Stand der AM-Normen und Ausblick

M. Schmid, inspire

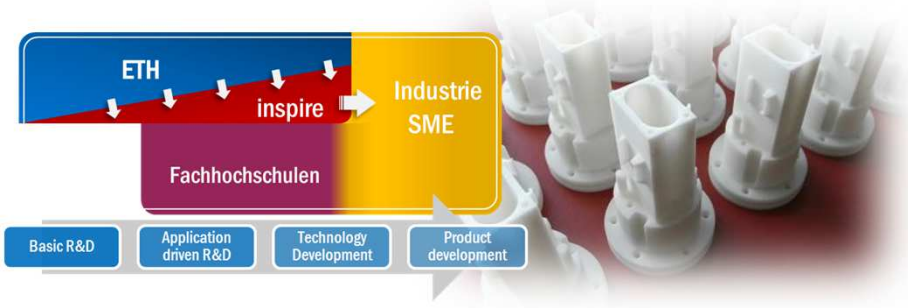
Innovation Center for Additive Manufacturing Switzerland (icams)

Introduction – inspire

Kompetenzzentrum für Produktionstechnik und Werkzeugmaschinen

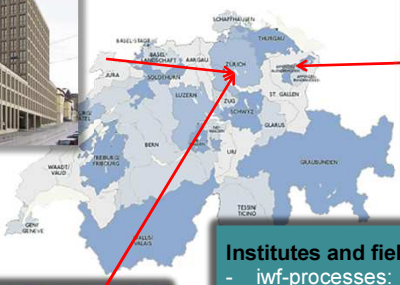
Gegründet auf Initiative der ETH-Zürich und schweizerischen Maschinenbaufirmen

Anerkannt als Forschungsinstitut von nationaler Bedeutung (non-profit foundation)



Introduction – inspire

ETH Zürich



Standort St.Gallen, icams

Technopark Zürich, Hauptsitz

Institutes and fields of activity

- iwf-processes: Grinding, Cutting, EDM, …
- iwf-machines: Machine Tools, Simulation, Analysis, Improvements
- iwf-micromachining: Laser- & micro fabrication
- **icams: Additive Manufacturing (SLS, SLM)**
- ipdz: Construction & Design
- ics: Composite-Structures
- icmi: Material integrity
- ifa: Automation, Optimisation, Mechatronic
- ivp: Virtual production / Forming technology

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Additive Fertigung –

Additive Manufacturing

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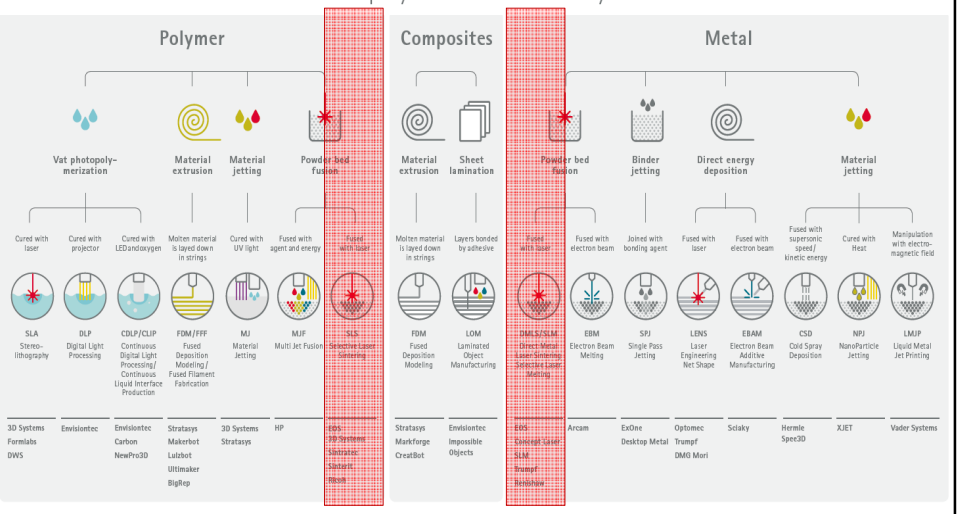
Additive manufacturing technologies
for polymers and metal alloys



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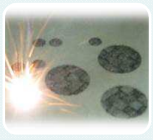
icams -Research focus in SLS & SLM

Materials
- Powder requirements
- Materials for AM
  - AM-adapted alloys (Al)
  - Hybrid materials
- Material characterization
  - Microstructure
  - Mechanical properties
  - ...

AM-Processes
- Processing windows for materials
- SLM- / SLS-Process Simulation
  - Internal stresses
  - Process effects
  - ...
- Process monitoring
- Process productivity & performance
- Process chain view

Machine
- Future machine concepts
- Optimization of machine components
- Interconnectivity, machine lines
- Quality management systems

Applications
Space / Aerospace / Industry
- Lightweight structures
- Structurally optimised parts
- Tooling, mould & die
- Pre-serial AM-Development
- Large structures & coating
- Industry 4.0

Standardisation (ASTM-ISO, VDI)

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AM Standardisation

- Why AM Standards
- History of AM standardisation
- Basics of AM standardization
- Bodies working on AM standardisation
- Results and ongoing work

Why AM standards

All experts agree that the lack of standards is an important barrier to the broader adoption of **Additive Manufacturing**!

Why AM standards

No doubt about the general need

Standards have been identified as the most important and urgent topic to enable commercialization and further push AM-tech

- Various **industries** ask for it as a prerequisite to **industrialize AM applications**
- In **certification**-relevant industries standards are a **must-have**
- **Supplier** to the **process chain** need guidance and defined interfaces
- **European Commission (EC)** and other funding bodies consider it as a must in **every project proposal on AM**
- Standard Developing Organizations (SDO) and **policy identified the need** in various inquiries

Basics of AM Standardization

How to approach

- Development of new AM standards plus adaptation of conventional standards (if partly applicable), but
  - not end up in **re-inventing the wheel**!
  - Involve the right people with the **right expertise**
  - not lay out too wide or too academic
  - **Avoid parallel activities**; risk of “losing” experts
- Common approach with all world-wide standardization bodies and industry associations, as in a global economy there is no reason why standards/guides should define the same context differently in Europe, Asia and the US:

  One world – One standard
- **In the future: Also involving certification authorities**

History of AM Standardization

- **1997** NIST (USA) hosted an industry workshop titled “Measurements and Standards Issues in Rapid Prototyping“
  → identification of core issues especially data format questions
- **2005** VDI (Germany) founded FA 105 „Rapid Prototyping“
  → 2009 VDI 3404 - Generative Fertigungsverfahren – Rapid-Technologien (Rapid Prototyping) – Grundlagen, Begriffe, Qualität, Liefervereinbarungen“
- **2009** ASTM F42 (USA)
- **2011** ISO TC 261 (International)
- **2013** Nottingham: ISO/TC261 and ASTM F42 agreed jointly to develop AM standards
- **2014** CEN/CENELEC Stair-AM (European Community – SASAM Project)
  → adopting ISO/ASTM standards

VDI

7 veröffentlichte Empfehlungen; 3 als Entwurf (Gründruck)

Name	Ausgabedatum	Status
VDI 3405 Additive Fertigungsverfahren - Grundlagen, Begriffe, Verfahrensbeschreibungen	2014-12	
VDI 3405 Blatt 2 Additive Fertigungsverfahren - Strahlschmelzen metallischer Bauteile - Qualifizierung, Qualitätssicherung und Nachbearbeitung	2013-08	
VDI 3405 Blatt 1 Additive Fertigungsverfahren, Rapid Manufacturing - Laser-Sintern von Kunststoffbauteilen - Güteüberwachung	2013-10	
VDI 3405 Blatt 2.1 Additive Fertigungsverfahren, Laser-Strahlschmelzen metallischer Bauteile - Materialkenndatenblatt Aluminiumlegierung AlSi10Mg	2015-07	
VDI 3405 Blatt 3 Additive Fertigungsverfahren - Konstruktionsempfehlungen für die Bauteilfertigung mit Laser-Sintern und Laser-Strahlschmelzen	2015-12	
VDI 3405 Blatt 2.1 Berichtigung Additive Fertigungsverfahren - Laser-Strahlschmelzen metallischer Bauteile - Materialkenndatenblatt, Aluminiumlegierung AlSi10Mg - Berichtigung zur Richtlinie VDI 3405 Blatt 2.1:2015-07	2017-01	
VDI 3405 Blatt 3.5 Additive Fertigungsverfahren - Konstruktionsempfehlungen für die Bauteilfertigung mit Elektronen-Strahlschmelzen	2017-04	
VDI 3405 Blatt 2.2 Additive Fertigungsverfahren - Laser-Strahlschmelzen metallischer Bauteile - Materialkenndatenblatt Nickellegierung Werkstoffnummer 2.4668	2017-07	
VDI 3405 Blatt 2.3 Additive Fertigungsverfahren - Strahlschmelzen metallischer Bauteile - Charakterisierung von Pulverwerkstoffen	2017-07	
VDI 3405 Blatt 1.1 Additive Fertigungsverfahren - Laser-Sintern von Kunststoffbauteilen - Materialqualifikation	2017-08	

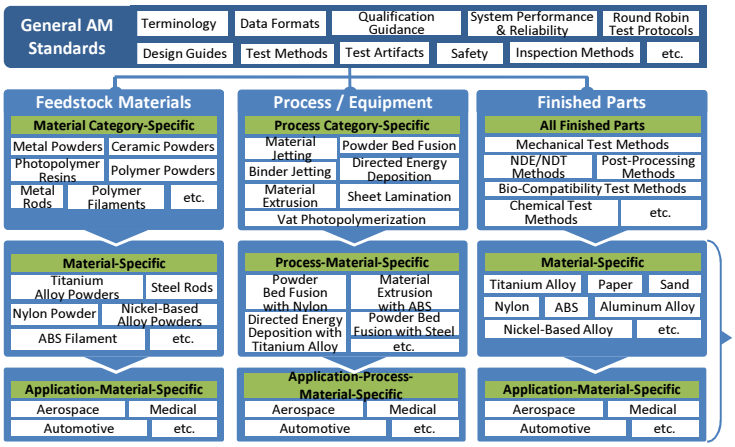
7 Projekte in Arbeit

VDI 3405 Blatt 1.2 Additive Fertigungsverfahren; Laser-Sintern von Kunststoffbauteilen; erreichbare Bauteilqualität		P
VDI 3405 Blatt 2.4 Additive Fertigungsverfahren; Strahlschmelzen metallischer Bauteile; Materialkenndatenblatt Ti-6Al-4V		P
VDI 3405 Blatt 3.1 Additive Fertigungsverfahren; Konstruktionsempfehlungen; Prüfkörper für verfahrensspezifische Geometriemerkmale		P
VDI 3405 Blatt 3.4 Additive Fertigungsverfahren; Konstruktionsempfehlungen für die Bauteilfertigung mit Strangablegeverfahren (Fused Layer Manufacturing)		P
VDI 3405 Blatt 5 Rechtliche Aspekte der additiven Fertigungsverfahren		P
VDI 3405 Blatt 6.1 Additive Fertigungsverfahren; Anwendersicherheit beim Betrieb der Fertigungsanlagen; Laser-Strahlschmelzen von Metallpulvern		P
VDI 3405 Blatt 7 Additive Fertigungsverfahren; Güteklassen für additiv gefertigte Kunststoffbauteile		P

E = Entwurf U = Überprüft X = Zurückgezogen P = Projekt

International Standardisation Bodies

Structuring the AM standard development



General Top-Level AM Standards

- General concepts
- Common requirements
- Generally applicable

Category AM Standards

Specific to material category or process category

Specialized AM Standards

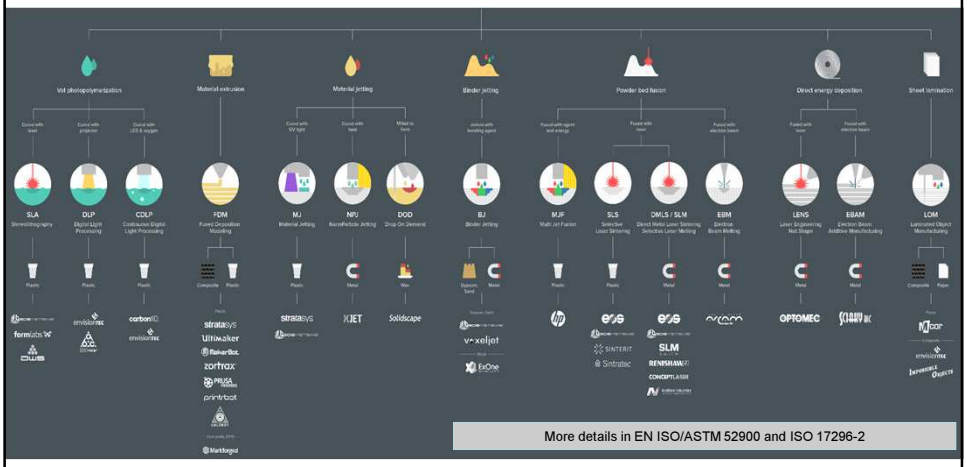
Specific to material, process, or application

PSDO agreed between ISO/TC 261 / ASTM F42

A unique opportunity

- Formal collaboration between ASTM and ISO (first of its kind!) for joint development of AM standards
- Will result in co-branded ISO and ASTM standards (same content, no need for future harmonization)
- Procedures for how ASTM and ISO will cooperate and work together in a practical sense are defined in the "Joint Plan for Standards Development"

AM Technologies according to EN ISO/ASTM 52900

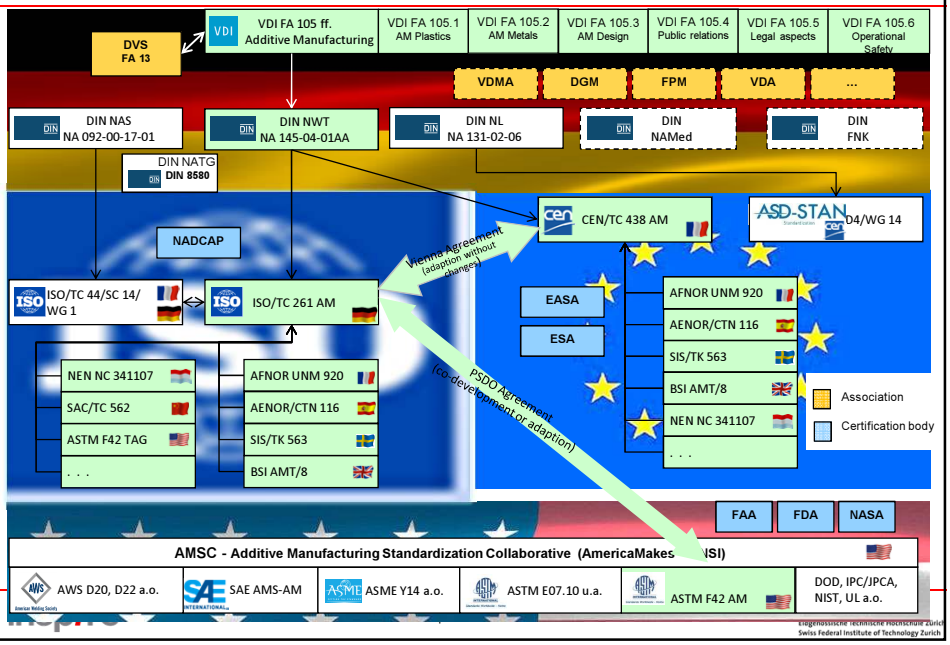


CEN/TC 438 on Additive Manufacturing

The European AM committee closely linked to ISO/TC 261

- The aim is to apply the Vienna Agreement with ISO/TC 261 "Additive Manufacturing" (DIN) to ensure consistency and harmonization
- To strengthen the link between European Research programs and standardization in additive manufacturing
- To ensure visibility to the European standardization in additive manufacturing by centralizing standardization initiatives in Europe on additive manufacturing

The world of AM standardization



Standards published

ISO/TC 261 ***(as of September 2017)***

- ISO/ASTM 52900:2015, Additive manufacturing -- General principles – Terminology
- ISO/ASTM 52901:2017, Additive manufacturing -- General principles -- Requirements for purchased AM parts
- ISO/ASTM 52915:2016, Standard specification for additive manufacturing file format (AMF) Version 1.2
- ISO/ASTM 52921:2013, Standard terminology for additive manufacturing -- Coordinate systems and test methodologies
- ISO 17296-2:2015, Additive manufacturing -- General principles -- Part 2: Overview of process categories and feedstock
- ISO 17296-3:2014, Additive manufacturing -- General principles -- Part 3: Main characteristics and corresponding test methods
- ISO 17296-4:2014, Additive manufacturing -- General principles -- Part 4: Overview of data processing

Standards published

ASTM F42 (as of September 2017)

- F2971-13 Standard Practice for Reporting Data for Test Specimens Prepared by Additive Manufacturing
- F3122-14 Standard Guide for Evaluating Mechanical Properties of Metal Materials Made via Additive Manufacturing Processes
- ISO/ASTM 52910 Guide for Design for Additive Manufacturing
- F2924-14 Standard Specification for Additive Manufacturing Titanium-6 Aluminum-4 Vanadium with PBF
- F3001-14 Standard Specification for Additive Manufacturing Titanium-6 Aluminum-4 Vanadium ELI (Extra Low Interstitial) with PBF
- F3049-14 Standard Guide for Characterizing Properties of Metal Powders Used for Additive Manufacturing Processes
- F3055-14a Standard Specification for Additive Manufacturing Nickel Alloy (UNS N07718) with PBF
- F3056-14e1 Standard Specification for Additive Manufacturing Nickel Alloy (UNS N06625) with PBF
- F3091/F3091M-14 Standard Specification for PBFof Plastic Materials
- F3184-16 Standard Specification for Additive Manufacturing Stainless Steel Alloy (UNS S31603) with PBF
- F3187-16 Standard Guide for Directed Energy Deposition of Metals

ISO/TC 261 and ASTM F42 collaboration

Joint Groups *(as of September 2017, much more to come)*

- JG51: Terminology – Klas Boivie: Klas.Boivie@sintef.no
- JG52: Standard Test Artifacts – Shawn Moylan: shawn.moylan@nist.gov
- JG53: Requirements for Purchased AM Parts – Philippe Bertrand: philippe.bertrand@enise.fr
- JG54: Design Guidelines – David Rosen david.rosen@me.gatech.edu
- JG55: Standard Specification for Extrusion Based Additive Manufacturing of Plastic Materials – Ralph Buoniconti: Ralph.Buoniconti@sabic.com
- JG56: Standard Practice for Metal PBF to Meet Rigid Quality Requirements – Shane Collins scollins@calraminc.com
- JG57: Specific Design Guidelines on PBF – Christian Seidel: christian.seidel@iwb.tum.de
- JG58: Qualification, Quality Assurance and Post Processing of PBF Metallic Parts – Marius Lakomiec: marius.lakomiec@eos.info
- JG59: NDT for AM Parts – Ben Dutton: ben.dutton@the-mtc.org

ISO/TC 261 and ASTM F42 collaboration

Joint Groups ***(as of September 2017, much more to come)***

- JG60: Guide for Intentionally Seeding Flaws in Additively Manufactured (AM) Parts – TBD
- JG61: Guide for Anisotropy Effects in Mechanical Properties of AM Parts – Mohsen Seifi mohsen.seifi@case.edu
- JG62: Guide for Conducting Round Robin Studies for Additive Manufacturing – Peter Wooliams peter.woollliams@npl.co.uk
- JG63: Test Methods for Characterization of Powder Flow Properties for AM Applications – Justin Whiting justin.whiting@nist.gov
- JG64: Specification for AMF Support for Solid Modeling: Voxel Information, Constructive Solid Geometry Representations and Solid Texturing – Jérémie Farret
- JG65: Specification for Additive Manufacturing Stainless Steel Alloy with PBF –
- JG66: Technical Specification on Metal Powders – Remi Giraud: remi.giraud@eramet-erasteel.com
- JG67: Design of Functionally Graded Materials – Eujin Pei eujinpei1@gmail.com
- JG68: Additive Manufacturing Safety – TBD

Summary

We are just in the beginning of exploring the many possibilities of AM technology

Knowledge is critical; this is a learning process for all of us

- Misdirected expectations leads to disappointments – Demand-orientation
- No one benefits from competing standards – Coordinated development
- Faster development/publishing of standards – without loss of quality !
- Acquire more experts by offering incentives

Thanks for suppling central parts of this information to:

Jörg Lenz

e-Manufacturing Solutions

Chairman of ISO/TC 261 on Additive Manufacturing
Executive Board member of ASTM F42
Member of VDI FA105 and DVS FA13
Vice-Chair of DIN NA145-04-01AA

THANK YOU FOR YOUR ATTENTION !