

## Ontology-based database for a materials manufacturing process

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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

### Manufacturing process

Wire Laser (WLAM)



Wire Arc (WAAM)

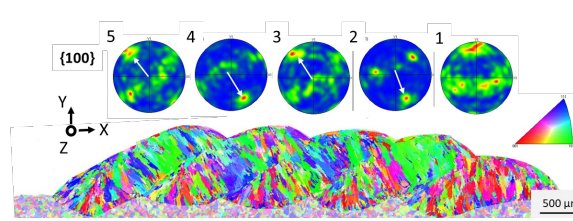


Manufactured sample

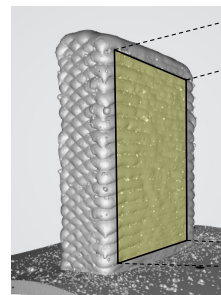


### Materials characterization

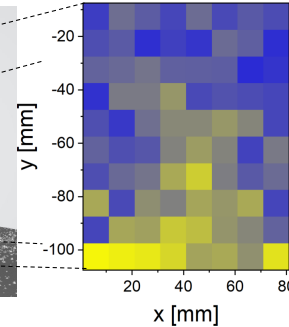
Measurement of grain orientation



3D-scan

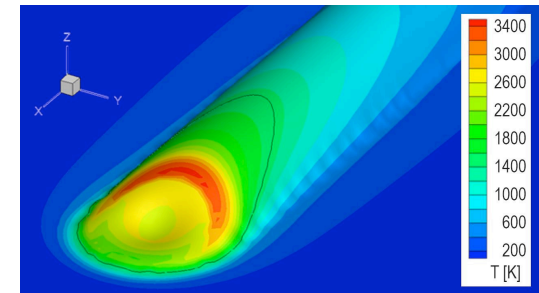


Hardness

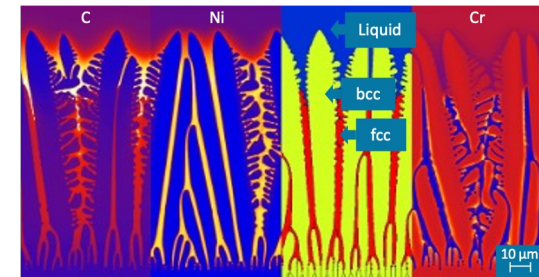


### Simulations

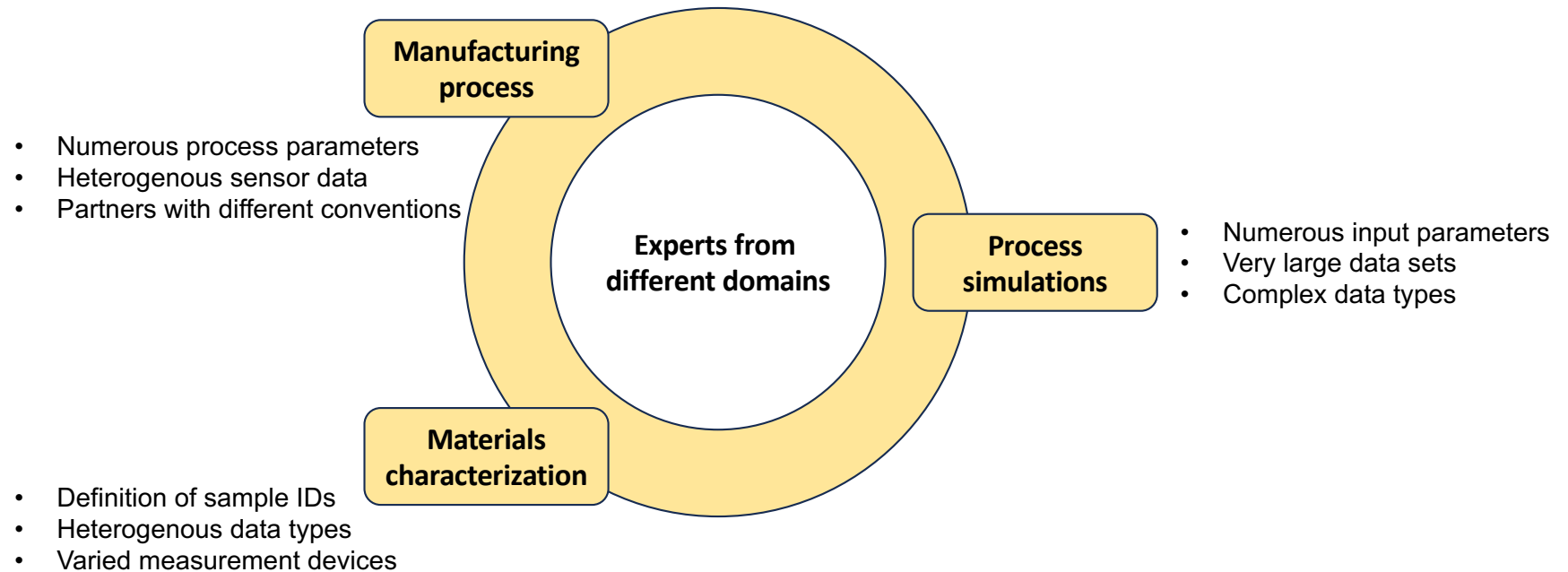
Thermal process simulations



Simulations of microstructure

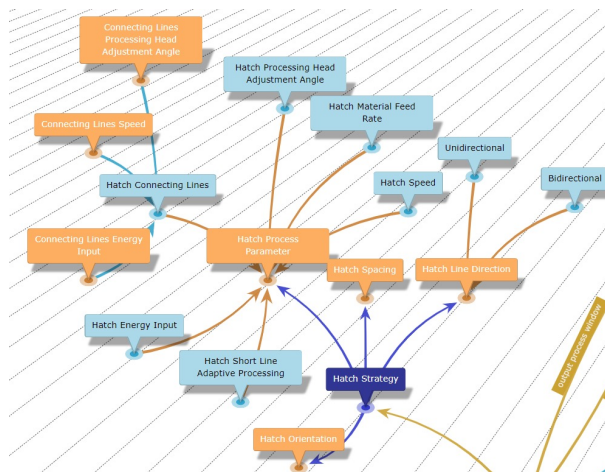


## Data challenges



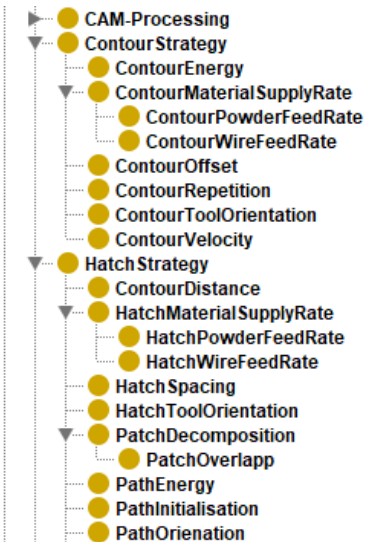
## Process ontology for WAAM and WLAM

### Knowledge Base Builder, kdb Files (Modules)



Node from **Knowledge Graph** Module CAD/CAM Preparation

### Protégé, owl File

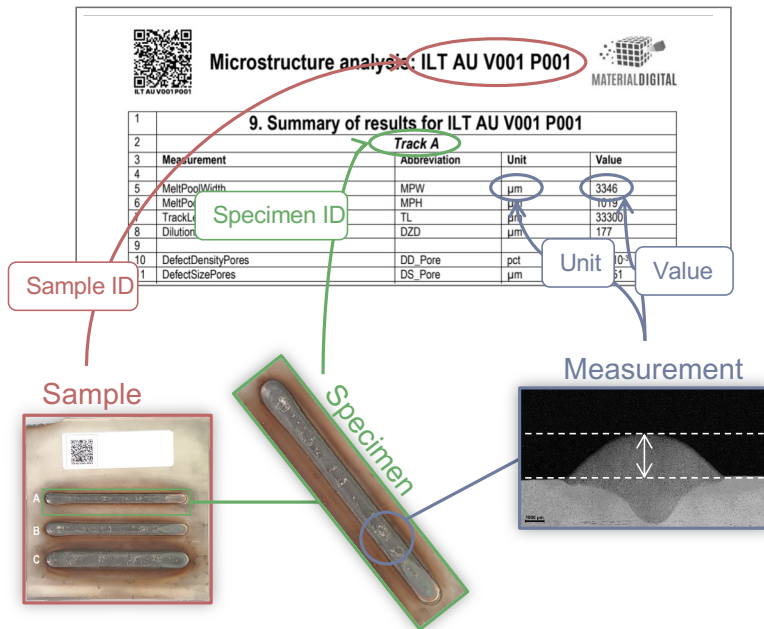


- Creation of a process knowledge graph with detailed information on the various heat sources
- Modularization in main nodes due to complexity
- Definition of the semantic background and data format in Protégé
- A Common Data Dictionary and Common Data Model for Additive Manufacturing is under Development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

## From datasheets to semantic graph database

### Conventional representation of microstructure data

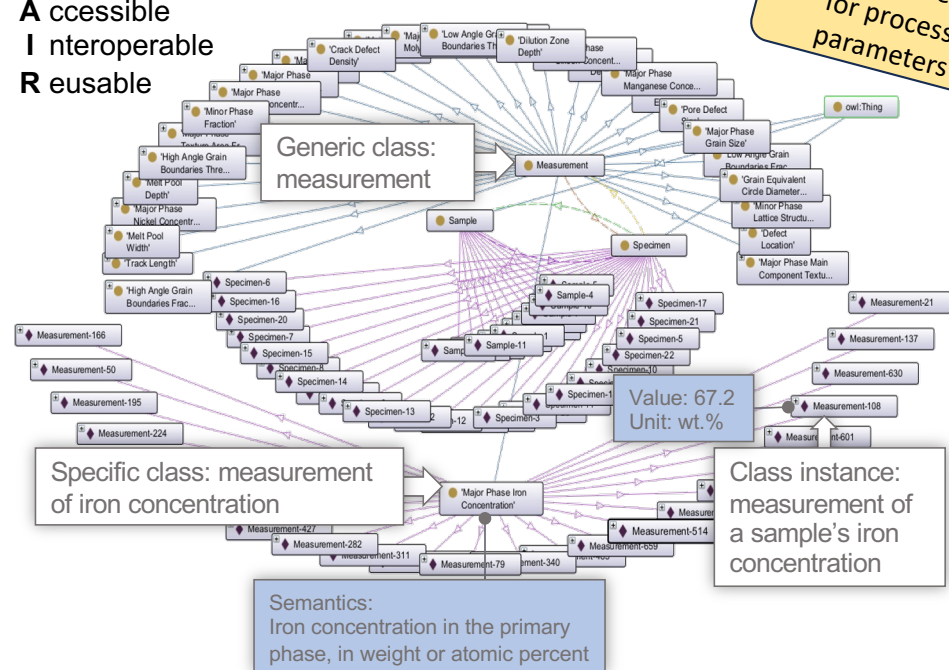
Datasheet for microstructure characterization



### PMD-compliant triple-store database

F indable  
A ccessible  
I nteroperable  
R eusable

Also implemented  
for process  
parameters

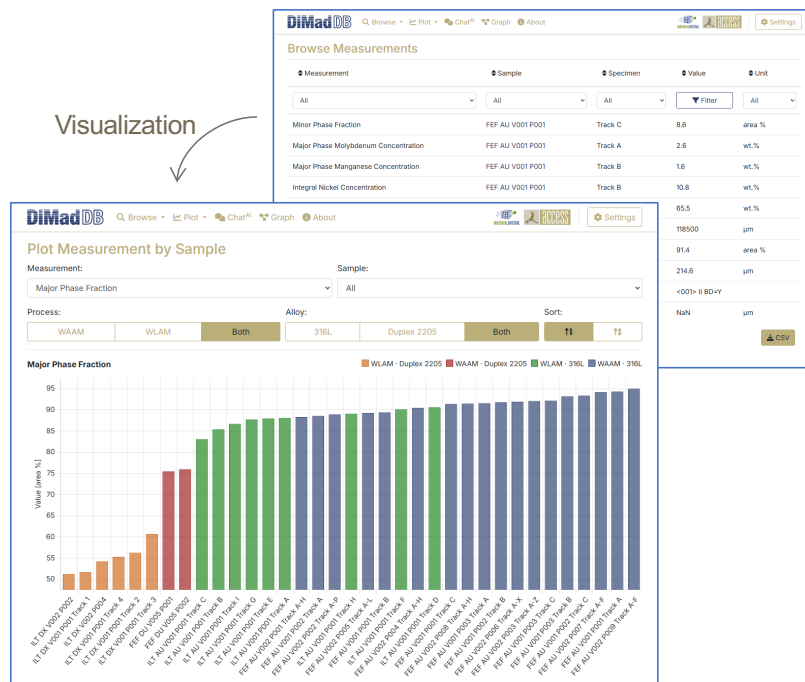




## Web-based frontend to search and display data

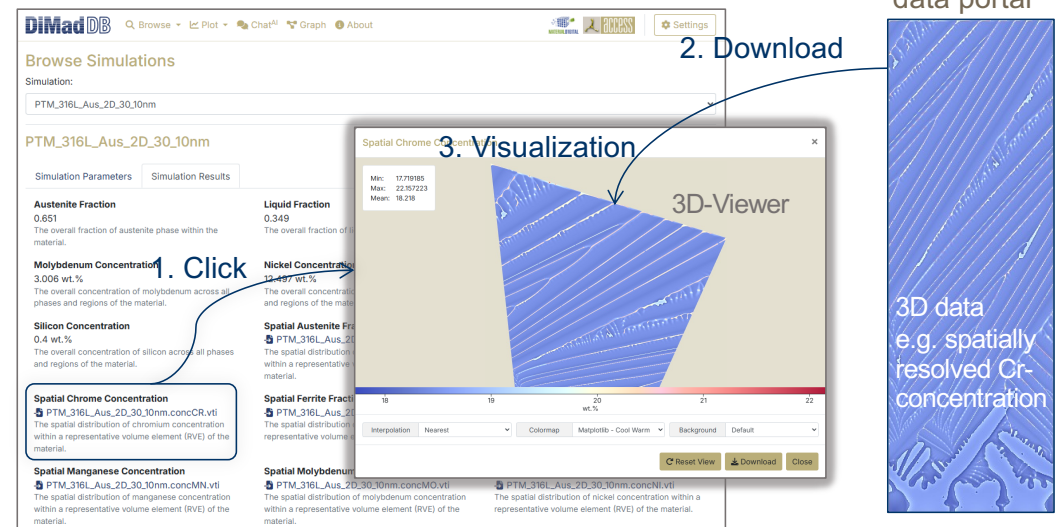
### Atomistic data

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



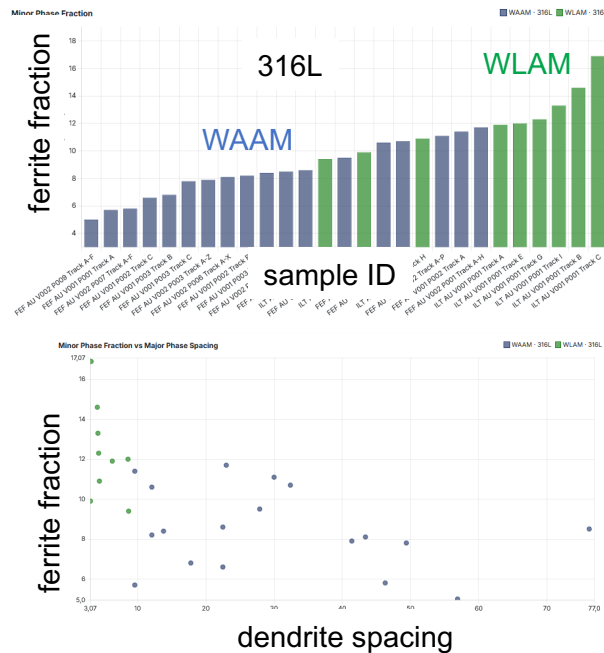
### Complex data, e.g. fields

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

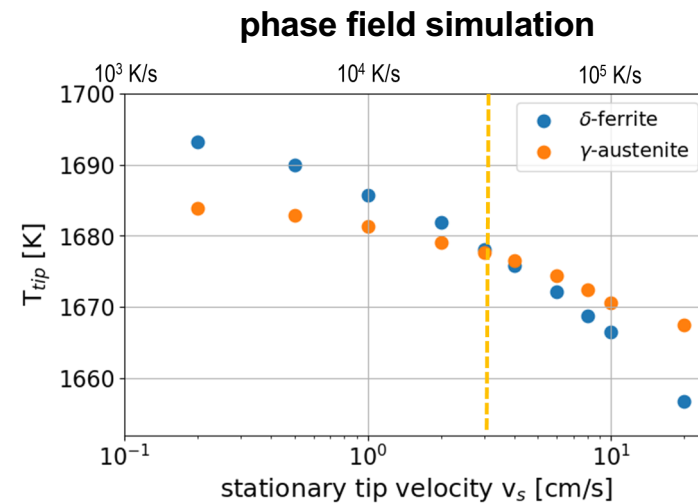


## Light-bulb moment

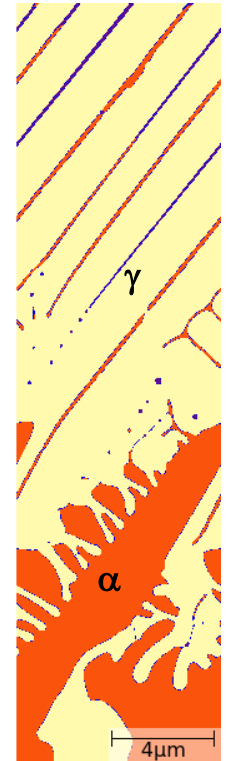
Graph database + web frontend → easy and fast access to the entire project dataset → new insight



faster cooling → more residual ferrite



→ solidification mode depends on cooling rate



## AI agent for database queries: No hallucinations!

**SPARQL database query**  
Which 5 samples have the highest iron concentration?

```
PREFIX : <http://dimad.aixvmap.com/db/microstructure#>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <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
}
```

### Advantages

- AI agent can only provide answers based on SPARQL the 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

### Natural language chat

**DiMadDB**

Q Browse Plot ChatAI Graph About

MATERIAL DIGITAL access

Settings

Chat with AI Assistant

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?

See poster and demonstrator by  
Lukas Koschmieder



## Summary

FAIR ontological database for additive manufacturing with AI-powered interface

