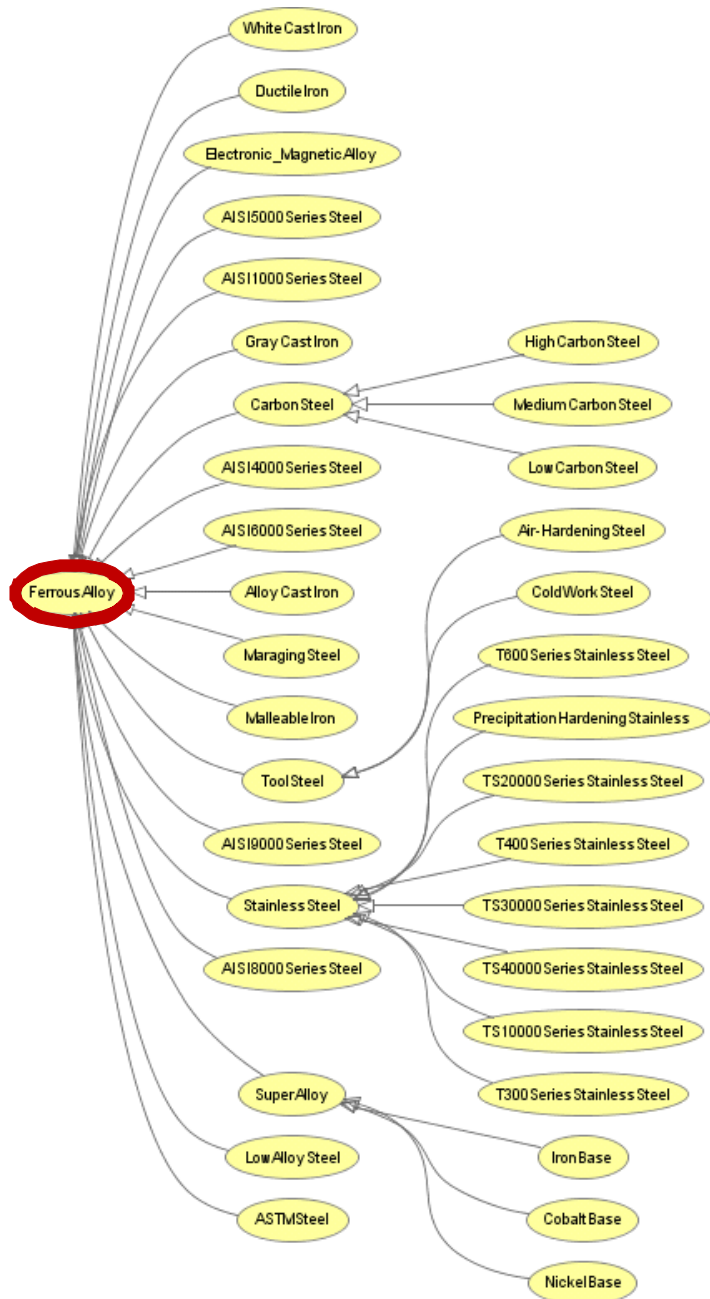


図 6. Substance オントロジー: FerrousAlloy クラスの構成要素(クラスのみ)と要素間の関係

Non-FerrousAlloy クラスは、TitaniumAlloy、NickelAlloy など非鉄合金を意味するサブクラスを持つ(図

7)。

表 3 に Substance オントロジーに属する全てのクラスを示す。



図 7. Substance オントロジー: Non-FerrousAlloy クラスの構成要素(クラスのみ)と要素間の関係

表 3. Substance オントロジー: クラス一覧

クラス名	上位クラス
FerrousAlloy	Alloy
Non-FerrousAlloy	
AluminumAlloy_1000Series	AluminumAlloy
AluminumAlloy_2000Series	
AluminumAlloy_3000Series	
AluminumAlloy_4000Series	
AluminumAlloy_5000Series	
AluminumAlloy_6000Series	
AluminumAlloy_6000Series	

AluminumAlloy_7000Series	
AluminumCastingAlloy	
OtherWroughtAlAlloy	
Ac	Atom
Ag	
Al	
Am	
Ar	
As	
At	
Au	
B	
Ba	
Be	
Bh	
Bi	
Bk	
Br	
C	
Ca	
Cd	
Ce	
Cf	
Cl	
Cm	
Co	
Cr	
Cs	
Cu	
Db	
Ds	
Dy	
Er	
Es	
Eu	
F	
Fe	

Fm
Fr
Ga
Gd
Ge
H
He
Hf
Hg
Ho
Hs
I
In
Ir
K
Kr
La
Li
Lr
Lu
Md
Mg
Mn
Mo
Mt
N
Na
Nb
Nd
Ne
Ni
No
Np
O
Os
P
Pa

Pb
Pd
Pm
Po
Pr
Pt
Pu
Ra
Rb
Re
Rf
Rg
Rh
Rn
Ru
S
Sb
Sc
Se
Sg
Si
Sm
Sn
Sr
Ta
Tb
Tc
Te
Th
Ti
Tl
Tm
U
Uub
Uuh
Uuo
Uup

Uuq	
Uus	
Uut	
V	
W	
Xe	
Y	
Yb	
Zn	
Zr	
HighCarbonSteel	CarbonSteel
LowCarbonSteel	
MediumCarbonSteel	
AmorphousMetal	CompoundSubstance
Boride	
Carbide	
Ceramic_MetallicCoating	
CompositeCoreMaterial	
CompositeFibers	
Concrete	
FibreComposites	
Foams	
FRM	
FRP	
Glass	
Glass-Amorphous	
GlassCeramic	
GlassFiber	
Halide	
HighTempCeramicResin	
InorganicMetalloid	
IntermetallicCompound	
MachinableCeramic	
Nitride	
Non-MetalicCompound	
OrganicMetalloid	
Oxide	

ParticulateComposites	
Phosphide_Pnictide	
Polymer_OrganicCompound	
Potting_CastingCeramic	
Semiconductor	
SolidSolution	
Sulfide_Chalcogenide	
Brass	CopperAlloy
Bronze	
Atom	ElementalSubstance
Metal	
AISI1000SeriesSteel	FerrousAlloy
AISI4000SeriesSteel	
AISI5000SeriesSteel	
AISI6000SeriesSteel	
AISI8000SeriesSteel	
AISI9000SeriesSteel	
AlloyCastIron	
ASTMSteel	
CarbonSteel	
DuctileIron	
Electronic_MagneticAlloy	
GrayCastIron	
LowAlloySteel	
MalleableIron	
MaragingSteel	
StainlessSteel	
SuperAlloy	
ToolSteel	
WhiteCastIron	
Alloy	
Bamboo	
Biological	
Clay	
Cork	
Glaze	
Grass	

Paper		
Rock		
Rubber		
Shell		
Wood		
AluminumAlloy	Non-FerrousAlloy	
BerylliumAlloy		
CopperAlloy		
MagnesiumAlloy		
MetalMatrixComposite		
NickelAlloy		
SolderAlloy		
TitaniumAlloy		
TungstenAlloy		
ZincAlloy		
Nylon11		Nylon
Nylon12		
Nylon46		
Nylon6		
Nylon610		
Nylon612		
Nylon66		
PolyetherBlockAmide-PEBA		
AluminumOxide	Oxide	
MagnesiumOxide		
SiliconOxide		
TitaniumOxide		
ZirconiumOxide		
PolybutyleneTerephthalate-PBT	Polyester-TP	
PolyethyleneTerephthalate-PET		
PolytrimethyleneTerephthalate-PTT		
HDPE	Polyethylene	
LDPE		
LLDPE		
MDPE		
Copolymer	Polymer_OrganicCompound	
Homopolymer		

Monomer	
Polyacrylics	
Polyamides_Thioamides	
Polyanhydrides_Thioanhydrides	
Polycarbonates_Thiocarbonates	
Polydienes	
Polyesters_Thioesters	
Polyethers	
PolyhaloOlefins	
Polyimides_Thioimides	
Polyimines-Polyamines	
Polyketones_Thioketones	
Polyolefines	
Polyphenylenes	
Polysiloxanes-Polysilanes	
Polystyrenes	
Polysulfides	
Polysulfones_Sulfoxides_Sulfonates_Suloamides	
Polyureas_Thioureas	
Polyurethanes_Thiourethanes	
Polyvinyls	
Thermoplastic	
Thermoset	
CompoundSubstance	PureSubstance
ElementalSubstance	
PrecipitationHardeningStainless	StainlessSteel
T300SeriesStainlessSteel	
T400SeriesStainlessSteel	
T600SeriesStainlessSteel	
TS10000SeriesStainlessSteel	
TS20000SeriesStainlessSteel	
TS30000SeriesStainlessSteel	
TS40000SeriesStainlessSteel	
Mixture	Substance
PureSubstance	
CobaltBase	SuperAlloy
IronBase	

NickelBase	
ABSPolymer	Thermoplastic
Acetal	
Acrylic	
Additive_Filler	
ASAPolymer	
Cellulosic	
Elastomer_TPE	
EthyleneAcrylicAcid	
EthyleneMethylAcrylate	
EthyleneVinylAcetate	
EthyleneVinylAlcohol	
Fluoropolymer	
Ionomer	
LiquidCrystalPolymer-LCP	
Nylon	
Polyamide-imide	
Polyarylamide	
Polycarbonate	
Polyester-TP	
Polyetherimide	
Polyethersulfone	
Polyethylene	
PolyimidePolymer	
Polyketone	
PolyphenyleneEther_PPO	
PolyphenyleneSulfide	
Polyphthalamide	
Polypropylene	
Polystyrene	
Polysulfone	
Polyurethane-TP	
PurgingCompound	
PVDC	
SANPolymer	
SMAPolymer	
Styrene-Butadiene	

Vinyl	
AdhesivePolymer	Thermoset
CarbonFiber_ThermosetComposite	
Cyanoacrylate	
DiallylPhthalate-DAP	
Elastomer-TS	
Epoxy	
Fluoropolymer-TS	
Phenolic	
Polyester-TS	
Polyimide-TS	
Polyurethane-TS	
Silicone	
Alpha_BetaTitaniumAlloy	
Alpha_NearAlphaTitaniumAlloy	
BetaTitaniumAlloy	
Unalloyed_ModifiedTitanium	
Air-HardeningSteel	ToolSteel
ColdWorkSteel	
Substance	

3.3.2 Property (材料特性に関するオントロジー)

Property オントロジーは、“Mechanical”や“PhysicalQuantity”などの 143 個のクラスと、7 個のプロパティから構成された材料特性に関するオントロジーである。このオントロジーは材料物性に関する階層構造を導く Property クラスと材料物性の評価式を表す Equation クラスを最上位に持つ。Property クラスでは材料物性を Mechanical、PhysicalQuantity など 11 個のクラスに分類する。図 8、図 9、図 10、図 11 に Property 以下のクラス構造を示す。

Property クラスは、Dimensions、Value、UnitDimension、UnitSystem という、物性値を表現する上で共通に必要なとされる項目である、データ配列の次元、値、物理系の次元、単位系をプロパティとして持つ。Dimensions プロパティはベクトルやテンソルを表現する際に用いる。UnitDimension、UnitSystem は、それぞれ周辺オントロジーの一つである UnitDimension の UnitDimension クラス、UnitSystem クラスを値域とするオブジェクトプロパティである。

Equation クラスは材料特性の評価式について記述する Eq プロパティを持つ。Symbol クラスは評価式で使われるシンボルについて記述する Notation と評価式で用いられるシンボルがどの物性値に対応するかを記述する PropertyName をプロパティとして持つ。

表 4 に Property クラスおよび Equation クラスが持つプロパティの一覧を記す。

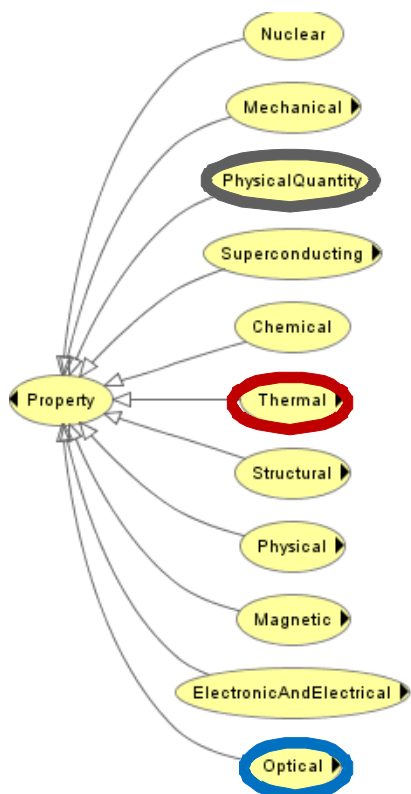


図 8. Property オントロジーの構成要素(クラスのみ)と要素間の関係

表 4. Property オントロジー全体のプロパティ一覧

プロパティ名	プロパティの種類	定義域	値域	意味
Dimensions	データタイプ	Property	文字列データ	材料特性値の配列宣言
Value	データタイプ		文字列データ	材料特性値
UnitDimension	オブジェクト		UnitDimension オントロジー: UnitDimension	材料特性値で用いる単位の次元
UnitSystem	オブジェクト		UnitDimension オントロジー: UnitSystem	材料特性値で用いる単位系
Eq	データタイプ	Equation	文字列データ	材料特性の評価式
Notation	データタイプ	Symbol	文字列データ	材料特性の評価式で使われるシンボル
PropertyName	オブジェクト		Property オントロジー: Property	材料特性の評価式で使われるシンボルの意味

PhysicalQuantity クラスは、Time クラス、Temperature クラスなど物理量を意味するサブクラスを持つ(図 9)。

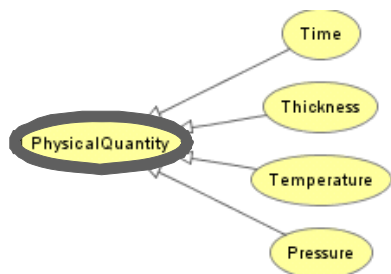


図 9. Property オントロジー: PhysicalQuantity クラスの構成要素(クラスのみ)と要素間の関係

Optical クラスのサブクラスには StaticPermittivity、Reflectivity など光学的特性を意味するクラスがある(図 10)。

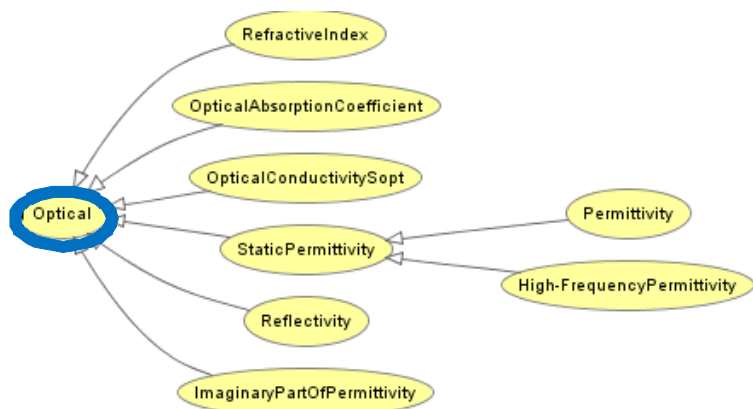


図 10. Property オントロジー: Optical クラスの構成要素(クラスのみ)と要素間の関係

Thermal クラスの階層構造を図 11 に示す。

なお表 5 に Property オントロジーに属する全てのクラスを示す。

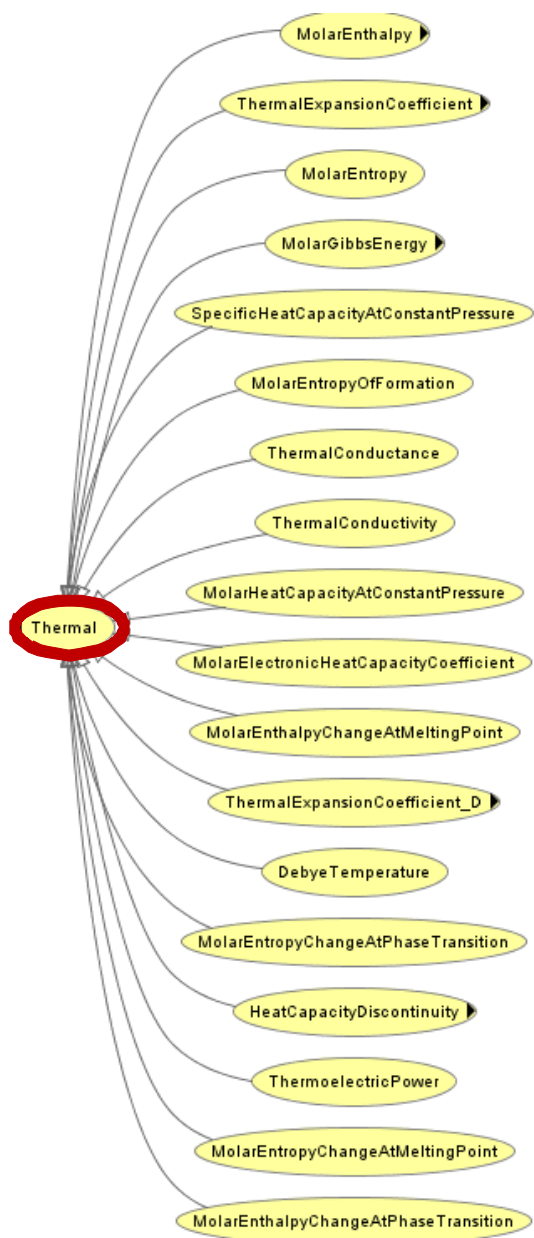


図 11. Property オントロジー: Thermal クラスの構成要素(クラスのみ)と要素間の関係

表 5. Property オントロジー: クラス一覧

クラス名	上位クラス
AdiabaticBulkModulus	BulkModulus
AdiabaticBulkModulusDiscontinuityAtNeelTemperature	
TemperatureDerivativeOfAdiabaticBulkModulus	
CoherenceLengthAt0K	CoherenceLength
CriticalMagneticFieldStrengthAt0K	CriticalMagneticFieldStrength

C11	ElasticStiffnessCoefficient
C11-C12	
C12	
C13	
C14	
C22	
C23	
C33	
C44	
C55	
C66	
ActivationEnergy	
EffectiveCharge	
EffectiveMassOfElectronsInConductionBand	
EffectiveMassOfHolesInValenceBand	
ElectricalConductivity	
ElectricalResistivity	
ElectricStrengthOfDielectric	
ElectronConcentration	
ElectronDensityOfStatesAtFermiLevel	
ElectronDensityOfStatesAtFermiLevelPerSpin	
ElectronMobility	
EnergyGap	
HallCoefficient	
HallMobility	
HoleConcentration	
HoleMobility	
MeanValence	
PressureDependenceOfPiezoresistivity	
TemperatureDerivativeOfEnergyGap	
ThermalEnergyGap	
EnergyGapForDirectTransition	EnergyGap
EnergyGapForIndirectTransition	
Symbol	Equation
HeatCapacityDiscontinuityAtPhaseTransition	HeatCapacityDiscontinuity
CriticalFieldForMagneticTransition	Magnetic
CriticalTemperatureForMagneticTransition	

CurieTemperature		
EffectiveBohrMagnetonNumber		
MagneticAnisotropyField		
MagneticFluxDensity		
MagneticMoment		
MassMagneticSusceptibility		
MolarMagneticSusceptibility		
NeelTemperature		
ParamagneticCurieTemperature		
SaturationMagneticMoment		
SaturationVolumeMagnetization		
SpontaneousMagneticMoment		
Temperature-IndependentPartOfMagneticSusceptibility		
VolumeMagnetization		
BulkModulus	Mechanical	
Creep		
ElasticStiffnessCoefficient		
KnoopHardnessNumber		
LinearCompressibility		
LongitudinalElasticCoefficient		
Microhardness		
PoissonRatio		
ShearModulus		
SoundVelocity		
VickersHardnessNumber		
VolumeCompressibility		
YoungsModulus		
MolarEnthalpyOfFormation		MolarEnthalpy
MolarGibbsEnergyOfFormation		MolarGibbsEnergy
ImaginaryPartOfPermittivity	Optical	
OpticalAbsorptionCoefficient		
OpticalConductivitySopt		
Reflectivity		
RefractiveIndex		
StaticPermittivity		
MeltingTemperature	PhaseTransition	
PeritecticTemperature		

PressuresForPhaseTransition		
StressDependenceOfTransitionTemperature		
TemperaturesForPhaseTransition		
PhaseTransition	Physical	
Pressure	PhysicalQuantity	
Temperature		
Thickness		
Time		
PhaseTransitionAtHighPressure	PressuresForPhaseTransition	
PhaseTransitionAtLowPressure		
PressureForPhaseTransition		
Chemical	Property	
ElectronicAndElectrical		
Magnetic		
Mechanical		
Nuclear		
Optical		
Physical		
PhysicalQuantity		
Structural		
Superconducting		
Thermal		
LongitudinalSoundVelocity		SoundVelocity
TransverseSoundVelocity		
SpontaneousMagnetization		SpontaneousMagneticMoment
High-FrequencyPermittivity	StaticPermittivity	
Permittivity		
Density	Structural	
CoherenceLength	Superconducting	
CriticalMagneticFieldStrength		
Electron-PhononInteractionParameter		
InitialSlopeOfBc2AtTc		
LondonPenetrationDepth		
LowerCriticalMagneticFieldStrength		
LowestTemperatureForNormalConductivity		
SlopeOfTcAt0GPa		
SuperconductingTransitionTemperature		

UpperCriticalMagneticFieldStrength	
TemperatureDerivativeOfEnergyGapForDirectTransition	TemperatureDerivativeOfEnergyGap
PhaseTransitionAtHighTemperature	TemperaturesForPhaseTransition
PhaseTransitionAtLowTemperature	
DebyeTemperature	Thermal
HeatCapacityDiscontinuity	
MolarElectronicHeatCapacityCoefficient	
MolarEnthalpy	
MolarEnthalpyChangeAtMeltingPoint	
MolarEnthalpyChangeAtPhaseTransition	
MolarEntropy	
MolarEntropyChangeAtMeltingPoint	
MolarEntropyChangeAtPhaseTransition	
MolarEntropyOfFormation	
MolarGibbsEnergy	
MolarHeatCapacityAtConstantPressure	
SpecificHeatCapacityAtConstantPressure	
ThermalConductance	
ThermalConductivity	
ThermalExpansionCoefficient	
ThermalExpansionCoefficient_D	
ThermoelectricPower	
LinearThermalExpansionCoefficient	ThermalExpansionCoefficient
VolumeThermalExpansionCoefficient	
LinearThermalExpansionCoefficient_D	ThermalExpansionCoefficient_D
VolumeThermalExpansionCoefficient_D	
UpperCriticalMagneticFieldStrengthAt0K	UpperCriticalMagneticFieldStrength
IsothermalVolumeCompressibility	VolumeCompressibility
Property	
Equation	

3.3.3 Environment (環境に関するオントロジー)

Environment オントロジーは材料の加工・試験などの際の環境に関するオントロジーである。階層構造を図 12 に示す。図 13 には Environment のサブクラスである Atmosphere のクラス構造を示す。

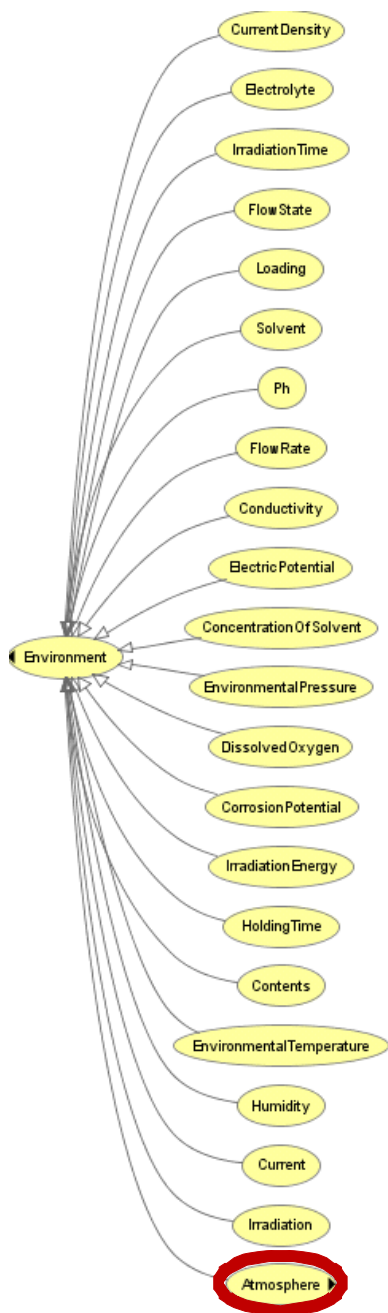


図 12. Environment オントロジーの構成要素(クラスのみ)と要素間の関係

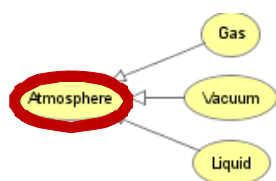


図 13. Environment オントロジー: Atmosphere クラスの構成要素(クラスのみ)と要素間の関係

Environment クラスは Value、Unit Dimension、UnitSystem プロパティを持つ。Value プロパティ(測定環境の状態値について記述)は String 型による文字列データを値域とするデータタイププロパティである。UnitDimension プロパティ(測定環境の状態値で用いる単位の次元について記述)、UnitSystem プロパティ(測定環境の状態値で用いる単位系について記述)は、それぞれ周辺オントロジーの一つである UnitDimension オントロジーの UnitDimension、UnitSystem を値域とするオブジェクトプロパティである。

Environment クラスのサブクラスである EnvironmentalTemperature、EnvironmentalPressure、Irradiation クラスは、それぞれ Temperature(測定環境の温度について記述)、Pressure (測定環境の圧力について記述)、typeOfIrradiation (照射環境について記述)をプロパティとして持つ。Temperature および Pressure は、それぞれ中核オントロジーの Property オントロジーに定義された Temperature、Pressure クラスを値域とするオブジェクトプロパティである。typeOfIrradiation クラスは、Electron、Neutron、Proton、Ion、Light という文字列データを値域とするデータタイププロパティである。

Atmosphere クラスのサブクラスである Gas、Liquid クラスは、それぞれ typeOfGas(ガス環境について記述)、typeOfLiquid(液体環境について記述)プロパティを持つ。typeOfGas プロパティは”Air、N、O、H、He、Ar、H2S、CarrierGas、Other”、typeOfLiquid プロパティは”Water、SeaWater”という文字列データを値域とするデータタイププロパティである。

表 6 に Environment オントロジーが持つ全てのプロパティを、表 7 に Environment オントロジーに属する全てのクラスを示す。

表 6. Environment オントロジーのプロパティ一覧

プロパティ名	プロパティの種類	定義域	値域	意味
Value	データタイプ	Environment	文字列データ	測定環境の状態値
UnitDimension	オブジェクト		UnitDimension オントロジー: UnitDimension	測定環境の状態値で用いる単位の次元
UnitSystem	オブジェクト		UnitDimension オントロジー: UnitSystem	測定環境の状態値で用いる単位系
Temperature	オブジェクト	EnvironmentalTemperature	Property オントロジー: Temperature	測定環境の温度
Pressure	オブジェクト	EnvironmentalPressure	Property オントロジー: Pressure	測定環境の圧力
typeOfIrradiation	データタイプ	Irradiation	Electron、Neutron、Proton、Ion、Light から選択	照射環境
typeOfGas	データタイプ	Gas	Air、N、O、H、He、Ar、H2S、CarrierGas、Other	ガス環境

			から選択	
typeOfLiquid	データタイプ	Liquid	Water、SeaWater から選択	液体環境

表 7. Environment オントロジー: クラス一覧

クラス名	上位クラス	
Gas	Atmosphere	
Liquid		
Vacuum		
Atmosphere	Environment	
ConcentrationOfSolvent		
Conductivity		
Contents		
CorrosionPotential		
Current		
CurrentDensity		
DissolvedOxygen		
ElectricPotential		
Electrolyte		
EnvironmentalPressure		
EnvironmentalTemperature		
FlowRate		
FlowState		
HoldingTime		
Humidity		
Irradiation		
IrradiationEnergy		
IrradiationTime		
Loading		
Ph		
Solvent		
Environment		

3.3.4 Process (製造工程や測定、熱処理に関するオントロジー)

Process オントロジーは、“MeasurementMethod”や“HeatTreatment”、“ManufacturingProcess”などの 6

個のクラスと、36 個のプロパティから構成された製造工程や測定、熱処理に関するオントロジーである。MeasurementMethod、HeatTreatment、ManufacturingProcess クラスが最上位にある。Process オントロジーの構造を図 14、表 8 に示す。表 9 に Process オントロジーが持つプロパティの一覧を記す。

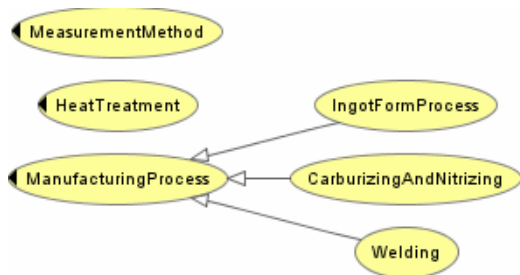


図 14. Process オントロジーの構成要素(クラスのみ)と要素間の関係

表 8. Process オントロジー: クラス一覧

クラス名	上位クラス
CarburizingAndNitriding	ManufacturingProcess
IngotFormProcess	
Welding	
HeatTreatment	
ManufacturingProcess	
MeasurementMethod	

表 9. Process オントロジーのプロパティ一覧

プロパティ名	プロパティの種類	定義域	値域
Atmosphere	データタイプ	HeatTreatment, Welding	Air、Vacuum、Argon、Nitrogen、Hydrogen、Other から選択
CoolingMethod	データタイプ		FurnaceCooling、AirCooling、OilQuench、WaterQuench から選択
CoolingRate	データタイプ	HeatTreatment	文字列データ
EndingTemperature	オブジェクト		Property オントロジー: Temperature
HoldingTime	オブジェクト		Property オントロジー: Time
NumberOfPath	データタイプ		文字列データ
ProcessImage	データタイプ		文字列データ
ProcessingTemperature	オブジェクト		Property オントロジー: Temperature
TypeOfHeatTreatment	データタイプ		Normalize、Temper、Quench、Solution、StressRelease、Anneal、GrainBoundaryPrecipitation、Other から選択

WorkingRate	データタイプ		文字列データ
DeoxidationProcess	データタイプ	IngotFormProcess	文字列データ
FurnaceCapacity	データタイプ		文字列データ
IngotSize	データタイプ		文字列データ
MeltedWeight	データタイプ		文字列データ
MethodOfManufacture	データタイプ		文字列データ
ProcessingAndThermalHistory	データタイプ		文字列データ
ProductFormAndSize	データタイプ		文字列データ
ReductionRatio	データタイプ		文字列データ
RefiningProcess	データタイプ		文字列データ
Thickness	データタイプ		文字列データ
TypeOfCastingAndSize	データタイプ		文字列データ
Dimension_Depth	データタイプ		Welding
Dimension_Width	データタイプ	文字列データ	
GrooveGeometry	データタイプ	文字列データ	
JointShape	データタイプ	文字列データ	
LayerMethod	データタイプ	ButtJoint、 T-joint、 C-joint、 L-joint、 Other から選択	
Pre-HeatingTemperature	オブジェクト	Property オントロジー: Temperature	
WeldingMethod	データタイプ	文字列データ	
WeldingRod	データタイプ	文字列データ	
Environment	オブジェクト	MeasurementMethod, ManufacturingProcess	Property オントロジー: Temperature
HeatTreatmentProcess	オブジェクト	CarburizingAndNitriding	Process オントロジー: HeatTreatment
Normination	データタイプ		文字列データ
ProducedCondition	データタイプ	ManufacturingProcess	文字列データ
RawMaterial	オブジェクト		Substance オントロジー: Atom
TypeOfManufacturing	データタイプ		文字列データ
TypeOfMeasurement	データタイプ		MeasurementMethod

3.3 周辺のオントロジー

3.3.1 UnitDimension (単位に関するオントロジー)

UnitDimension は、”UnitDimension”や”UnitSystem”、”AmountOfInformation”などの 78 個のクラスから構成された単位に関するオントロジーである。最上位は UnitDimension、UnitSystem クラスである。UnitDimension クラスは、物性値の単位の次元を定義し、基本物理量を表す Base と基本物理量を組み合

わせて表現された物理量である **Compound** の二つのサブクラスに分類される。**UnitSystem** クラスは **SI_units** クラスと **CGS_units** クラスをサブクラスとして持ち、単位系を意味する。**Unit Dimension** と **UnitSystem** で定義されているクラスの一覧を表 10 に示す。このオントロジーに属するクラスはそれぞれインスタンスを持つため、**Property** オントロジーの **UnitDimension** プロパティおよび **UnitSystem** プロパティからこのオントロジーを参照する際には表 10 に示す URI を用いる。

```
<property:UnitDimension rdf:resource="http://codata.jp/OML-UnitDimension.owl#electricCurrent"/>
<property:UnitSystem rdf:resource="http://codata.jp/OML-UnitDimension.owl#SI"/>
```

なお、このオントロジーは **Units in MathML⁴**を参考に作成した。

表 10. **UnitDimension** オントロジー: クラス一覧

クラス名	URI	上位クラス
AmountOfInformation	http://codata.jp/OML-UnitDimension.owl#amountOfInformation	Base
AmountOfSubstance	http://codata.jp/OML-UnitDimension.owl#amountOfSubstance	
ElectricCapacitance	http://codata.jp/OML-UnitDimension.owl#electricCapacitance	
ElectricCharge	http://codata.jp/OML-UnitDimension.owl#electricCharge	
ElectricConductance	http://codata.jp/OML-UnitDimension.owl#electricConductance	
ElectricCurrent	http://codata.jp/OML-UnitDimension.owl#electricCurrent	
ElectricInductance	http://codata.jp/OML-UnitDimension.owl#electricInductance	
ElectricPotentialDifference	http://codata.jp/OML-UnitDimension.owl#electricPotentialDifference	
ElectricResistance	http://codata.jp/OML-UnitDimension.owl#electricResistance	
Energy	http://codata.jp/OML-UnitDimension.owl#energy	
Force	http://codata.jp/OML-UnitDimension.owl#force	
Frequency	http://codata.jp/OML-UnitDimension.owl#frequency	
Illuminance	http://codata.jp/OML-UnitDimension.owl#illuminance	
Length	http://codata.jp/OML-UnitDimension.owl#length	
LuminousFlux	http://codata.jp/OML-UnitDimension.owl#luminousFlux	
LuminousIntensity	http://codata.jp/OML-UnitDimension.owl#luminousIntensity	
MagneticFlux	http://codata.jp/OML-UnitDimension.owl#magneticFlux	
MagneticFluxDensity	http://codata.jp/OML-UnitDimension.owl#magneticFluxDensity	
Mass	http://codata.jp/OML-UnitDimension.owl#mass	
PlaneAngle	http://codata.jp/OML-UnitDimension.owl#planeAngle	
Power	http://codata.jp/OML-UnitDimension.owl#power	

⁴ Douglas Wilhelm Harder and Stan Devitt, Units in MathML W3C Working Group Note 10 November 2003. Retrieved 22 February 2008 from the World Wide Web: <http://www.w3.org/TR/mathml-units/>

Pressure	http://codata.jp/OML-UnitDimension.owl#pressure	Compound
SolidAngle	http://codata.jp/OML-UnitDimension.owl#solidAngle	
ThermodynamicTemperature	http://codata.jp/OML-UnitDimension.owl#thermodynamicTemperature	
Time	http://codata.jp/OML-UnitDimension.owl#time	
AbsorbedDoseRate	http://codata.jp/OML-UnitDimension.owl#absorbedDoseRate	
Acceleration	http://codata.jp/OML-UnitDimension.owl#acceleration	
Action	http://codata.jp/OML-UnitDimension.owl#action	
AngularAcceleration	http://codata.jp/OML-UnitDimension.owl#angularAcceleration	
AngularSpeed	http://codata.jp/OML-UnitDimension.owl#angularSpeed	
Area	http://codata.jp/OML-UnitDimension.owl#area	
Concentration	http://codata.jp/OML-UnitDimension.owl#concentration	
CurrentDensity	http://codata.jp/OML-UnitDimension.owl#currentDensity	
DynamicViscosity	http://codata.jp/OML-UnitDimension.owl#dynamicViscosity	
ElectricChargeDensity	http://codata.jp/OML-UnitDimension.owl#electricChargeDensity	
ElectricFieldStrength	http://codata.jp/OML-UnitDimension.owl#electricFieldStrength	
ElectricFluxDensity	http://codata.jp/OML-UnitDimension.owl#electricFluxDensity	
EnergyDensity	http://codata.jp/OML-UnitDimension.owl#energyDensity	
Entropy	http://codata.jp/OML-UnitDimension.owl#entropy	
Exposure	http://codata.jp/OML-UnitDimension.owl#exposure	
HeatCapacity	http://codata.jp/OML-UnitDimension.owl#heatCapacity	
HeatFluxDensity	http://codata.jp/OML-UnitDimension.owl#heatFluxDensity	
Irradiance	http://codata.jp/OML-UnitDimension.owl#irradiance	
KinematicViscosity	http://codata.jp/OML-UnitDimension.owl#kinematicViscosity	
LinearFrequency	http://codata.jp/OML-UnitDimension.owl#linearFrequency	
LinearMassDensity	http://codata.jp/OML-UnitDimension.owl#linearMassDensity	
Luminance	http://codata.jp/OML-UnitDimension.owl#luminance	
MagneticFieldStrength	http://codata.jp/OML-UnitDimension.owl#magneticFieldStrength	
MassDensity	http://codata.jp/OML-UnitDimension.owl#massDensity	
MolarEnergy	http://codata.jp/OML-UnitDimension.owl#molarEnergy	
MolarEntropy	http://codata.jp/OML-UnitDimension.owl#molarEntropy	
MolarHeatCapacity	http://codata.jp/OML-UnitDimension.owl#molarHeatCapacity	
MomentOfForce	http://codata.jp/OML-UnitDimension.owl#momentOfForce	
MomentOfInertia	http://codata.jp/OML-UnitDimension.owl#momentOfInertia	
Momentum	http://codata.jp/OML-UnitDimension.owl#momentum	
Permeability	http://codata.jp/OML-UnitDimension.owl#permeability	
Permittivity	http://codata.jp/OML-UnitDimension.owl#permittivity	
PowerDensity	http://codata.jp/OML-UnitDimension.owl#powerDensity	

Radiance	http://codata.jp/OML-UnitDimension.owl#radiance	
RadiantIntenstiy	http://codata.jp/OML-UnitDimension.owl#radiantIntenstiy	
SpecificEnergy	http://codata.jp/OML-UnitDimension.owl#specificEnergy	
SpecificEntropy	http://codata.jp/OML-UnitDimension.owl#specificEntropy	
SpecificHeatCapacity	http://codata.jp/OML-UnitDimension.owl#specificHeatCapacity	
SpecificVolume	http://codata.jp/OML-UnitDimension.owl#specificVolume	
Speed	http://codata.jp/OML-UnitDimension.owl#speed	
SurfaceEnergyDensity	http://codata.jp/OML-UnitDimension.owl#surfaceEnergyDensity	
SurfacePowerDensity	http://codata.jp/OML-UnitDimension.owl#surfacePowerDensity	
SurfaceTension	http://codata.jp/OML-UnitDimension.owl#surfaceTension	
ThermalConductivity	http://codata.jp/OML-UnitDimension.owl#thermalConductivity	
Volume	http://codata.jp/OML-UnitDimension.owl#volume	
VolumeFlow	http://codata.jp/OML-UnitDimension.owl#volumeFlow	
WaveNumber	http://codata.jp/OML-UnitDimension.owl#waveNumber	
Base		UnitDimension
Compound		
CGS_units	http://codata.jp/OML-UnitDimension.owl#cgs	UnitSystem
SI_units	http://codata.jp/OML-UnitDimension.owl#SI	
UnitDimension		
UnitSystem		

3.3.2 PhysicalConstant (物理定数に関するオントロジー)

PhysicalConstant オントロジーは、“PhysicalConstant”や“UniversalConstant”、“BohrMagnetron”などの 17 個のクラスから構成された物理定数に関するオントロジーである。このオントロジーでは、PhysicalConstant クラスが最上位に、そのサブクラスとして AtomicAndNuclearConstant クラス、ElectromagneticConstant クラス、Physico-chemicalConstant クラス、UniversalConstant クラスを配置する。さらにそれらのクラスは各々サブクラスを持つ。なおクラス同士の関係を図表にすると表 11 のようになる。このオントロジーは、CODATA Internationally recommended values of the Fundamental Physical Constants⁵を参考に作成した。

表 11. PhysicalConstant オントロジー: クラス一覧

クラス名	上位クラス
BohrMagnetron	ElectromagneticConstant
AtomicAndNuclearConstant	PhysicalConstant

⁵ CODATA Internationally recommended values of the Fundamental Physical Constants, December 2007. Retrieved 22 February 2008 from the World Wide Web: <http://physics.nist.gov/cuu/Constants/index.html>

ElectromagneticConstant	
Physico-chemicalConstant	
UniversalConstant	
CharacteristicImpedanceOfVacuum	UniversalConstant
ElectricConstant	
MagneticConstant	
NewtonianConstantOfGravitation	
NewtonianConstantOfGravitation_over_h-bar_c	
PlanckConstant	
PlanckLength	
PlanckMass	
PlanckTemperature	
PlanckTime	
SpeedOfLight_in_vacuum	
PhysicalConstant	

Appendix -OWL により記述した Material Ontology -

1. MaterialInformation オントロジー

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:process="http://codata.jp/OML-Process.owl#"
  xmlns:protege="http://protege.stanford.edu/plugins/owl/protege#"
  xmlns="http://codata.jp/OML-MaterialInformation.owl#"
  xmlns:substance="http://codata.jp/OML-Substance.owl#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns:environment="http://codata.jp/OML-Environment.owl#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:geometry="http://codata.jp/OML-Geometry.owl#"
  xml:base="http://codata.jp/OML-MaterialInformation.owl">
  <owl:Ontology rdf:about="">
    <owl:imports rdf:resource="http://codata.jp/OML-Substance.owl"/>
    <owl:imports rdf:resource="http://codata.jp/OML-Geometry.owl"/>
    <owl:imports rdf:resource="http://codata.jp/OML-Environment.owl"/>
    <owl:imports rdf:resource="http://codata.jp/OML-Process.owl"/>
    <owl:versionInfo rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
      ></owl:versionInfo>
  </owl:Ontology>
  <owl:Class rdf:ID="MaterialInformation"/>
  <owl:Class rdf:ID="EngineeringMaterial">
    <rdfs:subClassOf rdf:resource="#MaterialInformation"/>
  </owl:Class>
  <owl:Class rdf:ID="InformationSource">
    <rdfs:subClassOf rdf:resource="#MaterialInformation"/>
  </owl:Class>
  <owl:Class rdf:ID="MaterialProperty">
    <rdfs:subClassOf rdf:resource="#MaterialInformation"/>
  </owl:Class>
  <owl:ObjectProperty rdf:ID="ChemicalComposition">
    <rdfs:domain rdf:resource="#EngineeringMaterial"/>
    <rdfs:range rdf:resource="http://codata.jp/OML-Substance.owl#Atom"/>
  </owl:ObjectProperty>
</rdf:RDF>
```

```

</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="ManufacturingCondition">
  <rdfs:range rdf:resource="http://codata.jp/OML-Process.owl#ManufacturingProcess"/>
  <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="Property">
  <rdfs:range rdf:resource="http://codata.jp/OML-Property.owl#Property"/>
  <rdfs:domain rdf:resource="#MaterialProperty"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="MeasurementMethod">
  <rdfs:domain rdf:resource="#MaterialProperty"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="Environment">
  <rdfs:range rdf:resource="http://codata.jp/OML-Environment.owl#Environment"/>
  <rdfs:domain rdf:resource="#MaterialProperty"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="SubstanceClass">
  <rdfs:domain rdf:resource="#EngineeringMaterial"/>
  <rdfs:range rdf:resource="http://codata.jp/OML-Substance.owl#Substance"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="Specimen">
  <rdfs:domain rdf:resource="#MaterialProperty"/>
  <rdfs:range rdf:resource="#EngineeringMaterial"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="Equation">
  <rdfs:range rdf:resource="http://codata.jp/OML-Property.owl#Equation"/>
  <rdfs:domain rdf:resource="#MaterialProperty"/>
</owl:ObjectProperty>
<owl:DatatypeProperty rdf:ID="Application">
  <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="CuttingPosition">
  <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Standard">
  <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Geometry">

```

```

    <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Orientation">
    <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="SpecimenSize">
    <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="CommonName">
    <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Project">
    <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Form">
    <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="DataCategory">
    <rdfs:range>
        <owl:DataRange>
            <owl:oneOf rdf:parseType="Resource">
                <rdf:rest rdf:parseType="Resource">
                    <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                    >Calculated</rdf:first>
                    <rdf:rest rdf:parseType="Resource">
                        <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                        >Theoretical</rdf:first>
                        <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
                    </rdf:rest>
                </rdf:rest>
            </owl:oneOf>
        </owl:DataRange>
    </rdfs:range>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="MaterialCharacteristics">
    <rdfs:domain rdf:resource="#EngineeringMaterial"/>

```



```

</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="ChemicalFormula">
  <rdfs:domain rdf:resource="#EngineeringMaterial"/>
</owl:DatatypeProperty>
<owl:AnnotationProperty rdf:ID="Source">
  <rdfs:domain rdf:resource="#InformationSource"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#DatatypeProperty"/>
</owl:AnnotationProperty>
<owl:DataRange>
  <owl:oneOf rdf:parseType="Resource">
    <rdf:rest rdf:parseType="Resource">
      <rdf:rest rdf:parseType="Resource">
        <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
          >composition%</rdf:first>
        <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
      </rdf:rest>
      <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
        >wt%</rdf:first>
    </rdf:rest>
    <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
      >at%</rdf:first>
  </owl:oneOf>
</owl:DataRange>
<rdf:Description rdf:about="http://www.w3.org/2002/07/owl#Thing">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    ></rdfs:comment>
</rdf:Description>
</rdf:RDF>

```

2. Substance オントロジー

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns="http://codata.jp/OML-Substance.owl#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xml:base="http://codata.jp/OML-Substance.owl">
  <owl:Ontology rdf:about="">
    <owl:versionInfo rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
      ></owl:versionInfo>
  </owl:Ontology>
  <owl:Class rdf:ID="OtherWroughtAlAlloy">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="AluminumAlloy"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="Polyethersulfone">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="Thermoplastic"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="Mo">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="Atom"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="Zr">
    <rdfs:subClassOf>
      <owl:Class rdf:about="#Atom"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="As">
    <rdfs:subClassOf>
      <owl:Class rdf:about="#Atom"/>
    </rdfs:subClassOf>
  </owl:Class>
```

```

</owl:Class>
<owl:Class rdf:ID="Clay">
  <rdfs:subClassOf>
    <owl:Class rdf:ID="Mixture"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Sb">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="AluminumAlloy_6000Series">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#AluminumAlloy"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Potting_CastingCeramic">
  <rdfs:subClassOf>
    <owl:Class rdf:ID="CompoundSubstance"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Uus">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Mn">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Polyester-TS">
  <rdfs:subClassOf>
    <owl:Class rdf:ID="Thermoset"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="PolybutyleneTerephthalate-PBT">
  <rdfs:subClassOf>

```

```

    <owl:Class rdf:ID="Polyester-TP"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="AluminumAlloy_4000Series">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#AluminumAlloy"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="FerrousAlloy">
  <rdfs:subClassOf>
    <owl:Class rdf:ID="Alloy"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Tb">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="P">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Semiconductor">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#CompoundSubstance"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Polydienes">
  <rdfs:subClassOf>
    <owl:Class rdf:ID="Polymer_OrganicCompound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Sr">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>

```

```

<owl:Class rdf:ID="LLDPE">
  <rdfs:subClassOf>
    <owl:Class rdf:ID="Polyethylene"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Electronic_MagneticAlloy">
  <rdfs:subClassOf rdf:resource="#FerrousAlloy"/>
</owl:Class>
<owl:Class rdf:ID="Cd">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Yb">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="IntermetallicCompound">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#CompoundSubstance"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="CompositeFibers">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#CompoundSubstance"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Polycarbonates_Thiocarbonates">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Polymer_OrganicCompound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Ce">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>

```

```

<owl:Class rdf:ID="Uut">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Substance"/>
<owl:Class rdf:ID="Ar">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Ta">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="CopperAlloy">
  <rdfs:subClassOf>
    <owl:Class rdf:ID="Non-FerrousAlloy"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Br">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Li">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Fluoropolymer">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Thermoplastic"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Be">
  <rdfs:subClassOf>

```

```

    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Gd">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="EthyleneVinylAlcohol">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Thermoplastic"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Rn">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Polysulfone">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Thermoplastic"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="S">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="GrayCastIron">
  <rdfs:subClassOf rdf:resource="#FerrousAlloy"/>
</owl:Class>
<owl:Class rdf:ID="Uub">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Ba">
  <rdfs:subClassOf>

```

```

    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Elastomer_TPE">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Thermoplastic"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="MalleableIron">
  <rdfs:subClassOf rdf:resource="#FerrousAlloy"/>
</owl:Class>
<owl:Class rdf:ID="TS4000SeriesStainlessSteel">
  <rdfs:subClassOf>
    <owl:Class rdf:ID="StainlessSteel"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Carbide">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#CompoundSubstance"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="OrganicMetalloid">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#CompoundSubstance"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Uuq">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="B">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Cf">
  <rdfs:subClassOf>

```



```

    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Fluoropolymer-TS">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Thermoset"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="In">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Polyarylamide">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Thermoplastic"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Cellulosic">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Thermoplastic"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Ge">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Acetal">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Thermoplastic"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Fr">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>

```

```

<owl:Class rdf:ID="TS10000SeriesStainlessSteel">
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    <owl:Class rdf:about="#Atom"/>
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</owl:Class>
<owl:Class rdf:ID="Polysulfones_Sulfoxides_Sulfonates_Suloamides">
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  <rdfs:subClassOf rdf:resource="#CopperAlloy"/>
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  <rdfs:subClassOf rdf:resource="#TitaniumAlloy"/>
</owl:Class>
<owl:Class rdf:ID="Pu">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="FRM">
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</owl:Class>

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<owl:Class rdf:about="#ToolSteel">
  <rdfs:subClassOf rdf:resource="#FerrousAlloy"/>
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</owl:Class>
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  <rdfs:subClassOf rdf:resource="#StainlessSteel"/>
</owl:Class>
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  </rdfs:subClassOf>
</owl:Class>
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  <rdfs:subClassOf rdf:resource="#Thermoset"/>
</owl:Class>

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  </rdfs:subClassOf>
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    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
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  <rdfs:subClassOf rdf:resource="#AluminumAlloy"/>
</owl:Class>
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    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
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  </rdfs:subClassOf>
</owl:Class>
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  </rdfs:subClassOf>
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</owl:Class>
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  <rdfs:subClassOf>

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    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
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  <rdfs:subClassOf rdf:resource="#TitaniumAlloy"/>
</owl:Class>
<owl:Class rdf:ID="Acrylic">
  <rdfs:subClassOf rdf:resource="#Thermoplastic"/>
</owl:Class>
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</owl:Class>
<owl:Class rdf:about="#Oxide">
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</owl:Class>
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  </rdfs:subClassOf>
</owl:Class>
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  </rdfs:subClassOf>
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    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
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    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
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    <owl:Class rdf:about="#Polyester-TP"/>

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    </rdfs:subClassOf>
</owl:Class>
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  </rdfs:subClassOf>
</owl:Class>
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</owl:Class>
<owl:Class rdf:ID="LowAlloySteel">
  <rdfs:subClassOf rdf:resource="#FerrousAlloy"/>
</owl:Class>
<owl:Class rdf:ID="Nitride">
  <rdfs:subClassOf rdf:resource="#CompoundSubstance"/>
</owl:Class>
<owl:Class rdf:ID="Nd">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Polyketones_Thioketones">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Polymer_OrganicCompound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Polyanhydrides_Thioanhydrides">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Polymer_OrganicCompound"/>
  </rdfs:subClassOf>
</owl:Class>
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    <rdfs:subClassOf rdf:resource="#Thermoset"/>
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</owl:Class>
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</owl:Class>
<owl:Class rdf:ID="Ceramic_MetallicCoating">
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<owl:Class rdf:ID="AISI5000SeriesSteel">
    <rdfs:subClassOf rdf:resource="#FerrousAlloy"/>
</owl:Class>
<owl:Class rdf:ID="Kr">
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        <owl:Class rdf:about="#Atom"/>
    </rdfs:subClassOf>
</owl:Class>
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    <rdfs:subClassOf rdf:resource="#SuperAlloy"/>
</owl:Class>
<owl:Class rdf:ID="FibreComposites">
    <rdfs:subClassOf rdf:resource="#CompoundSubstance"/>
</owl:Class>
<owl:Class rdf:ID="Nylon12">
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</owl:Class>
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        <owl:Class rdf:about="#Polymer_OrganicCompound"/>
    </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:about="#Alloy">
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    <rdfs:subClassOf rdf:resource="#CompoundSubstance"/>
</owl:Class>
<owl:Class rdf:ID="Zn">

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  </owl:Class>
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    <rdfs:subClassOf>
      <owl:Class rdf:about="#Atom"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:about="#Polymer_OrganicCompound">
    <rdfs:subClassOf rdf:resource="#CompoundSubstance"/>
  </owl:Class>
  <owl:Class rdf:ID="Grass">
    <rdfs:subClassOf rdf:resource="#Mixture"/>
  </owl:Class>
  <owl:Class rdf:ID="SolderAlloy">
    <rdfs:subClassOf rdf:resource="#Non-FerrousAlloy"/>
  </owl:Class>
  <owl:Class rdf:ID="CobaltBase">
    <rdfs:subClassOf rdf:resource="#SuperAlloy"/>
  </owl:Class>
  <owl:Class rdf:ID="Os">
    <rdfs:subClassOf>
      <owl:Class rdf:about="#Atom"/>
    </rdfs:subClassOf>
  </owl:Class>
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    <rdfs:subClassOf rdf:resource="#Thermoplastic"/>
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    <rdfs:subClassOf>
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    </rdfs:subClassOf>
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  <owl:Class rdf:ID="Na">
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    </rdfs:subClassOf>
  </owl:Class>

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</owl:Class>
<owl:Class rdf:ID="TS3000SeriesStainlessSteel">
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</owl:Class>
<owl:Class rdf:ID="WhiteCastIron">
  <rdfs:subClassOf rdf:resource="#FerrousAlloy"/>
</owl:Class>
<owl:Class rdf:ID="O">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Cr">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Polyurethanes_Thiourethanes">
  <rdfs:subClassOf rdf:resource="#Polymer_OrganicCompound"/>
</owl:Class>
<owl:Class rdf:ID="AmorphousMetal">
  <rdfs:subClassOf rdf:resource="#CompoundSubstance"/>
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<owl:Class rdf:ID="AISI1000SeriesSteel">
  <rdfs:subClassOf rdf:resource="#FerrousAlloy"/>
</owl:Class>
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    <owl:Class rdf:about="#Atom"/>
  </rdfs:subClassOf>
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<owl:Class rdf:about="#Atom">
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  </rdfs:subClassOf>

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</owl:Class>
<owl:Class rdf:ID="Sc">
  <rdfs:subClassOf rdf:resource="#Atom"/>
</owl:Class>
<owl:Class rdf:ID="DiallylPhthalate-DAP">
  <rdfs:subClassOf rdf:resource="#Thermoset"/>
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<owl:Class rdf:ID="Rubber">
  <rdfs:subClassOf rdf:resource="#Mixture"/>
</owl:Class>
<owl:Class rdf:ID="No">
  <rdfs:subClassOf rdf:resource="#Atom"/>
</owl:Class>
<owl:Class rdf:ID="Rb">
  <rdfs:subClassOf rdf:resource="#Atom"/>
</owl:Class>
<owl:Class rdf:ID="Polyamide-imide">
  <rdfs:subClassOf rdf:resource="#Thermoplastic"/>
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  <rdfs:subClassOf rdf:resource="#Thermoplastic"/>
</owl:Class>
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  <rdfs:subClassOf>
    <owl:Class rdf:about="#PureSubstance"/>
  </rdfs:subClassOf>
</owl:Class>
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</owl:Class>
<owl:Class rdf:about="#PureSubstance">
  <rdfs:subClassOf rdf:resource="#Substance"/>
</owl:Class>
<owl:Class rdf:ID="Np">
  <rdfs:subClassOf rdf:resource="#Atom"/>

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</owl:Class>
<owl:Class rdf:ID="Polyimines-Polyamines">
  <rdfs:subClassOf rdf:resource="#Polymer_OrganicCompound"/>
</owl:Class>
<owl:Class rdf:ID="PolyetherBlockAmide-PEBA">
  <rdfs:subClassOf rdf:resource="#Nylon"/>
</owl:Class>
<owl:Class rdf:ID="Po">
  <rdfs:subClassOf rdf:resource="#Atom"/>
</owl:Class>
<owl:Class rdf:ID="Polyethers">
  <rdfs:subClassOf rdf:resource="#Polymer_OrganicCompound"/>
</owl:Class>
<owl:Class rdf:ID="Glass">
  <rdfs:subClassOf rdf:resource="#CompoundSubstance"/>
</owl:Class>
<owl:Class rdf:ID="La">
  <rdfs:subClassOf rdf:resource="#Atom"/>
</owl:Class>
<owl:Class rdf:ID="Polyimide-TS">
  <rdfs:subClassOf rdf:resource="#Thermoset"/>
</owl:Class>
<owl:Class rdf:ID="AluminumAlloy_3000Series">
  <rdfs:subClassOf rdf:resource="#AluminumAlloy"/>
</owl:Class>
<owl:Class rdf:ID="Er">
  <rdfs:subClassOf rdf:resource="#Atom"/>
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<owl:Class rdf:ID="LowCarbonSteel">
  <rdfs:subClassOf rdf:resource="#CarbonSteel"/>
</owl:Class>
<owl:Class rdf:ID="SANPolymer">
  <rdfs:subClassOf rdf:resource="#Thermoplastic"/>
</owl:Class>
<owl:Class rdf:ID="Glaze">
  <rdfs:subClassOf rdf:resource="#Mixture"/>
</owl:Class>
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    <rdfs:subClassOf rdf:resource="#Atom"/>
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    <rdfs:subClassOf rdf:resource="#Thermoplastic"/>
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</owl:Class>
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</owl:Class>
<owl:Class rdf:ID="Ir">
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</owl:Class>
<owl:Class rdf:ID="Polypropylene">
    <rdfs:subClassOf rdf:resource="#Thermoplastic"/>
</owl:Class>
<owl:Class rdf:ID="Y">
    <rdfs:subClassOf rdf:resource="#Atom"/>
</owl:Class>
<owl:Class rdf:ID="Additive_Filler">
    <rdfs:subClassOf rdf:resource="#Thermoplastic"/>
</owl:Class>
<owl:Class rdf:ID="BetaTitaniumAlloy">
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</owl:Class>
<owl:Class rdf:ID="Ra">
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</owl:Class>
<owl:Class rdf:ID="HDPE">
    <rdfs:subClassOf rdf:resource="#Polyethylene"/>
</owl:Class>
<owl:Class rdf:ID="MagnesiumOxide">
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<owl:Class rdf:ID="Rock">
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</owl:Class>

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<owl:Class rdf:ID="DuctileIron">
  <rdfs:subClassOf rdf:resource="#FerrousAlloy"/>
</owl:Class>
<owl:Class rdf:ID="Pa">
  <rdfs:subClassOf rdf:resource="#Atom"/>
</owl:Class>
<owl:Class rdf:ID="Ca">
  <rdfs:subClassOf rdf:resource="#Atom"/>
</owl:Class>
<owl:Class rdf:ID="CompositeCoreMaterial">
  <rdfs:subClassOf rdf:resource="#CompoundSubstance"/>
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<owl:Class rdf:ID="Polyphenylenes">
  <rdfs:subClassOf rdf:resource="#Polymer_OrganicCompound"/>
</owl:Class>
<owl:Class rdf:ID="Th">
  <rdfs:subClassOf rdf:resource="#Atom"/>
</owl:Class>
<owl:Class rdf:ID="Shell">
  <rdfs:subClassOf rdf:resource="#Mixture"/>
</owl:Class>
<owl:Class rdf:ID="Es">
  <rdfs:subClassOf rdf:resource="#Atom"/>
</owl:Class>
<owl:Class rdf:ID="Polyketone">
  <rdfs:subClassOf rdf:resource="#Thermoplastic"/>
</owl:Class>
<owl:Class rdf:ID="LDPE">
  <rdfs:subClassOf rdf:resource="#Polyethylene"/>
</owl:Class>
<owl:Class rdf:ID="Biological">
  <rdfs:subClassOf rdf:resource="#Mixture"/>
</owl:Class>
<owl:DatatypeProperty rdf:ID="MinimumContentRatio"/>
<owl:DatatypeProperty rdf:ID="State">
  <rdfs:domain rdf:resource="#Substance"/>
  <rdfs:range>
    <owl:DataRange>

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<owl:oneOf rdf:parseType="Resource">
  <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Gas</rdf:first>
  <rdf:rest rdf:parseType="Resource">
    <rdf:rest rdf:parseType="Resource">
      <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
      <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
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    </rdf:rest>
    <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Solid</rdf:first>
  </rdf:rest>
</owl:oneOf>
</owl:DataRange>
</rdfs:range>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="UnitOfRatio">
  <rdfs:range>
    <owl:DataRange>
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        >wt%</rdf:first>
        <rdf:rest rdf:parseType="Resource">
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            >mol%</rdf:first>
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              >volume%</rdf:first>
            </rdf:rest>
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        </rdf:rest>
        <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
        >at%</rdf:first>
      </rdf:rest>
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  </owl:DataRange>
</rdfs:range>

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    <rdfs:domain rdf:resource="#Substance"/>
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</owl:DatatypeProperty>
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<Carbide rdf:ID="carbide"/>
<Nitride rdf:ID="nitride"/>
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<PolyphenyleneSulfide rdf:ID="polyphenylene_sulfide"/>
<Sg rdf:ID="sg"/>
<ABSPolymer rdf:ID="ABS_polymer"/>
<Nb rdf:ID="nb"/>
<Polyesters_Thioesters rdf:ID="polyesters_thioesters"/>
<FibreComposites rdf:ID="fibre_composites"/>
<IronBase rdf:ID="iron_base"/>
<Cf rdf:ID="cf"/>
<Polyamides_Thioamides rdf:ID="polyamides_thioamides"/>
<FRM rdf:ID="frm"/>
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<Polyvinyls rdf:ID="polyvinyls"/>
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<TitaniumAlloy rdf:ID="titanium_alloy"/>
<W rdf:ID="w"/>
<Additive_Filler rdf:ID="additive_filler"/>
<Ce rdf:ID="ce"/>
<StainlessSteel rdf:ID="stainless_steel"/>
<FRP rdf:ID="frp"/>
<Ti rdf:ID="ti"/>
<SolidSolution rdf:ID="solid_solution"/>
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<Ra rdf:ID="ra"/>
<Polyimide-TS rdf:ID="polyimide-TS"/>
<Si rdf:ID="si"/>
<Uuh rdf:ID="uuh"/>
<Zn rdf:ID="zn"/>

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<Fe rdf:ID="fe"/>
<V rdf:ID="v"/>
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<Ac rdf:ID="ac"/>
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<Na rdf:ID="na"/>
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<Shell rdf:ID="shell"/>
<Rock rdf:ID="rock"/>
<U rdf:ID="u"/>
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<Rg rdf:ID="rg"/>
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<Sb rdf:ID="sb"/>
<S rdf:ID="s"/>
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<Se rdf:ID="se"/>
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<Nd rdf:ID="nd"/>
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<Mixture rdf:ID="mixture"/>
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<Te rdf:ID="te"/>
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<Pd rdf:ID="pd"/>
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<Bh rdf:ID="bh"/>
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<Ne rdf:ID="ne"/>
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<MetalMatrixComposite rdf:ID="metal_matrix_composite"/>
<Gd rdf:ID="gd"/>
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<Fluoropolymer rdf:ID="fluoropolymer"/>
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<LowAlloySteel rdf:ID="low_alloy_steel"/>
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<T300SeriesStainlessSteel rdf:ID="T300_series_stainless_steel"/>
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<Mg rdf:ID="mg"/>
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<Biological rdf:ID="biological"/>
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</rdf:Description>
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<MalleableIron rdf:ID="malleableIron"/>
<EthyleneAcrylicAcid rdf:ID="ethylene_acrylic_acid"/>
<InorganicMetalloid rdf:ID="inorganic_metalloid"/>
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<Polyimides_Thioimides rdf:ID="polyimides_thioimides"/>
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<CarbonSteel rdf:ID="carbon_steel"/>
<Polyketone rdf:ID="polyketone"/>
<Rubber rdf:ID="rubber"/>
<Zr rdf:ID="zr"/>
</rdf:RDF>

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3. Property オントロジー

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  xmlns:unitd="http://codata.jp/OML-UnitDimension.owl#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns="http://codata.jp/OML-Property.owl#"
  xml:base="http://codata.jp/OML-Property.owl">
  <owl:Ontology rdf:about="">
    <owl:imports rdf:resource="http://codata.jp/OML-UnitDimension.owl"/>
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      ></owl:versionInfo>
  </owl:Ontology>
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      <owl:Class rdf:ID="Mechanical"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="OpticalConductivitySopt">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="Optical"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="Permittivity">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="StaticPermittivity"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="SoundVelocity">
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    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="Structural">
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  </rdfs:subClassOf>
</owl:Class>
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</owl:Class>
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    <owl:Class rdf:ID="ElectronicAndElectrical"/>
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</owl:Class>
<owl:Class rdf:ID="PhysicalQuantity">
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</owl:Class>
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</owl:Class>
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  </rdfs:subClassOf>
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</owl:Class>
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</owl:Class>
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  <owl:Class rdf:about="#StaticPermittivity">
    <rdfs:subClassOf rdf:resource="#Optical"/>
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  <owl:Class rdf:ID="TemperatureDerivativeOfEnergyGap">
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  </owl:Class>
  <owl:Class rdf:ID="ThermalExpansionCoefficient">
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    <owl:Class rdf:about="#Magnetic"/>
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  <rdfs:subClassOf rdf:resource="#ElasticStiffnessCoefficient"/>
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    <owl:Class rdf:about="#ThermalExpansionCoefficient_D"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="LinearThermalExpansionCoefficient">
  <rdfs:subClassOf rdf:resource="#ThermalExpansionCoefficient"/>
</owl:Class>
<owl:Class rdf:ID="CriticalMagneticFieldStrength">
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    <owl:Class rdf:about="#Superconducting"/>
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</owl:Class>
<owl:Class rdf:ID="ElectronMobility">
  <rdfs:subClassOf rdf:resource="#ElectronicAndElectrical"/>
</owl:Class>
<owl:Class rdf:ID="StressDependenceOfTransitionTemperature">
  <rdfs:subClassOf rdf:resource="#PhaseTransition"/>
</owl:Class>
<owl:Class rdf:about="#Magnetic">
  <rdfs:subClassOf rdf:resource="#Property"/>

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</owl:Class>
<owl:Class rdf:ID="ThermalConductivity">
  <rdfs:subClassOf rdf:resource="#Thermal"/>
</owl:Class>
<owl:Class rdf:ID="HoleConcentration">
  <rdfs:subClassOf rdf:resource="#ElectronicAndElectrical"/>
</owl:Class>
<owl:Class rdf:ID="SpontaneousMagnetization">
  <rdfs:subClassOf rdf:resource="#SpontaneousMagneticMoment"/>
</owl:Class>
<owl:Class rdf:ID="Density">
  <rdfs:subClassOf rdf:resource="#Structural"/>
</owl:Class>
<owl:Class rdf:ID="LongitudinalSoundVelocity">
  <rdfs:subClassOf rdf:resource="#SoundVelocity"/>
</owl:Class>
<owl:Class rdf:ID="PhaseTransitionAtLowPressure">
  <rdfs:subClassOf rdf:resource="#PressuresForPhaseTransition"/>
</owl:Class>
<owl:Class rdf:ID="TransverseSoundVelocity">
  <rdfs:subClassOf rdf:resource="#SoundVelocity"/>
</owl:Class>
<owl:Class rdf:ID="InitialSlopeOfBc2AtTc">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Superconducting"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="RefractiveIndex">
  <rdfs:subClassOf rdf:resource="#Optical"/>
</owl:Class>
<owl:Class rdf:ID="ShearModulus">
  <rdfs:subClassOf rdf:resource="#Mechanical"/>
</owl:Class>
<owl:Class rdf:ID="Microhardness">
  <rdfs:subClassOf rdf:resource="#Mechanical"/>
</owl:Class>
<owl:Class rdf:ID="C11">
  <rdfs:subClassOf rdf:resource="#ElasticStiffnessCoefficient"/>

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</owl:Class>
<owl:Class rdf:ID="ElectricalResistivity">
  <rdfs:subClassOf rdf:resource="#ElectronicAndElectrical"/>
</owl:Class>
<owl:Class rdf:ID="VolumeMagnetization">
  <rdfs:subClassOf rdf:resource="#Magnetic"/>
</owl:Class>
<owl:Class rdf:ID="CriticalMagneticFieldStrengthAt0K">
  <rdfs:subClassOf rdf:resource="#CriticalMagneticFieldStrength"/>
</owl:Class>
<owl:Class rdf:ID="EnergyGapForDirectTransition">
  <rdfs:subClassOf rdf:resource="#EnergyGap"/>
</owl:Class>
<owl:Class rdf:ID="ElectricalConductivity">
  <rdfs:subClassOf rdf:resource="#ElectronicAndElectrical"/>
</owl:Class>
<owl:Class rdf:ID="AdiabaticBulkModulus">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#BulkModulus"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="LinearCompressibility">
  <rdfs:subClassOf rdf:resource="#Mechanical"/>
</owl:Class>
<owl:Class rdf:ID="VolumeCompressibility">
  <rdfs:subClassOf rdf:resource="#Mechanical"/>
</owl:Class>
<owl:Class rdf:ID="MolarEntropyOfFormation">
  <rdfs:subClassOf rdf:resource="#Thermal"/>
</owl:Class>
<owl:Class rdf:ID="LowerCriticalMagneticFieldStrength">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Superconducting"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="High-FrequencyPermittivity">
  <rdfs:subClassOf rdf:resource="#StaticPermittivity"/>
</owl:Class>

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<owl:Class rdf:ID="EffectiveCharge">
  <rdfs:subClassOf rdf:resource="#ElectronicAndElectrical"/>
</owl:Class>
<owl:Class rdf:ID="PhaseTransitionAtHighPressure">
  <rdfs:subClassOf rdf:resource="#PressuresForPhaseTransition"/>
</owl:Class>
<owl:Class rdf:ID="MagneticMoment">
  <rdfs:subClassOf rdf:resource="#Magnetic"/>
</owl:Class>
<owl:Class rdf:ID="MolarEnthalpyChangeAtPhaseTransition">
  <rdfs:subClassOf rdf:resource="#Thermal"/>
</owl:Class>
<owl:Class rdf:ID="TemperatureDerivativeOfEnergyGapForDirectTransition">
  <rdfs:subClassOf rdf:resource="#TemperatureDerivativeOfEnergyGap"/>
</owl:Class>
<owl:Class rdf:about="#TemperaturesForPhaseTransition">
  <rdfs:subClassOf rdf:resource="#PhaseTransition"/>
</owl:Class>
<owl:Class rdf:ID="C12">
  <rdfs:subClassOf rdf:resource="#ElasticStiffnessCoefficient"/>
</owl:Class>
<owl:Class rdf:ID="ElectronDensityOfStatesAtFermiLevel">
  <rdfs:subClassOf rdf:resource="#ElectronicAndElectrical"/>
</owl:Class>
<owl:Class rdf:ID="C22">
  <rdfs:subClassOf rdf:resource="#ElasticStiffnessCoefficient"/>
</owl:Class>
<owl:Class rdf:ID="YoungsModulus">
  <rdfs:subClassOf rdf:resource="#Mechanical"/>
</owl:Class>
<owl:Class rdf:ID="VolumeThermalExpansionCoefficient">
  <rdfs:subClassOf rdf:resource="#ThermalExpansionCoefficient"/>
</owl:Class>
<owl:Class rdf:ID="ElectronConcentration">
  <rdfs:subClassOf rdf:resource="#ElectronicAndElectrical"/>
</owl:Class>
<owl:Class rdf:ID="SpecificHeatCapacityAtConstantPressure">
  <rdfs:subClassOf rdf:resource="#Thermal"/>

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</owl:Class>
<owl:Class rdf:ID="NeelTemperature">
  <rdfs:subClassOf rdf:resource="#Magnetic"/>
</owl:Class>
<owl:Class rdf:ID="LondonPenetrationDepth">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Superconducting"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Electron-PhononInteractionParameter">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Superconducting"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:about="#ThermalExpansionCoefficient_D">
  <rdfs:subClassOf rdf:resource="#Thermal"/>
</owl:Class>
<owl:Class rdf:ID="LowestTemperatureForNormalConductivity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Superconducting"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="CurieTemperature">
  <rdfs:subClassOf rdf:resource="#Magnetic"/>
</owl:Class>
<owl:Class rdf:ID="C23">
  <rdfs:subClassOf rdf:resource="#ElasticStiffnessCoefficient"/>
</owl:Class>
<owl:Class rdf:ID="Pressure">
  <rdfs:subClassOf rdf:resource="#PhysicalQuantity"/>
</owl:Class>
<owl:Class rdf:about="#Superconducting">
  <rdfs:subClassOf rdf:resource="#Property"/>
</owl:Class>
<owl:Class rdf:ID="MeltingTemperature">
  <rdfs:subClassOf rdf:resource="#PhaseTransition"/>
</owl:Class>
<owl:Class rdf:ID="MolarEnthalpyOfFormation">

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    <rdfs:subClassOf rdf:resource="#MolarEnthalpy"/>
</owl:Class>
<owl:Class rdf:ID="C44">
    <rdfs:subClassOf rdf:resource="#ElasticStiffnessCoefficient"/>
</owl:Class>
<owl:Class rdf:ID="CriticalFieldForMagneticTransition">
    <rdfs:subClassOf rdf:resource="#Magnetic"/>
</owl:Class>
<owl:Class rdf:ID="HoleMobility">
    <rdfs:subClassOf rdf:resource="#ElectronicAndElectrical"/>
</owl:Class>
<owl:Class rdf:ID="MagneticAnisotropyField">
    <rdfs:subClassOf rdf:resource="#Magnetic"/>
</owl:Class>
<owl:Class rdf:ID="Temperature">
    <rdfs:subClassOf rdf:resource="#PhysicalQuantity"/>
</owl:Class>
<owl:Class rdf:about="#MolarGibbsEnergy">
    <rdfs:subClassOf rdf:resource="#Thermal"/>
</owl:Class>
<owl:Class rdf:ID="PeritecticTemperature">
    <rdfs:subClassOf rdf:resource="#PhaseTransition"/>
</owl:Class>
<owl:Class rdf:ID="PressureForPhaseTransition">
    <rdfs:subClassOf rdf:resource="#PressuresForPhaseTransition"/>
</owl:Class>
<owl:Class rdf:ID="Creep">
    <rdfs:subClassOf rdf:resource="#Mechanical"/>
</owl:Class>
<owl:Class rdf:ID="UpperCriticalMagneticFieldStrengthAt0K">
    <rdfs:subClassOf rdf:resource="#UpperCriticalMagneticFieldStrength"/>
</owl:Class>
<owl:Class rdf:about="#CoherenceLength">
    <rdfs:subClassOf rdf:resource="#Superconducting"/>
</owl:Class>
<owl:Class rdf:ID="IsothermalVolumeCompressibility">
    <rdfs:subClassOf rdf:resource="#VolumeCompressibility"/>
</owl:Class>

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<owl:Class rdf:ID="SlopeOfTcAt0GPa">
  <rdfs:subClassOf rdf:resource="#Superconducting"/>
</owl:Class>
<owl:Class rdf:about="#BulkModulus">
  <rdfs:subClassOf rdf:resource="#Mechanical"/>
</owl:Class>
<owl:Class rdf:ID="OpticalAbsorptionCoefficient">
  <rdfs:subClassOf rdf:resource="#Optical"/>
</owl:Class>
<owl:Class rdf:ID="MolarEntropyChangeAtMeltingPoint">
  <rdfs:subClassOf rdf:resource="#Thermal"/>
</owl:Class>
<owl:Class rdf:ID="EnergyGapForIndirectTransition">
  <rdfs:subClassOf rdf:resource="#EnergyGap"/>
</owl:Class>
<owl:Class rdf:ID="SaturationMagneticMoment">
  <rdfs:subClassOf rdf:resource="#Magnetic"/>
</owl:Class>
<owl:Class rdf:ID="SaturationVolumeMagnetization">
  <rdfs:subClassOf rdf:resource="#Magnetic"/>
</owl:Class>
<owl:ObjectProperty rdf:ID="PropertyName">
  <rdfs:range rdf:resource="#Property"/>
  <rdfs:domain rdf:resource="#Symbol"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="TimeToReachTotalStrain0.5">
  <rdfs:domain rdf:resource="#Creep"/>
  <rdfs:range rdf:resource="#Time"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="UnitSystem">
  <rdfs:domain rdf:resource="#Property"/>
  <rdfs:range rdf:resource="http://codata.jp/OML-UnitDimension.owl#UnitSystem"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="TestTemperature">
  <rdfs:range rdf:resource="#Temperature"/>
  <rdfs:domain rdf:resource="#Creep"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="UnitDimension">

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    <rdfs:range rdf:resource="http://codata.jp/OML-UnitDimension.owl#UnitDimension"/>
    <rdfs:domain rdf:resource="#Property"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="TimeToReachTotalStrain5.0">
    <rdfs:range rdf:resource="#Time"/>
    <rdfs:domain rdf:resource="#Creep"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="TimeToSecondaryCreep">
    <rdfs:domain rdf:resource="#Creep"/>
    <rdfs:range rdf:resource="#Time"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="TimeToReachTotalStrain2.0">
    <rdfs:domain rdf:resource="#Creep"/>
    <rdfs:range rdf:resource="#Time"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="TimeToReachTotalStrain1.0">
    <rdfs:domain rdf:resource="#Creep"/>
    <rdfs:range rdf:resource="#Time"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="TimeToTertiaryCreep">
    <rdfs:domain rdf:resource="#Creep"/>
    <rdfs:range rdf:resource="#Time"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="CreepTime">
    <rdfs:range rdf:resource="#Time"/>
    <rdfs:domain rdf:resource="#Creep"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="TimeToRupture">
    <rdfs:range rdf:resource="#Time"/>
    <rdfs:domain rdf:resource="#Creep"/>
</owl:ObjectProperty>
<owl:DatatypeProperty rdf:ID="StrainAtOnsetOfTertiaryCteep">
    <rdfs:domain rdf:resource="#Creep"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Strain">
    <rdfs:domain rdf:resource="#Creep"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="ReductionOfArea">

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    <rdfs:domain rdf:resource="#Creep"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Eq">
    <rdfs:domain rdf:resource="#Equation"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Value">
    <rdfs:domain rdf:resource="#Property"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="CreepCurve">
    <rdfs:domain rdf:resource="#Creep"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="StrainRate">
    <rdfs:domain rdf:resource="#Creep"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="MaximalValue">
    <rdfs:domain rdf:resource="#Property"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="CreepTestResults">
    <rdfs:domain rdf:resource="#Creep"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="MinimumValue">
    <rdfs:domain rdf:resource="#Property"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="MinimumCreepRate">
    <rdfs:domain rdf:resource="#Creep"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Elongation">
    <rdfs:domain rdf:resource="#Creep"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="InstantaneousStrain">
    <rdfs:domain rdf:resource="#Creep"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Notation">
    <rdfs:domain rdf:resource="#Symbol"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="AppliedStress">
    <rdfs:domain rdf:resource="#Creep"/>
</owl:DatatypeProperty>

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<SpontaneousMagnetization rdf:ID="spontaneous_magnetization">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >A / m</rdfs:comment>
  <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#magnetic_field_strength"/>
</SpontaneousMagnetization>
<HallCoefficient rdf:ID="hall_coefficient">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >m3 / C</rdfs:comment>
</HallCoefficient>
<C22 rdf:ID="c22">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Pa</rdfs:comment>
</C22>
<MassMagneticSusceptibility rdf:ID="mass_magnetic_susceptibility">
  <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#specific_volume"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >m3 / kg</rdfs:comment>
</MassMagneticSusceptibility>
<ThermalEnergyGap rdf:ID="thermal_energy_gap"/>
<DebyeTemperature rdf:ID="debye_temperature">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >K</rdfs:comment>
</DebyeTemperature>
<PhaseTransitionAtLowPressure rdf:ID="phase_transition_at_low_pressure">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Pa</rdfs:comment>
</PhaseTransitionAtLowPressure>
<MolarGibbsEnergyOfFormation rdf:ID="molar_gibbs_energy_of_formation">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >J / mol</rdfs:comment>
</MolarGibbsEnergyOfFormation>
<C11-C12 rdf:ID="c11-c12">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Pa</rdfs:comment>
</C11-C12>
<MeltingTemperature rdf:ID="melting_temperature">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >K</rdfs:comment>

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<UnitSystem
rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#thermodynamic_temperature"/>
</MeltingTemperature>
<C23 rdf:ID="c23">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Pa</rdfs:comment>
</C23>
<LinearThermalExpansionCoefficient rdf:ID="linear_thermal_expansion_coefficient">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >1 / K</rdfs:comment>
</LinearThermalExpansionCoefficient>
<IsothermalVolumeCompressibility rdf:ID="isothermal_volume_compressibility">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >1 / Pa</rdfs:comment>
</IsothermalVolumeCompressibility>
<PressureDependenceOfPiezoresistivity rdf:ID="pressure_dependence_of_piezoresistivity">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >1 / GPa</rdfs:comment>
</PressureDependenceOfPiezoresistivity>
<HeatCapacityDiscontinuity rdf:ID="heat_capacity_discontinuity">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >J / K mol</rdfs:comment>
</HeatCapacityDiscontinuity>
<MolarEnthalpyChangeAtPhaseTransition rdf:ID="molar_enthalpy_change_at_phase_transition">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >J / mol</rdfs:comment>
</MolarEnthalpyChangeAtPhaseTransition>
<MolarElectronicHeatCapacityCoefficient rdf:ID="molar_electronic_heat_capacity_coefficient">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >J / K2 mol</rdfs:comment>
</MolarElectronicHeatCapacityCoefficient>
<TemperatureDerivativeOfEnergyGap rdf:ID="temperature_derivative_of_energy_gap"/>
<C44 rdf:ID="c44">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Pa</rdfs:comment>
</C44>
<MeanValence rdf:ID="mean_valence"/>
<ElectricStrengthOfDielectric rdf:ID="electric_strength_of_dielectric">

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<UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#electric_field_strength"/>
<rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>V / m</rdfs:comment>
</ElectricStrengthOfDielectric>
<RefractiveIndex rdf:ID="refractive_index"/>
<MolarEnthalpyChangeAtMeltingPoint rdf:ID="molar_enthalpy_change_at_melting_point">
<rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>J / mol</rdfs:comment>
</MolarEnthalpyChangeAtMeltingPoint>
<TemperaturesForPhaseTransition rdf:ID="temperatures_for_phase_transition">
<rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>K</rdfs:comment>
<UnitSystem
rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#thermodynamic_temperature"/>
</TemperaturesForPhaseTransition>
<SuperconductingTransitionTemperature rdf:ID="superconducting_transition_temperature">
<rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>K</rdfs:comment>
</SuperconductingTransitionTemperature>
<AdiabaticBulkModulus rdf:ID="adiabatic_bulkModulus">
<rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>Pa</rdfs:comment>
</AdiabaticBulkModulus>
<C14 rdf:ID="c14">
<rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>Pa</rdfs:comment>
</C14>
<LongitudinalSoundVelocity rdf:ID="longitudinal_sound_velocity">
<UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#speed"/>
<rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>m / s</rdfs:comment>
</LongitudinalSoundVelocity>
<MolarGibbsEnergy rdf:ID="molar_gibbs_energy">
<rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>J / mol</rdfs:comment>
</MolarGibbsEnergy>
<EffectiveMassOfElectronsInConductionBand
rdf:ID="effective_mass_of_electronsIn_conduction_band"/>

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```

<MolarEnthalpyOfFormation rdf:ID="molar_enthalpy_of_formation">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >J / mol</rdfs:comment>
</MolarEnthalpyOfFormation>
<LondonPenetrationDepth rdf:ID="london_penetration_depth">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >m</rdfs:comment>
</LondonPenetrationDepth>
<C55 rdf:ID="c55">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</C55>
<LowestTemperatureForNormalConductivity rdf:ID="lowest_temperature_for_normal_conductivity">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >K</rdfs:comment>
</LowestTemperatureForNormalConductivity>
<UpperCriticalMagneticFieldStrength rdf:ID="upper_critical_magnetic_field_strength">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >T</rdfs:comment>
</UpperCriticalMagneticFieldStrength>
<PhaseTransitionAtLowTemperature rdf:ID="phase_transition_at_low_temperature">
  <UnitSystem
rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#thermodynamic_temperature"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >K</rdfs:comment>
</PhaseTransitionAtLowTemperature>
<VolumeThermalExpansionCoefficient rdf:ID="volume_thermal_expansion_coefficient">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / K</rdfs:comment>
</VolumeThermalExpansionCoefficient>
<LowerCriticalMagneticFieldStrength rdf:ID="lower_critical_magnetic_field_strength">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >T</rdfs:comment>
</LowerCriticalMagneticFieldStrength>
<ThermalExpansionCoefficient_D rdf:ID="thermal_expansion_coefficient_D">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / K</rdfs:comment>
</ThermalExpansionCoefficient_D>

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<ThermalConductivity rdf:ID="thermal_conductivity">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >W / m K</rdfs:comment>
</ThermalConductivity>
<EnergyGap rdf:ID="energy_gap"/>
<HoleMobility rdf:ID="hole_mobility">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >m2 / V s</rdfs:comment>
</HoleMobility>
<MolarEnthalpy rdf:ID="molar_enthalpy">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >J / mol</rdfs:comment>
</MolarEnthalpy>
<StressDependenceOfTransitionTemperature
rdf:ID="stress_dependence_of_transition_temperature">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >K / Pa</rdfs:comment>
</StressDependenceOfTransitionTemperature>
<MolarEntropyOfFormation rdf:ID="molar_entropy_of_formation">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >J / K mol</rdfs:comment>
</MolarEntropyOfFormation>
<HoleConcentration rdf:ID="hole_concentration">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / m3</rdfs:comment>
</HoleConcentration>
<High-FrequencyPermittivity rdf:ID="high-frequency_permittivity"/>
<C33 rdf:ID="c33"/>
<MolarMagneticSusceptibility rdf:ID="molar_magnetic_susceptibility">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >m3 / mol</rdfs:comment>
</MolarMagneticSusceptibility>
<OpticalAbsorptionCoefficient rdf:ID="optical_absorption_coefficient">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / m</rdfs:comment>
  <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#wave_number"/>
</OpticalAbsorptionCoefficient>
<PhaseTransitionAtHighTemperature rdf:ID="phase_transition_at_high_temperature">

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```

<UnitSystem
rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#thermodynamic_temperature"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >K</rdfs:comment>
</PhaseTransitionAtHighTemperature>
<MagneticAnisotropyField rdf:ID="magnetic_anisotropy_field">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >T</rdfs:comment>
  <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#magnetic_flux_density"/>
</MagneticAnisotropyField>
<CoherenceLength rdf:ID="coherence_length">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >m</rdfs:comment>
</CoherenceLength>
<ElasticStiffnessCoefficient rdf:ID="elastic_stiffness_coefficient">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Pa</rdfs:comment>
</ElasticStiffnessCoefficient>
<YoungsModulus rdf:ID="youngs_modulus">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Pa</rdfs:comment>
</YoungsModulus>
<PressureForPhaseTransition rdf:ID="pressure_for_phase_transition">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Pa</rdfs:comment>
</PressureForPhaseTransition>
<VolumeThermalExpansionCoefficient_D rdf:ID="volume_thermal_expansion_coefficient_D">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >1 / K</rdfs:comment>
</VolumeThermalExpansionCoefficient_D>
<SoundVelocity rdf:ID="sound_velocity">
  <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#speed"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >m / s</rdfs:comment>
</SoundVelocity>
<CriticalTemperatureForMagneticTransition rdf:ID="critical_temperature_for_magnetic_transition">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >K</rdfs:comment>

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    <UnitSystem
rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#thermodynamic_temperature"/>
  </CriticalTemperatureForMagneticTransition>
  <ThermoelectricPower rdf:ID="thermoelectric_power">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >V / K</rdfs:comment>
  </ThermoelectricPower>
  <PeritecticTemperature rdf:ID="peritectic_temperature">
    <UnitSystem
rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#thermodynamic_temperature"/>
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >K</rdfs:comment>
  </PeritecticTemperature>
  <VolumeCompressibility rdf:ID="volume_compressibility">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / Pa</rdfs:comment>
  </VolumeCompressibility>
  <SaturationMagneticMoment rdf:ID="saturation_magnetic_moment"/>
  <TransverseSoundVelocity rdf:ID="transverse_sound_velocity">
    <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#speed"/>
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >m / s</rdfs:comment>
  </TransverseSoundVelocity>
  <LinearThermalExpansionCoefficient_D rdf:ID="linear_thermal_expansion_coefficient_D">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / K</rdfs:comment>
  </LinearThermalExpansionCoefficient_D>
  <SpontaneousMagneticMoment rdf:ID="spontaneous_magnetic_moment"/>
  <ThermalExpansionCoefficient rdf:ID="thermal_expansion_coefficient">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / K</rdfs:comment>
  </ThermalExpansionCoefficient>
  <SlopeOfTcAt0GPa rdf:ID="slope_of_Tc_at0_GPa">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >K / Pa</rdfs:comment>
  </SlopeOfTcAt0GPa>
  <UpperCriticalMagneticFieldStrengthAt0K rdf:ID="upper_critical_magnetic_field_strength_at_0K">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"

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    >T</rdfs:comment>
</UpperCriticalMagneticFieldStrengthAt0K>
<VolumeMagnetization rdf:ID="volume_magnetization">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >A / m</rdfs:comment>
  <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#magnetic_field_strength"/>
</VolumeMagnetization>
<ImaginaryPartOfPermittivity rdf:ID="imaginary_part_of_permittivity"/>
<ShearModulus rdf:ID="shear_modulus">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</ShearModulus>
<Reflectivity rdf:ID="reflectivity"/>
<MolarHeatCapacityAtConstantPressure rdf:ID="molar_heat_capacity_at_constant_pressure">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >J / K mol</rdfs:comment>
</MolarHeatCapacityAtConstantPressure>
<CriticalMagneticFieldStrengthAt0K rdf:ID="critical_magnetic_field_strength_at_0K">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >T</rdfs:comment>
</CriticalMagneticFieldStrengthAt0K>
<ElectricalConductivity rdf:ID="electrical_conductivity">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / W m</rdfs:comment>
</ElectricalConductivity>
<Electron-PhononInteractionParameter rdf:ID="electron-phononInteraction_parameter"/>
<EffectiveBohrMagnetonNumber rdf:ID="effective_bohr_magneton_number">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    ></rdfs:comment>
</EffectiveBohrMagnetonNumber>
<ElectricalResistivity rdf:ID="electrical_resistivity">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >W m</rdfs:comment>
</ElectricalResistivity>
<NeelTemperature rdf:ID="neel_temperature">
  <UnitSystem
rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#thermodynamic_temperature"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"

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    >K</rdfs:comment>
</NeelTemperature>
<BulkModulus rdf:ID="bulk_modulus">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</BulkModulus>
<LongitudinalElasticCoefficient rdf:ID="longitudinal_elastic_coefficient">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</LongitudinalElasticCoefficient>
<TemperatureDerivativeOfEnergyGapForDirectTransition
rdf:ID="temperature_derivative_of_energy_gap_for_direct_transition"/>
<OpticalConductivitySopt rdf:ID="optical_conductivity_sopt">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / W m</rdfs:comment>
</OpticalConductivitySopt>
<ActivationEnergy rdf:ID="activation_energy"/>
<MagneticMoment rdf:ID="magnetic_moment">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    ></rdfs:comment>
</MagneticMoment>
<CriticalFieldForMagneticTransition rdf:ID="critical_field_for_magnetic_transition">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >A / m</rdfs:comment>
  <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#magnetic_field_strength"/>
</CriticalFieldForMagneticTransition>
<HallMobility rdf:ID="hall_mobility"/>
<PhaseTransitionAtHighPressure rdf:ID="phase_transition_at_high_pressure">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</PhaseTransitionAtHighPressure>
<StaticPermittivity rdf:ID="static_permittivity"/>
<ElectronDensityOfStatesAtFermiLevel rdf:ID="electron_density_of_states_at_fermi_level">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    ></rdfs:comment>
</ElectronDensityOfStatesAtFermiLevel>
<CoherenceLengthAt0K rdf:ID="coherence_length_at_0K">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"

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    >m</rdfs:comment>
</CoherenceLengthAt0K>
<EnergyGapForDirectTransition rdf:ID="energy_gap_for_direct_transition"/>
<EnergyGapForIndirectTransition rdf:ID="energy_gap_for_indirect_transition"/>
<MolarEntropyChangeAtPhaseTransition rdf:ID="molar_entropy_change_at_phase_transition">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >J / K mol</rdfs:comment>
</MolarEntropyChangeAtPhaseTransition>
<Temperature-IndependentPartOfMagneticSusceptibility
rdf:ID="temperature-independent_part_of_magnetic_susceptibility">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >m3 / mol</rdfs:comment>
</Temperature-IndependentPartOfMagneticSusceptibility>
<C13 rdf:ID="c13">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</C13>
<CriticalMagneticFieldStrength rdf:ID="critical_magnetic_field_strength">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >T</rdfs:comment>
</CriticalMagneticFieldStrength>
<LinearCompressibility rdf:ID="linear_compressibility">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / Pa</rdfs:comment>
</LinearCompressibility>
<HeatCapacityDiscontinuityAtPhaseTransition
rdf:ID="heat_capacity_discontinuity_at_phase_transition">
  <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#heat_capacity"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >J / K mol</rdfs:comment>
</HeatCapacityDiscontinuityAtPhaseTransition>
<InitialSlopeOfBc2AtTc rdf:ID="initial_slope_of_Bc2_at_Tc">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >T / K</rdfs:comment>
</InitialSlopeOfBc2AtTc>
<EffectiveCharge rdf:ID="effective_charge"/>
<ElectronMobility rdf:ID="electron_mobility">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"

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    >m2 / V s</rdfs:comment>
</ElectronMobility>
<C12 rdf:ID="c12">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</C12>
<rdf:Description rdf:about="http://www.w3.org/2002/07/owl#Thing">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    ></rdfs:comment>
</rdf:Description>
<CurieTemperature rdf:ID="curie_temperature">
  <UnitSystem
rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#thermodynamic_temperature"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >K</rdfs:comment>
</CurieTemperature>
<ElectronConcentration rdf:ID="electron_concentration">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >1 / m3</rdfs:comment>
</ElectronConcentration>
<EffectiveMassOfHolesInValenceBand rdf:ID="effective_mass_of_holes_in_valence_band"/>
<PressuresForPhaseTransition rdf:ID="pressures_for_phase_transition">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</PressuresForPhaseTransition>
<C11 rdf:ID="c11">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</C11>
<Permittivity rdf:ID="permittivity"/>
<C66 rdf:ID="c66">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</C66>
<AdiabaticBulkModulusDiscontinuityAtNeelTemperature
rdf:ID="adiabatic_bulk_modulus_discontinuity_at_neel_temperature">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>

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</AdiabaticBulkModulusDiscontinuityAtNeelTemperature>
<SaturationVolumeMagnetization rdf:ID="saturation_volume_magnetization">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >A / m</rdfs:comment>
  <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#magnetic_field_strength"/>
</SaturationVolumeMagnetization>
<ElectronDensityOfStatesAtFermiLevelPerSpin
rdf:ID="electron_density_of_states_at_fermi_level_per_spin"/>
  <ParamagneticCurieTemperature rdf:ID="paramagnetic_curie_temperature">
    <UnitSystem
rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#thermodynamic_temperature"/>
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >K</rdfs:comment>
  </ParamagneticCurieTemperature>
  <MolarEntropyChangeAtMeltingPoint rdf:ID="molar_entropy_change_at_melting_point">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >J / K mol</rdfs:comment>
  </MolarEntropyChangeAtMeltingPoint>
  <TemperatureDerivativeOfAdiabaticBulkModulus
rdf:ID="temperature_derivative_of_adiabatic_bulk_modulus">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
  </TemperatureDerivativeOfAdiabaticBulkModulus>
  <MolarEntropy rdf:ID="molar_entropy">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >J / K mol</rdfs:comment>
  </MolarEntropy>
  <Density rdf:ID="density">
    <UnitSystem rdf:resource="http://codata.jp/NEDO-UnitDimensions.owl#linear_mass_density"/>
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >kg / m3</rdfs:comment>
  </Density>
</rdf:RDF>

```

4. Environment オントロジー

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:unitd="http://codata.jp/OML-UnitDimension.owl#"
  xmlns:protege="http://protege.stanford.edu/plugins/owl/protege#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns="http://codata.jp/OML-Environment.owl#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:property="http://codata.jp/OML-Property.owl#"
  xml:base="http://codata.jp/OML-Environment.owl">
  <owl:Ontology rdf:about="">
    <owl:versionInfo rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    ></owl:versionInfo>
    <owl:imports rdf:resource="http://codata.jp/OML-UnitDimension.owl"/>
    <owl:imports rdf:resource="http://codata.jp/OML-Property.owl"/>
  </owl:Ontology>
  <owl:Class rdf:ID="Current">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="Environment"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="Atmosphere">
    <rdfs:subClassOf rdf:resource="#Environment"/>
  </owl:Class>
  <owl:Class rdf:ID="ElectricPotential">
    <rdfs:subClassOf rdf:resource="#Environment"/>
  </owl:Class>
  <owl:Class rdf:ID="Gas">
    <rdfs:subClassOf rdf:resource="#Atmosphere"/>
  </owl:Class>
  <owl:Class rdf:ID="FlowState">
    <rdfs:subClassOf rdf:resource="#Environment"/>
  </owl:Class>
  <owl:Class rdf:ID="Humidity">
    <rdfs:subClassOf rdf:resource="#Environment"/>
  </owl:Class>
</rdf:RDF>
```

```
</owl:Class>
<owl:Class rdf:ID="Irradiation">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="Ph">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="IrradiationEnergy">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="HoldingTime">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="Contents">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="Vacuum">
  <rdfs:subClassOf rdf:resource="#Atmosphere"/>
</owl:Class>
<owl:Class rdf:ID="CurrentDensity">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="Conductivity">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="Loading">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="IrradiationTime">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="Electrolyte">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="Solvent">
  <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="DissolvedOxygen">
```

```

    <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="ConcentrationOfSolvent">
    <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="EnvironmentalTemperature">
    <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="Liquid">
    <rdfs:subClassOf rdf:resource="#Atmosphere"/>
</owl:Class>
<owl:Class rdf:ID="CorrosionPotential">
    <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="FlowRate">
    <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:Class rdf:ID="EnvironmentalPressure">
    <rdfs:subClassOf rdf:resource="#Environment"/>
</owl:Class>
<owl:ObjectProperty rdf:ID="UnitDimension">
    <rdfs:range rdf:resource="http://codata.jp/OML-UnitDimension.owl#UnitDimension"/>
    <rdfs:domain rdf:resource="#Environment"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="Pressure">
    <rdfs:domain rdf:resource="#EnvironmentalPressure"/>
    <rdfs:range rdf:resource="http://codata.jp/OML-Property.owl#Pressure"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="Temperature">
    <rdfs:domain rdf:resource="#EnvironmentalTemperature"/>
    <rdfs:range rdf:resource="http://codata.jp/OML-Property.owl#Temperature"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="UnitSystem">
    <rdfs:domain rdf:resource="#Environment"/>
    <rdfs:range rdf:resource="http://codata.jp/OML-UnitDimension.owl#UnitSystem"/>
</owl:ObjectProperty>
<owl:DatatypeProperty rdf:ID="typeOfLiquid">
    <rdfs:range>

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```

<owl:DataRange>
  <owl:oneOf rdf:parseType="Resource">
    <rdf:rest rdf:parseType="Resource">
      <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
        >SeaWater</rdf:first>
      <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
    </rdf:rest>
    <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
      >Water</rdf:first>
  </owl:oneOf>
</owl:DataRange>
</rdfs:range>
<rdfs:domain rdf:resource="#Liquid"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="typeOfIrradiation">
  <rdfs:domain rdf:resource="#Irradiation"/>
  <rdfs:range>
    <owl:DataRange>
      <owl:oneOf rdf:parseType="Resource">
        <rdf:rest rdf:parseType="Resource">
          <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
            >Neutron</rdf:first>
          <rdf:rest rdf:parseType="Resource">
            <rdf:rest rdf:parseType="Resource">
              <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                >lon</rdf:first>
              <rdf:rest rdf:parseType="Resource">
                <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
                <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                  >Light</rdf:first>
              </rdf:rest>
            </rdf:rest>
          </rdf:rest>
          <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
            >Proton</rdf:first>
        </rdf:rest>
      </rdf:rest>
    </owl:DataRange>
  </rdfs:range>
  <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Electron</rdf:first>

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    </owl:oneOf>
  </owl:DataRange>
</rdfs:range>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="typeOfGas">
  <rdfs:range>
    <owl:DataRange>
      <owl:oneOf rdf:parseType="Resource">
        <rdf:rest rdf:parseType="Resource">
          <rdf:rest rdf:parseType="Resource">
            <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
            >O</rdf:first>
            <rdf:rest rdf:parseType="Resource">
              <rdf:rest rdf:parseType="Resource">
                <rdf:rest rdf:parseType="Resource">
                  <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                  >Ar</rdf:first>
                  <rdf:rest rdf:parseType="Resource">
                    <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                    >H2S</rdf:first>
                    <rdf:rest rdf:parseType="Resource">
                      <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                      >CarrierGas</rdf:first>
                      <rdf:rest rdf:parseType="Resource">
                        <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                        >Other</rdf:first>
                        <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
                      </rdf:rest>
                    </rdf:rest>
                  </rdf:rest>
                </rdf:rest>
              </rdf:rest>
            </rdf:rest>
          </rdf:rest>
        <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
        >He</rdf:first>
      </rdf:rest>
      <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
      >H</rdf:first>
    </rdf:rest>
  </rdf:rest>
</rdf:rest>

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        <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
        >N</rdf:first>
    </rdf:rest>
    <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Air</rdf:first>
</owl:oneOf>
</owl:DataRange>
</rdfs:range>
<rdfs:domain rdf:resource="#Gas"/>
</owl:DatatypeProperty>
<Gas rdf:ID="gas-Air">
    <typeOfGas rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Air</typeOfGas>
</Gas>
<Gas rdf:ID="gas-N">
    <typeOfGas rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >N</typeOfGas>
</Gas>
<Irradiation rdf:ID="irradiation-Proton">
    <typeOfIrradiation rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Proton</typeOfIrradiation>
</Irradiation>
<Gas rdf:ID="gas-CarrierGas">
    <typeOfGas rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >CarrierGas</typeOfGas>
</Gas>
<Vacuum rdf:ID="Vacuum_4">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Pa</rdfs:comment>
</Vacuum>
<Irradiation rdf:ID="irradiation-Light">
    <typeOfIrradiation rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Light</typeOfIrradiation>
</Irradiation>
<Gas rdf:ID="gas-O">
    <typeOfGas rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >O</typeOfGas>
</Gas>

```

```

<rdf:Description rdf:about="http://www.w3.org/2002/07/owl#Thing">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  ></rdfs:comment>
</rdf:Description>
<Gas rdf:ID="gas-He">
  <typeOfGas rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >He</typeOfGas>
</Gas>
<Irradiation rdf:ID="irradiation-Electron">
  <typeOfIrradiation rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Electron</typeOfIrradiation>
</Irradiation>
<Gas rdf:ID="gas-H">
  <typeOfGas rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >H</typeOfGas>
</Gas>
<Gas rdf:ID="gas-Ar">
  <typeOfGas rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Ar</typeOfGas>
</Gas>
<Gas rdf:ID="gas-Other">
  <typeOfGas rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Other</typeOfGas>
</Gas>
<Liquid rdf:ID="liquid_SeaWater">
  <typeOfLiquid rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >SeaWater</typeOfLiquid>
</Liquid>
<Irradiation rdf:ID="irradiation-Ion">
  <typeOfIrradiation rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Ion</typeOfIrradiation>
</Irradiation>
<Gas rdf:ID="gas-H2S">
  <typeOfGas rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >H2S</typeOfGas>
</Gas>
<Irradiation rdf:ID="irradiation-Neutron">
  <typeOfIrradiation rdf:datatype="http://www.w3.org/2001/XMLSchema#string"

```

```
>Neutron</typeOfIrradiation>
</Irradiation>
<Liquid rdf:ID="liquid-Water">
  <typeOfLiquid rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Water</typeOfLiquid>
</Liquid>
</rdf:RDF>
```

5. Process オントロジー

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns="http://codata.jp/OML-Process.owl#"
  xmlns:protege="http://protege.stanford.edu/plugins/owl/protege#"
  xmlns:substance="http://codata.jp/OML-Substance.owl#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns:environment="http://codata.jp/OML-Environment.owl#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:property="http://codata.jp/OML-Property.owl#"
  xml:base="http://codata.jp/OML-Process.owl">
  <owl:Ontology rdf:about="">
    <owl:imports rdf:resource="http://codata.jp/OML-Substance.owl"/>
    <owl:imports rdf:resource="http://codata.jp/OML-Environment.owl"/>
    <owl:versionInfo rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
      ></owl:versionInfo>
  </owl:Ontology>
  <owl:Class rdf:ID="HeatTreatment"/>
  <owl:Class rdf:ID="Welding">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="ManufacturingProcess"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="IngotFormProcess">
    <rdfs:subClassOf rdf:resource="#ManufacturingProcess"/>
  </owl:Class>
  <owl:Class rdf:ID="MeasurementMethod"/>
  <owl:Class rdf:ID="CarburizingAndNitriding">
    <rdfs:subClassOf rdf:resource="#ManufacturingProcess"/>
  </owl:Class>
  <owl:ObjectProperty rdf:ID="EndingTemperature">
    <rdfs:range rdf:resource="http://codata.jp/OML-Property.owl#Temperature"/>
    <rdfs:domain rdf:resource="#HeatTreatment"/>
  </owl:ObjectProperty>
  <owl:ObjectProperty rdf:ID="RawMaterial">
```

```

    <rdfs:domain rdf:resource="#ManufacturingProcess"/>
    <rdfs:range rdf:resource="http://codata.jp/OML-Substance.owl#Atom"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="Environment">
  <rdfs:domain>
    <owl:Class>
      <owl:unionOf rdf:parseType="Collection">
        <owl:Class rdf:about="#MeasurementMethod"/>
        <owl:Class rdf:about="#ManufacturingProcess"/>
      </owl:unionOf>
    </owl:Class>
  </rdfs:domain>
  <rdfs:range rdf:resource="http://codata.jp/OML-Environment.owl#Environment"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="Pre-HeatingTemperature">
  <rdfs:range rdf:resource="http://codata.jp/OML-Property.owl#Temperature"/>
  <rdfs:domain rdf:resource="#Welding"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="HoldingTime">
  <rdfs:domain rdf:resource="#HeatTreatment"/>
  <rdfs:range rdf:resource="http://codata.jp/OML-Property.owl#Time"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="ProcessingTemperature">
  <rdfs:range rdf:resource="http://codata.jp/OML-Property.owl#Temperature"/>
  <rdfs:domain rdf:resource="#HeatTreatment"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="HeatTreatmentProcess">
  <rdfs:range rdf:resource="#HeatTreatment"/>
  <rdfs:domain rdf:resource="#CarburizingAndNitriding"/>
</owl:ObjectProperty>
<owl:DatatypeProperty rdf:ID="GrooveGeometry">
  <rdfs:domain rdf:resource="#Welding"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="TypeOfCastingAndSize">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >mm</rdfs:comment>
  <rdfs:domain rdf:resource="#IngotFormProcess"/>
</owl:DatatypeProperty>

```

```

<owl:DatatypeProperty rdf:ID="Normination">
  <rdfs:domain rdf:resource="#CarburizingAndNitriding"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Dimension_Depth">
  <rdfs:domain rdf:resource="#Welding"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Dimension_Width">
  <rdfs:domain rdf:resource="#Welding"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="RefiningProcess">
  <rdfs:domain rdf:resource="#IngotFormProcess"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="JointShape">
  <rdfs:domain rdf:resource="#Welding"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="TypeOfHeatTreatment">
  <rdfs:domain rdf:resource="#HeatTreatment"/>
  <rdfs:range>
    <owl:DataRange>
      <owl:oneOf rdf:parseType="Resource">
        <rdf:rest rdf:parseType="Resource">
          <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
            >Temper</rdf:first>
          <rdf:rest rdf:parseType="Resource">
            <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
              >Quench</rdf:first>
            <rdf:rest rdf:parseType="Resource">
              <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                >Solution</rdf:first>
              <rdf:rest rdf:parseType="Resource">
                <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                  >StressRelease</rdf:first>
                <rdf:rest rdf:parseType="Resource">
                  <rdf:rest rdf:parseType="Resource">
                    <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                      >GrainBoundaryPrecipitation</rdf:first>
                    <rdf:rest rdf:parseType="Resource">
                      <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
                    </rdf:rest>
                  </rdf:rest>
                </rdf:rest>
              </rdf:rest>
            </rdf:rest>
          </rdf:rest>
        </rdf:rest>
      </owl:oneOf>
    </owl:DataRange>
  </rdfs:range>
</owl:DatatypeProperty>

```

```

        <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
        >others</rdf:first>
    </rdf:rest>
</rdf:rest>
<rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>Anneal</rdf:first>
</rdf:rest>
</rdf:rest>
</rdf:rest>
</rdf:rest>
</rdf:rest>
<rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>Normalize</rdf:first>
</owl:oneOf>
</owl:DataRange>
</rdfs:range>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="CoolingRate">
    <rdfs:domain rdf:resource="#HeatTreatment"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Atmosphere">
    <rdfs:domain>
        <owl:Class>
            <owl:unionOf rdf:parseType="Collection">
                <owl:Class rdf:about="#HeatTreatment"/>
                <owl:Class rdf:about="#Welding"/>
            </owl:unionOf>
        </owl:Class>
    </rdfs:domain>
    <rdfs:range>
        <owl:DataRange>
            <owl:oneOf rdf:parseType="Resource">
                <rdf:rest rdf:parseType="Resource">
                    <rdf:rest rdf:parseType="Resource">
                        <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                        >Argon</rdf:first>
                    <rdf:rest rdf:parseType="Resource">
                        <rdf:rest rdf:parseType="Resource">

```



```

    <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Hydrogen</rdf:first>
    <rdf:rest rdf:parseType="Resource">
      <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
      >Others</rdf:first>
      <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
    </rdf:rest>
  </rdf:rest>
  <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Nitrogen</rdf:first>
</rdf:rest>
</rdf:rest>
<rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>Vacuum</rdf:first>
</rdf:rest>
<rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>Air</rdf:first>
</owl:oneOf>
</owl:DataRange>
</rdfs:range>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="CoolingMethod">
  <rdfs:domain>
    <owl:Class>
      <owl:unionOf rdf:parseType="Collection">
        <owl:Class rdf:about="#HeatTreatment"/>
        <owl:Class rdf:about="#Welding"/>
      </owl:unionOf>
    </owl:Class>
  </rdfs:domain>
  <rdfs:range>
    <owl:DataRange>
      <owl:oneOf rdf:parseType="Resource">
        <rdf:rest rdf:parseType="Resource">
          <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
          >AirCooling</rdf:first>
          <rdf:rest rdf:parseType="Resource">
            <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"

```

```

    >OilQuench</rdf:first>
    <rdf:rest rdf:parseType="Resource">
      <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
      <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
        >WaterQuench</rdf:first>
    </rdf:rest>
  </rdf:rest>
</rdf:rest>
<rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >FurnaceCooling</rdf:first>
</owl:oneOf>
</owl:DataRange>
</rdfs:range>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="FurnaceCapacity">
  <rdfs:domain rdf:resource="#IngotFormProcess"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >t</rdfs:comment>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="ProcessingAndThermalHistory">
  <rdfs:domain rdf:resource="#IngotFormProcess"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="ProcessImage">
  <rdfs:domain rdf:resource="#HeatTreatment"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="WeldingRod">
  <rdfs:domain rdf:resource="#Welding"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Thickness">
  <rdfs:domain rdf:resource="#IngotFormProcess"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >mm</rdfs:comment>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="WeldingMethod">
  <rdfs:domain rdf:resource="#Welding"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="NumberOfPath">
  <rdfs:domain rdf:resource="#HeatTreatment"/>

```

```

</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="WorkingRate">
  <rdfs:domain rdf:resource="#HeatTreatment"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="DeoxidationProcess">
  <rdfs:domain rdf:resource="#IngotFormProcess"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="ReductionRatio">
  <rdfs:domain rdf:resource="#IngotFormProcess"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="MeltedWeight">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >kg</rdfs:comment>
  <rdfs:domain rdf:resource="#IngotFormProcess"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="MethodOfManufacture">
  <rdfs:domain rdf:resource="#IngotFormProcess"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="IngotSize">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >kg</rdfs:comment>
  <rdfs:domain rdf:resource="#IngotFormProcess"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="LayerMethod">
  <rdfs:range>
    <owl:DataRange>
      <owl:oneOf rdf:parseType="Resource">
        <rdf:rest rdf:parseType="Resource">
          <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
          >T-joint</rdf:first>
          <rdf:rest rdf:parseType="Resource">
            <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
            >C-joint</rdf:first>
            <rdf:rest rdf:parseType="Resource">
              <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
              >L-joint</rdf:first>
              <rdf:rest rdf:parseType="Resource">
                <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
              </rdf:rest>
            </rdf:rest>
          </rdf:rest>
        </rdf:rest>
      </owl:oneOf>
    </owl:DataRange>
  </rdfs:range>
</owl:DatatypeProperty>

```

```

        <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
        >Others</rdf:first>
    </rdf:rest>
</rdf:rest>
</rdf:rest>
</rdf:rest>
<rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>ButtJoint</rdf:first>
</owl:oneOf>
</owl:DataRange>
</rdfs:range>
<rdfs:domain rdf:resource="#Welding"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="ProducedCondition">
    <rdfs:domain rdf:resource="#ManufacturingProcess"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="ProductFormAndSize">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >mm</rdfs:comment>
    <rdfs:domain rdf:resource="#IngotFormProcess"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="TypeOfMeasurement">
    <rdfs:domain rdf:resource="#MeasurementMethod"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="TypeOfManufacturing">
    <rdfs:domain rdf:resource="#ManufacturingProcess"/>
</owl:DatatypeProperty>
<rdf:Description rdf:about="http://www.w3.org/2002/07/owl#Thing">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    ></rdfs:comment>
</rdf:Description>
<owl:DataRange>
    <owl:oneOf rdf:parseType="Resource">
        <rdf:rest rdf:parseType="Resource">
            <rdf:rest rdf:parseType="Resource">
                <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
                <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                >composition%</rdf:first>
            </rdf:rest>
        </rdf:rest>
    </owl:oneOf>
</owl:DataRange>

```

```
</rdf:rest>
<rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>wt%</rdf:first>
</rdf:rest>
<rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>at%</rdf:first>
</owl:oneOf>
</owl:DataRange>
</rdf:RDF>
```

6. UnitDimension オントロジー

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns="http://codata.jp/OML-UnitDimension.owl#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xml:base="http://codata.jp/OML-UnitDimension.owl">
  <owl:Ontology rdf:about="">
    <owl:versionInfo rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
      ></owl:versionInfo>
  </owl:Ontology>
  <owl:Class rdf:ID="Pressure">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="Base"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="Time">
    <rdfs:subClassOf>
      <owl:Class rdf:about="#Base"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="VolumeFlow">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="Compound"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="Exposure">
    <rdfs:subClassOf>
      <owl:Class rdf:about="#Compound"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="Mass">
    <rdfs:subClassOf>
      <owl:Class rdf:about="#Base"/>
    </rdfs:subClassOf>
  </owl:Class>
</rdf:RDF>
```

```

</owl:Class>
<owl:Class rdf:ID="MolarEntropy">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Area">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Energy">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Power">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="LinearMassDensity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="DynamicViscosity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="LuminousIntensity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="ElectricInductance">
  <rdfs:subClassOf>

```

```

    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="ThermalConductivity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="MomentOfForce">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="ElectricCharge">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="UnitDimension"/>
<owl:Class rdf:ID="RadiantIntenstiy">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="MagneticFlux">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="ThermodynamicTemperature">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="CGS_units">
  <rdfs:subClassOf>
    <owl:Class rdf:ID="UnitSystem"/>
  </rdfs:subClassOf>

```



```

</owl:Class>
<owl:Class rdf:ID="Action">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="AmountOfSubstance">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Permeability">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="MagneticFluxDensity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Permittivity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="AmountOfInformation">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="SpecificEnergy">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Force">
  <rdfs:subClassOf>

```

```

    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="ElectricChargeDensity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="PowerDensity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="SurfaceTension">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="CurrentDensity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="MolarHeatCapacity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="SpecificHeatCapacity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="MassDensity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>

```

```

<owl:Class rdf:ID="Luminance">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Illuminance">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Base"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:about="#Base">
  <rdfs:subClassOf rdf:resource="#UnitDimension"/>
</owl:Class>
<owl:Class rdf:ID="MolarEnergy">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="AngularSpeed">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="PlaneAngle">
  <rdfs:subClassOf rdf:resource="#Base"/>
</owl:Class>
<owl:Class rdf:ID="Volume">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="LuminousFlux">
  <rdfs:subClassOf rdf:resource="#Base"/>
</owl:Class>
<owl:Class rdf:ID="LinearFrequency">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>

```

```

</owl:Class>
<owl:Class rdf:ID="ElectricPotentialDifference">
  <rdfs:subClassOf rdf:resource="#Base"/>
</owl:Class>
<owl:Class rdf:ID="KinematicViscosity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="SurfaceEnergyDensity">
  <rdfs:subClassOf>
    <owl:Class rdf:about="#Compound"/>
  </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Frequency">
  <rdfs:subClassOf rdf:resource="#Base"/>
</owl:Class>
<owl:Class rdf:about="#Compound">
  <rdfs:subClassOf rdf:resource="#UnitDimension"/>
</owl:Class>
<owl:Class rdf:ID="ElectricFluxDensity">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="ElectricFieldStrength">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="Concentration">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="Radiance">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="Speed">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="SurfacePowerDensity">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>

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```
<owl:Class rdf:ID="EnergyDensity">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="SpecificEntropy">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="WaveNumber">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="ElectricResistance">
  <rdfs:subClassOf rdf:resource="#Base"/>
</owl:Class>
<owl:Class rdf:ID="Irradiance">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="SolidAngle">
  <rdfs:subClassOf rdf:resource="#Base"/>
</owl:Class>
<owl:Class rdf:ID="HeatFluxDensity">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="ElectricCapacitance">
  <rdfs:subClassOf rdf:resource="#Base"/>
</owl:Class>
<owl:Class rdf:ID="AbsorbedDoseRate">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="Entropy">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="MagneticFieldStrength">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="HeatCapacity">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="SI_units">
  <rdfs:subClassOf rdf:resource="#UnitSystem"/>
```

```

</owl:Class>
<owl:Class rdf:ID="SpecificVolume">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="AngularAcceleration">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="ElectricCurrent">
  <rdfs:subClassOf rdf:resource="#Base"/>
</owl:Class>
<owl:Class rdf:ID="Momentum">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="Acceleration">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<owl:Class rdf:ID="ElectricConductance">
  <rdfs:subClassOf rdf:resource="#Base"/>
</owl:Class>
<owl:Class rdf:ID="Length">
  <rdfs:subClassOf rdf:resource="#Base"/>
</owl:Class>
<owl:Class rdf:ID="MomentOfInertia">
  <rdfs:subClassOf rdf:resource="#Compound"/>
</owl:Class>
<Time rdf:ID="AmountOfTime"/>
<ThermalConductivity rdf:ID="Thermal_Conductivity"/>
<rdf:Description rdf:about="http://www.w3.org/2002/07/owl#Thing">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  ></rdfs:comment>
</rdf:Description>
<SI_units rdf:ID="SI"/>
<ThermodynamicTemperature rdf:ID="Temperature"/>
</rdf:RDF>

```

7. PhysicalConstant オントロジー

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:unitd="http://codata.jp/OML-UnitDimension.owl#"
  xmlns:protege="http://protege.stanford.edu/plugins/owl/protege#"
  xmlns="http://codata.jp/PhysicalConstant.owl#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xml:base="http://codata.jp/PhysicalConstant.owl">
  <owl:Ontology rdf:about="">
    <owl:versionInfo rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
      ></owl:versionInfo>
    <owl:imports rdf:resource="http://codata.jp/OML-UnitDimension.owl"/>
  </owl:Ontology>
  <owl:Class rdf:ID="SpeedOfLight_in_vacuum">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="UniversalConstant"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:about="#UniversalConstant">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="PhysicalConstant"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="NewtonianConstantOfGravitation">
    <rdfs:subClassOf rdf:resource="#UniversalConstant"/>
  </owl:Class>
  <owl:Class rdf:ID="BohrMagneton">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="ElectromagneticConstant"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:Class rdf:ID="PlanckConstant">
    <rdfs:subClassOf rdf:resource="#UniversalConstant"/>
  </owl:Class>
```

```

<owl:Class rdf:ID="PlanckTemperature">
  <rdfs:subClassOf rdf:resource="#UniversalConstant"/>
</owl:Class>
<owl:Class rdf:ID="CharacteristicImpedanceOfVacuum">
  <rdfs:subClassOf rdf:resource="#UniversalConstant"/>
</owl:Class>
<owl:Class rdf:ID="AtomicAndNuclearConstant">
  <rdfs:subClassOf rdf:resource="#PhysicalConstant"/>
</owl:Class>
<owl:Class rdf:about="#ElectromagneticConstant">
  <rdfs:subClassOf rdf:resource="#PhysicalConstant"/>
</owl:Class>
<owl:Class rdf:ID="PlanckTime">
  <rdfs:subClassOf rdf:resource="#UniversalConstant"/>
</owl:Class>
<owl:Class rdf:ID="PlanckMass">
  <rdfs:subClassOf rdf:resource="#UniversalConstant"/>
</owl:Class>
<owl:Class rdf:ID="NewtonianConstantOfGravitation_over_h-bar_c">
  <rdfs:subClassOf rdf:resource="#UniversalConstant"/>
</owl:Class>
<owl:Class rdf:ID="MagneticConstant">
  <rdfs:subClassOf rdf:resource="#UniversalConstant"/>
</owl:Class>
<owl:Class rdf:ID="Physico-chemicalConstant">
  <rdfs:subClassOf rdf:resource="#PhysicalConstant"/>
</owl:Class>
<owl:Class rdf:ID="ElectricConstant">
  <rdfs:subClassOf rdf:resource="#UniversalConstant"/>
</owl:Class>
<owl:Class rdf:ID="PlanckLength">
  <rdfs:subClassOf rdf:resource="#UniversalConstant"/>
</owl:Class>
<owl:ObjectProperty rdf:ID="UnitSystem">
  <rdfs:domain rdf:resource="#PhysicalConstant"/>
  <rdfs:range rdf:resource="http://codata.jp/OML-UnitDimension.owl#UnitSystem"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="UnitDimension">

```



```

    <rdfs:domain rdf:resource="#PhysicalConstant"/>
    <rdfs:range rdf:resource="http://codata.jp/OML-UnitDimension.owl#UnitDimension"/>
</owl:ObjectProperty>
<owl:DatatypeProperty rdf:ID="ConciseForm">
    <rdfs:domain rdf:resource="#PhysicalConstant"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Reference">
    <rdfs:domain rdf:resource="#PhysicalConstant"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="Value">
    <rdfs:domain rdf:resource="#PhysicalConstant"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="StandardUncertainty">
    <rdfs:domain rdf:resource="#PhysicalConstant"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="RelativeStandardUncertainty">
    <rdfs:domain rdf:resource="#PhysicalConstant"/>
</owl:DatatypeProperty>
<PhysicalConstant rdf:ID="PhysicalConstant_NIST">
    <Reference rdf:datatype="http://www.w3.org/2001/XMLSchema#anyURI"
    >http://physics.nist.gov/cuu/Constants/index.html</Reference>
</PhysicalConstant>
<CharacteristicImpedanceOfVacuum rdf:ID="electric_resistance">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >ohm</rdfs:comment>
    <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
    >376.730313461</ConciseForm>
    <UnitDimension>
        <unitd:ElectricResistance rdf:ID="ElectricResistance"/>
    </UnitDimension>
    <UnitSystem>
        <unitd:SI_units rdf:ID="SI_units"/>
    </UnitSystem>
    <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >exact</StandardUncertainty>
    <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >exact</RelativeStandardUncertainty>
</CharacteristicImpedanceOfVacuum>

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```

<BohrMagneton rdf:ID="bohr_magneton">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >J / T</rdfs:comment>
  <UnitSystem rdf:resource="#SI_units"/>
  <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >0.000023e-26</StandardUncertainty>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >2.5e-8</RelativeStandardUncertainty>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >927.400915e-26</Value>
  <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >927.400915(23)e-26</ConciseForm>
</BohrMagneton>
<unitd:Mass rdf:ID="mass"/>
<MagneticConstant rdf:ID="magnetic_constant">
  <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >exact</StandardUncertainty>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >12.566370614e-7</Value>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >exact</RelativeStandardUncertainty>
  <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >12.566370614e-7</ConciseForm>
  <UnitSystem rdf:resource="#SI_units"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >N / A2</rdfs:comment>
</MagneticConstant>
<PlanckTime rdf:ID="planck_time">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >s</rdfs:comment>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >5.0e-5</RelativeStandardUncertainty>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >5.39124e-44</Value>
  <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >0.00027e-44</StandardUncertainty>
  <UnitDimension>
    <unitd:Time rdf:ID="Time"/>

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</UnitDimension>
<ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>5.39124(27)e-44</ConciseForm>
<UnitSystem rdf:resource="#SI_units"/>
</PlanckTime>
<ElectricConstant rdf:ID="electric_constant">
  <UnitSystem rdf:resource="#SI_units"/>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
>8.854187817e-12</Value>
  <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>exact</StandardUncertainty>
  <UnitDimension>
    <unitd:Permittivity rdf:ID="Permittivity"/>
  </UnitDimension>
  <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
>8.854187817e-12</ConciseForm>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>F / m</rdfs:comment>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>exact</RelativeStandardUncertainty>
</ElectricConstant>
<unitd:Length rdf:ID="Length"/>
<PlanckTemperature rdf:ID="planck_temperature">
  <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>1.416 785(71)e-32</ConciseForm>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
>1.416785e-32</Value>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
>5.0e-5</RelativeStandardUncertainty>
  <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>0.000071e-32</StandardUncertainty>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>K</rdfs:comment>
  <UnitDimension>
    <unitd:ThermodynamicTemperature rdf:ID="ThermodynamicTemperature"/>
  </UnitDimension>
  <UnitSystem rdf:resource="#SI_units"/>
</PlanckTemperature>

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<PlanckMass rdf:ID="planck_mass">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >kg</rdfs:comment>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >5.0e-5</RelativeStandardUncertainty>
  <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >0.00011e-8</StandardUncertainty>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >2.17644e-8</Value>
  <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >2.17644(11)e-8</ConciseForm>
  <UnitDimension rdf:resource="#mass"/>
  <UnitSystem rdf:resource="#SI_units"/>
</PlanckMass>
<SpeedOfLight_in_vacuum rdf:ID="speed_of_light_in_vacuum">
  <UnitDimension>
    <unitd:Speed rdf:ID="Speed"/>
  </UnitDimension>
  <UnitSystem rdf:resource="#SI_units"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >m / s</rdfs:comment>
  <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >299792458</ConciseForm>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >exact</RelativeStandardUncertainty>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >299792458</Value>
  <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >exact</StandardUncertainty>
</SpeedOfLight_in_vacuum>
<PlanckConstant rdf:ID="planck_constant">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >J s</rdfs:comment>
  <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >6.62606896(33)e-34</ConciseForm>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >6.62606896e-34</Value>
  <UnitSystem rdf:resource="#SI_units"/>

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```

<StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
>0.00000033e-34</StandardUncertainty>
<RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>5.0e-8</RelativeStandardUncertainty>
</PlanckConstant>
<rdf:Description rdf:about="http://codata.jp/NEDO-MatData.owl#electric_constant">
  <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >8.854187817e-12</ConciseForm>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >8.854187817e-12</Value>
  <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >exact</StandardUncertainty>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >exact</RelativeStandardUncertainty>
</rdf:Description>
<NewtonianConstantOfGravitation_over_h-bar_c
rdf:ID="newtonian_constant_of_gravitation_over_h-bar_c">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >(GeV / c2)-2</rdfs:comment>
  <UnitSystem rdf:resource="#SI_units"/>
  <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >6.708 81(67)e-39</ConciseForm>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >6.708 81e-39</Value>
  <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >0.00067e-39</StandardUncertainty>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >1.0e-4</RelativeStandardUncertainty>
</NewtonianConstantOfGravitation_over_h-bar_c>
<rdf:Description rdf:about="http://www.w3.org/2002/07/owl#Thing">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  ></rdfs:comment>
</rdf:Description>
<NewtonianConstantOfGravitation rdf:ID="newtonian_constant_of_gravitation">
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >m3 / kg s2</rdfs:comment>
  <UnitSystem rdf:resource="#SI_units"/>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"

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>1.0e-4</RelativeStandardUncertainty>
<Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
>6.67428e-11</Value>
<StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
>0.00067e-11</StandardUncertainty>
<ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>6.67428(67)e-11</ConciseForm>
</NewtonianConstantOfGravitation>
<PlanckLength rdf:ID="planck_length">
  <ConciseForm rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >1.616252(81)e-35</ConciseForm>
  <UnitDimension rdf:resource="#Length"/>
  <UnitSystem rdf:resource="#SI_units"/>
  <RelativeStandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >5.0e-5</RelativeStandardUncertainty>
  <StandardUncertainty rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >0.000081e-35</StandardUncertainty>
  <Value rdf:datatype="http://www.w3.org/2001/XMLSchema#double"
  >1.616252e-35</Value>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >m</rdfs:comment>
</PlanckLength>
</rdf:RDF>

```