

Ontology-based database for a materials manufacturing process

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DiMad consortium

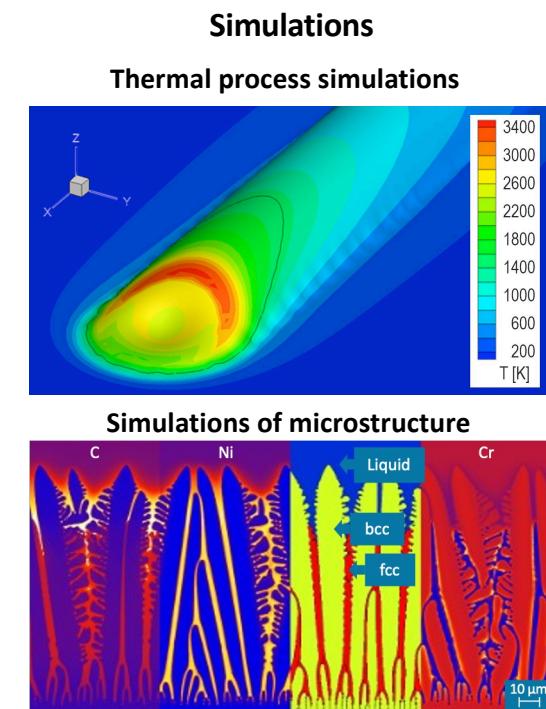
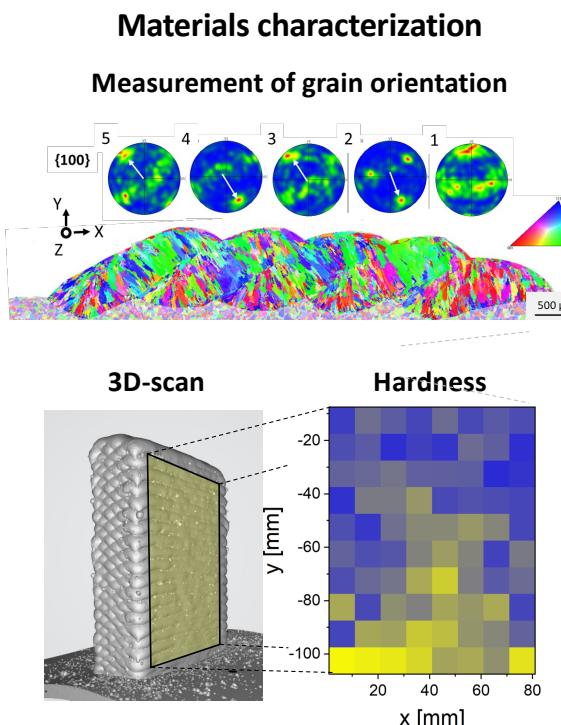
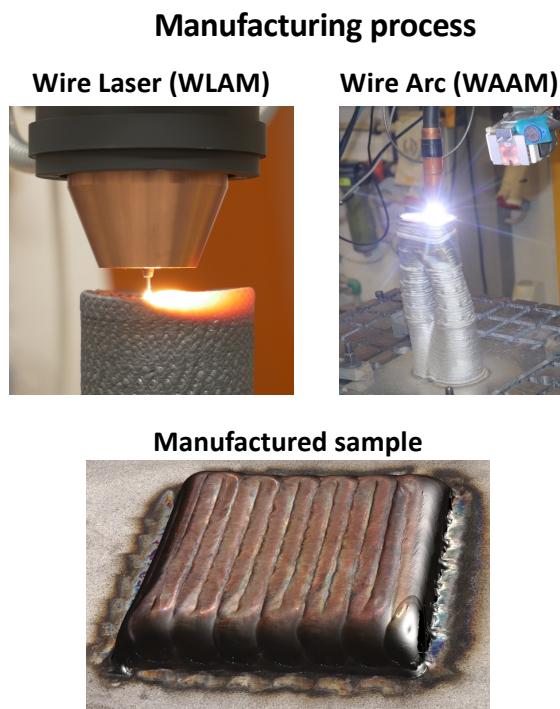
MaterialDigital General Assembly, 27.11.2025



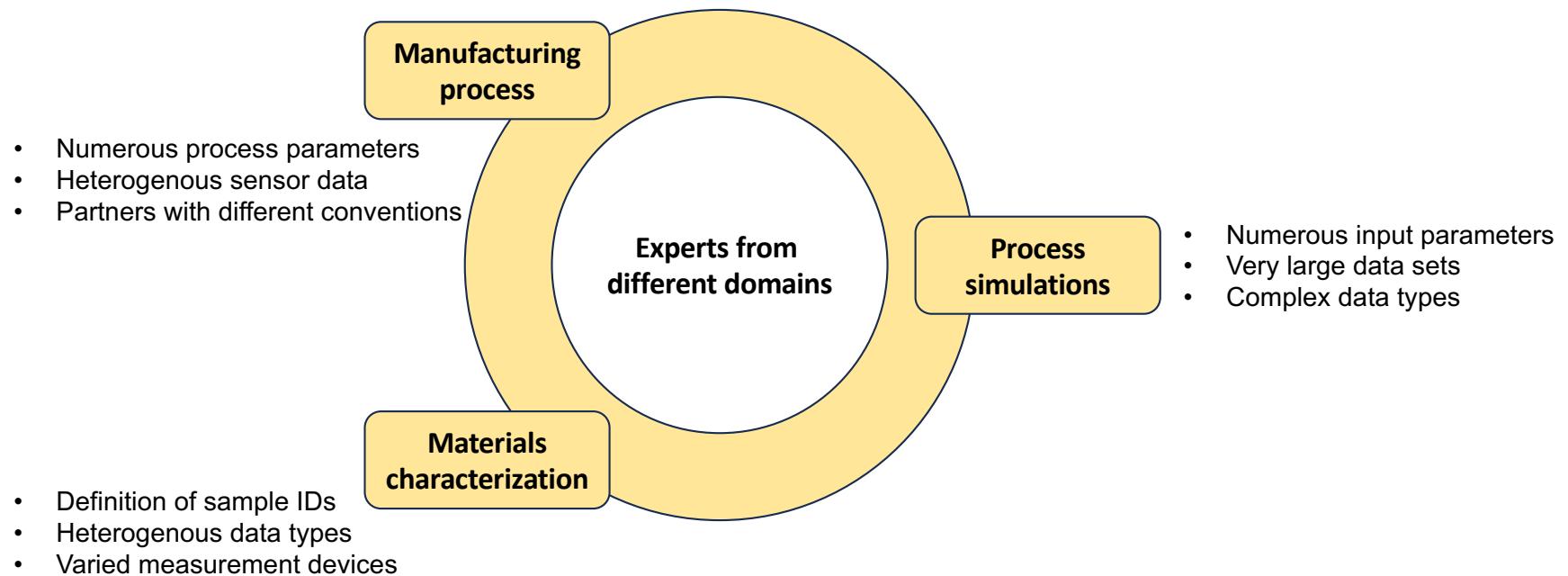
DiMad:
Digital Material and Process Design
for Wire-Based Additive Manufacturing

Introduction: additive manufacturing

Project aim: Use digitalization to improve how robot welding of steel is used for additive manufacturing

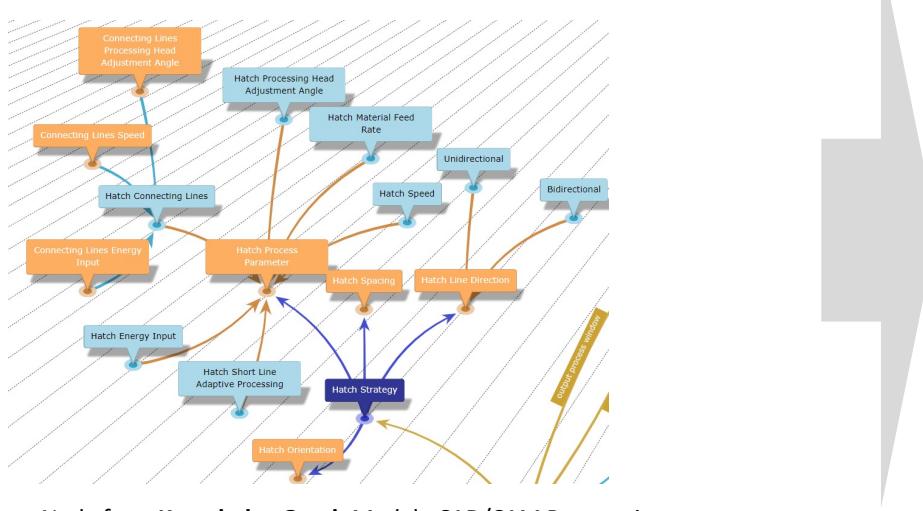


Data challenges

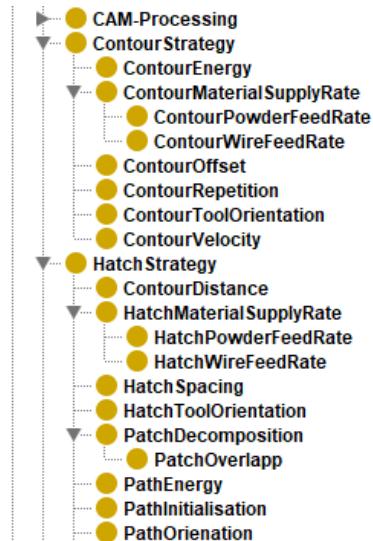


Process ontology for WAAM and WLAM

Knowledge Base Builder, kdb Files (Modules)



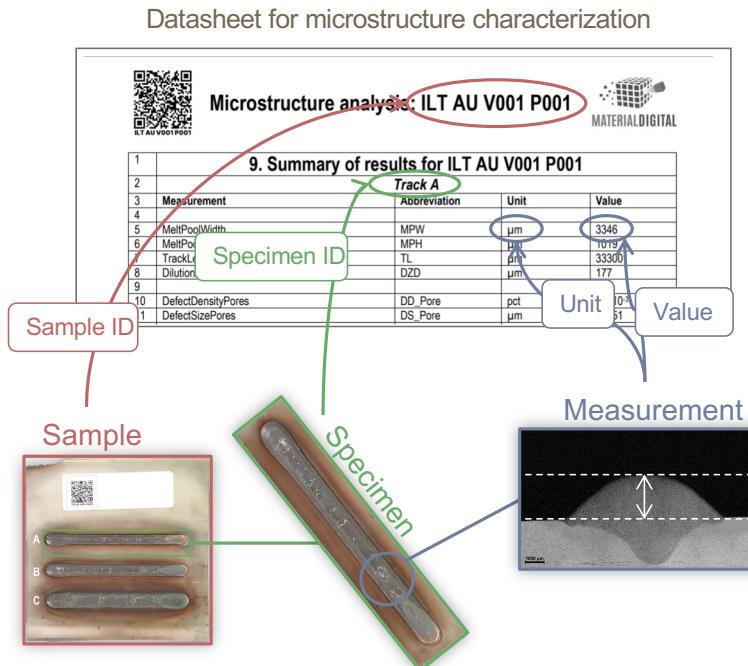
Protégé, owl File



- Creation of a process knowledge graph with detailed information on the various heat sources
- Modularization in main nodes due to complexity
- Definition of the semantic background and data format in Protégé
- A Common Data Dictionary and Common Data Model for Additive Manufacturing is under Development (Literature).

From datasheets to semantic graph database

Conventional representation of microstructure data



PMD-compliant triple-store database

Findable
Accessible
Interoperable
Reusable

Generic class: measurement

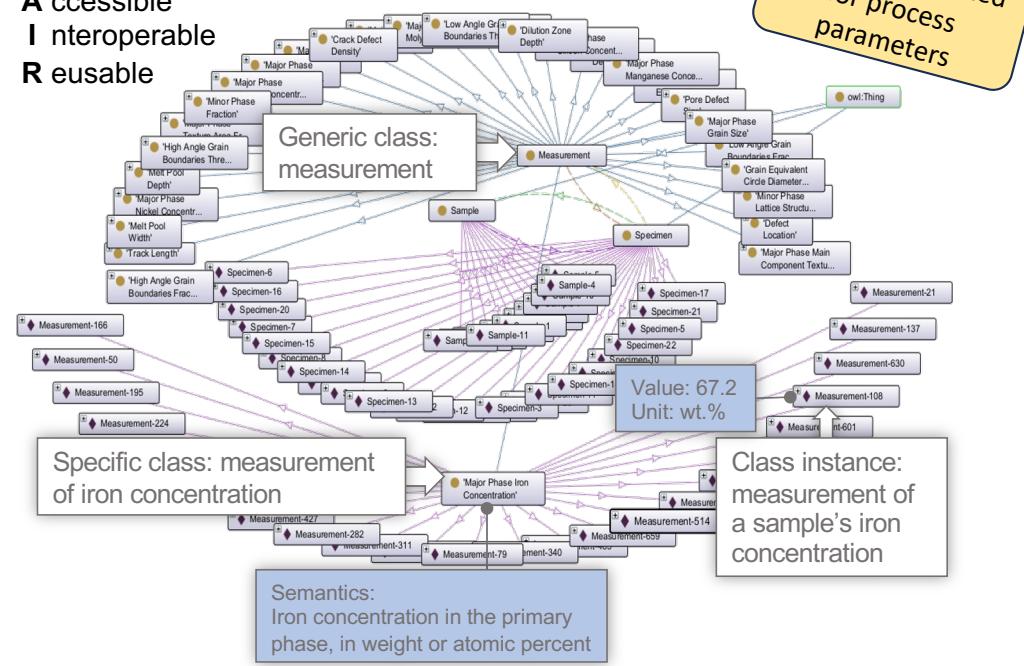
Specific class: measurement of iron concentration

Semantics:
 Iron concentration in the primary phase, in weight or atomic percent

Value: 67.2
 Unit: wt.%

Class instance:
 measurement of a sample's iron concentration

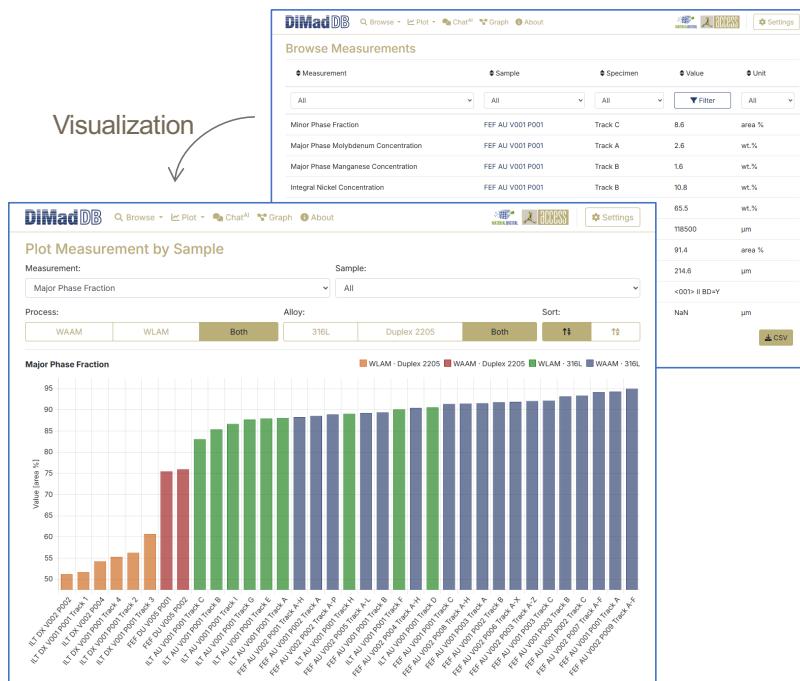
Also implemented
 for process
 parameters



Web-based frontend to search and display data

Atomistic data

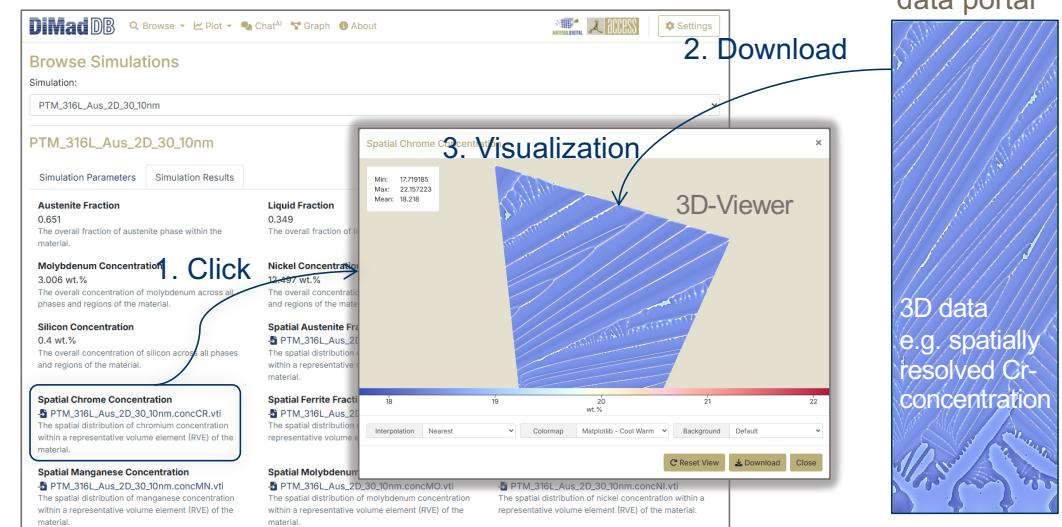
- Simple tabular view of all data
- Simple bar chart with basic filtering



Visualization

Complex data, e.g. fields

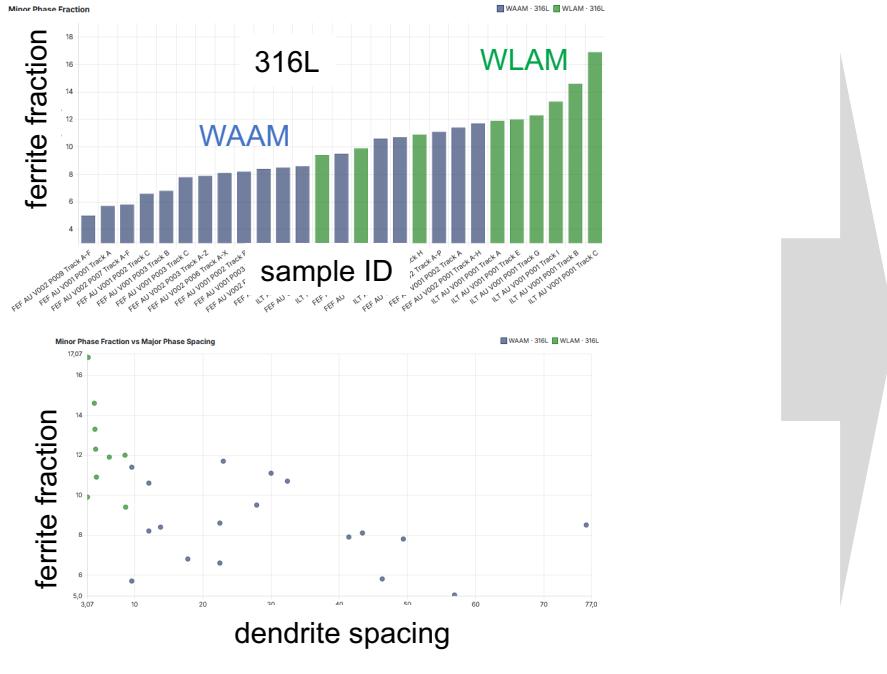
- Use of linked data principle to access complex simulation results in CKAN data portal
- Integrated interactive viewer for 3D data



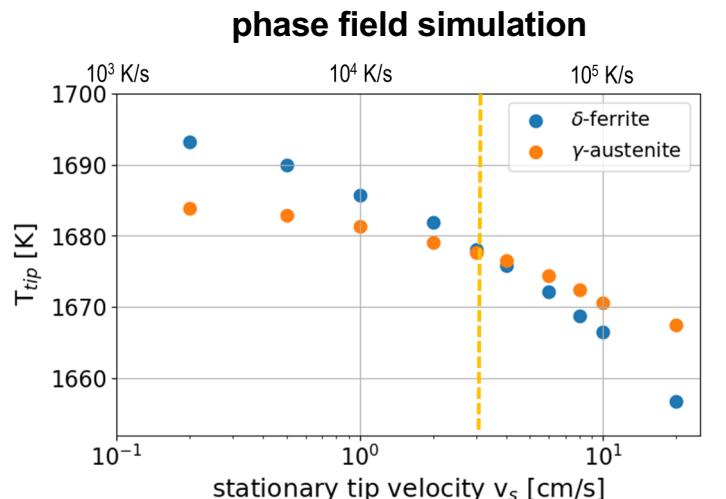
CKAN
data portal

Light-bulb moment

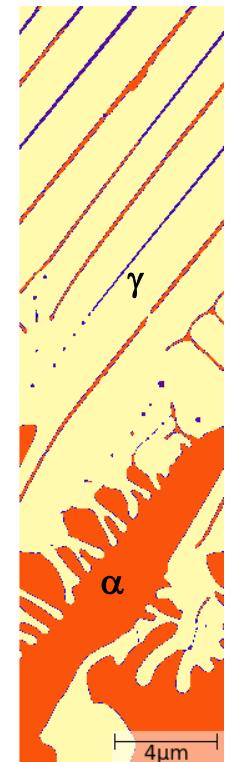
Graph database + web frontend → easy and fast access to the entire project dataset → new insight



faster cooling → more residual ferrite



→ solidification mode depends on cooling rate



AI agent for database queries: No hallucinations!

DIMad

SPARQL database query

Which 5 samples have the highest iron concentration?

```
PREFIX : <http://dimad.aixvipmap.com/db/microstructure#>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdf: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT ?sampleName WHERE {
  ?specimen :isSpecimenOf ?sample .
  ?specimen :hasMeasurement ?measurement .
  ?measurement rdf:type :IntegralIronConcentration .
  ?measurement :MeasurementValue ?value .
  ?sample :SampleIdentifier ?sampleName .
  BIND(xsd:decimal(?value) AS ?decimalValue)
} ORDER BY DESC(?decimalValue) LIMIT 5
```

Natural language chat

DIMadDB  Browse  Plot  Chat^{AI}  Graph  About   

Chat with AI Assistant X

give me the samples with highest integral mo conc (top 5)

Here are the top 5 samples ranked by highest Integral Molybdenum Concentration (IntegralMolybdenumConcentration). Units are wt.-%:

1. FEF DU V005 P001 — 3.4 wt.%
2. FEF DU V005 P002 — 3.3 wt.%
3. ILT DX V002 P004 — 3.1 wt.%
4. FEF AU V002 P009 — 2.9 wt.%
5. ILT AU V001 P001 — 2.9 wt.%

Would you like the underlying measurement records (IDs, specimen links, or raw MeasurementValue/MeasurementUnit) for any of these samples?

Advantages

- AI agent can only provide answers based on SPARQL database queries
➔ No hallucinations
- AI agent chooses the reasoning strategy to answer complex questions
- Use previous questions as context
- Prepare response in human-friendly form

See poster and demonstrator by Lukas Koschmieder

OSCAR
Plasma-Laser-Technologie

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Besser Fügen.

 **ICONPRO**

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ILT

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und Raumfahrt

Summary

DIMad

FAIR ontological database for additive manufacturing with AI-powered interface

