Material knowledge the basis of Powder Metallurgy and Additive Manufacturing

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Material knowledge
the base of Powder Metallurgy
and Additive Manufacturing

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Eindhoven

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Overview

Introduction powder metallurgy (PM)

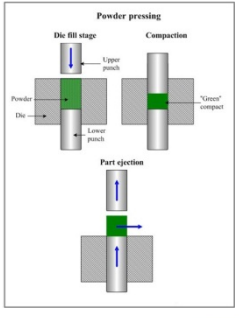
High performance Tungsten components by Metal Injection Moulding (MIM)

Additive Manufacturing (AM) of ceramics
Introduction to Digital Light Processing (DLP)

Additive Manufacturing (AM) of metals

What does ECN offer You

Powder Metallurgy (PM) basic process



blending

compaction

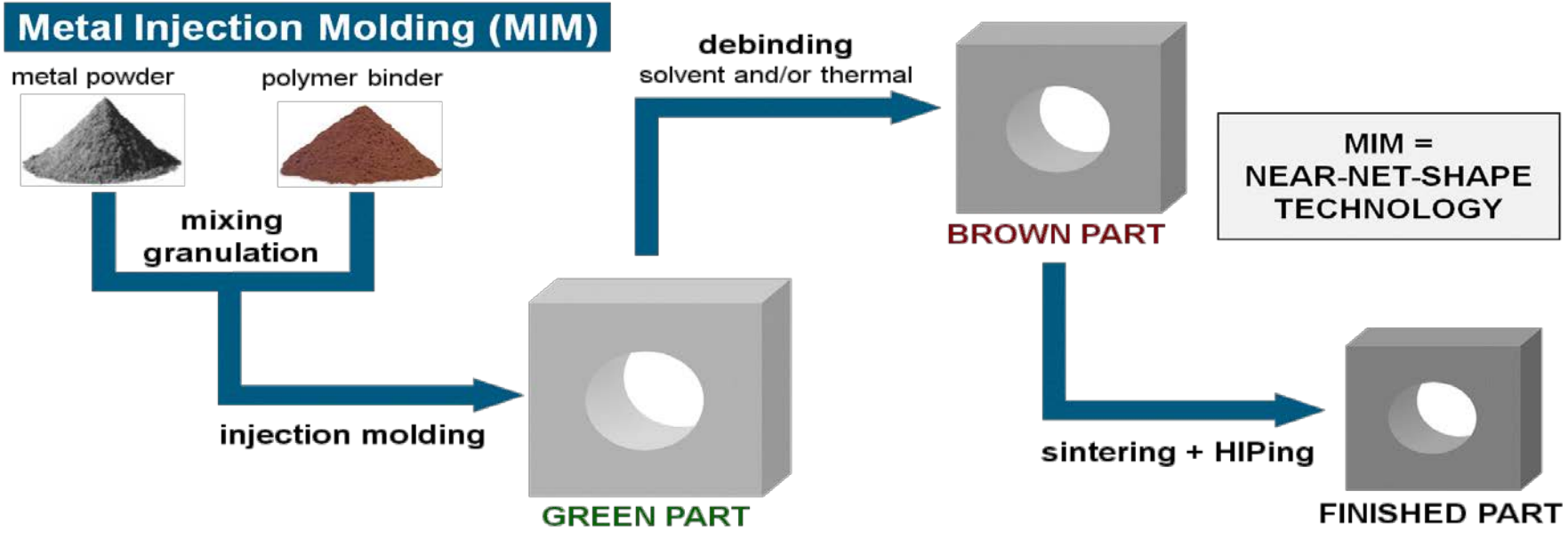
sintering

- Particle size, distribution, shape
- Impurities
- Homogeneity
- Stability
- Strength green product
- Sintering dopes
- Sintering ambient, Temp
- Density / porosity
- Strength
- Hardness
- De-gassing

Unique features MIM and AM (PM based)

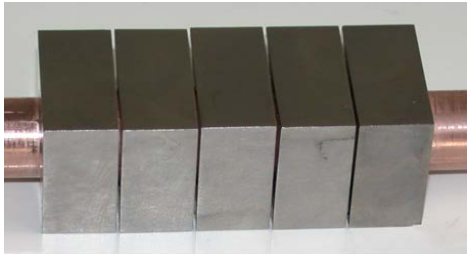
- Free Shaping, avoiding machining
- Isotropic properties and microstructure
- Ultra high purity materials
- Flexibility by unique alloying/doping
- Less energy consumption, less loss of material, less process steps

MIM W: the process



Net shaped W components

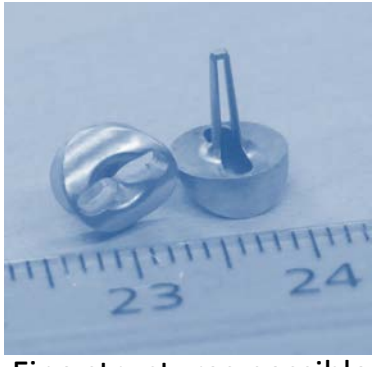
Mockup manufactured by Ansaldo



As sintered mono-blocks and mock up for ITER divertor target

Internal voids e.g. cooling channels possible

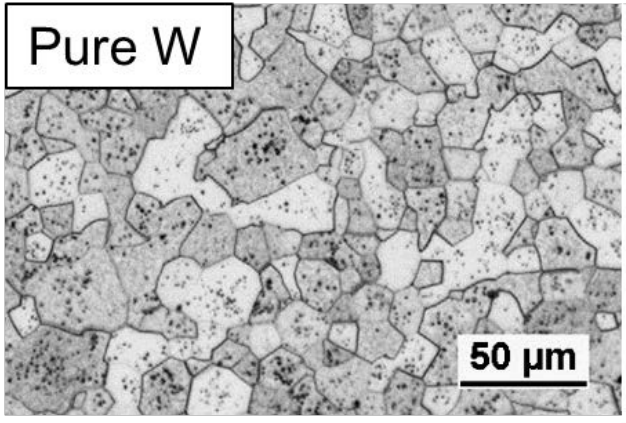
As sintered bolts

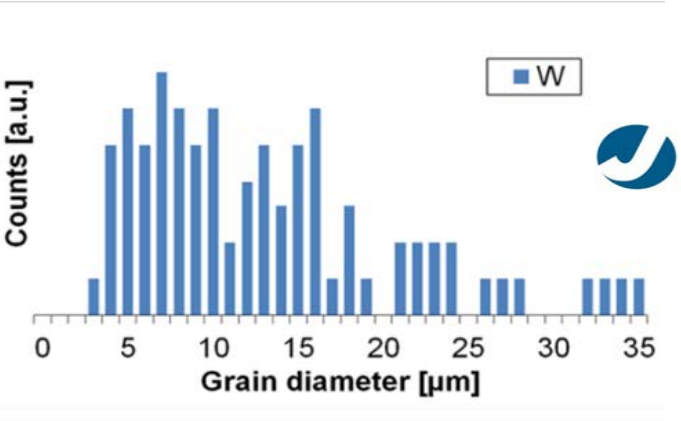


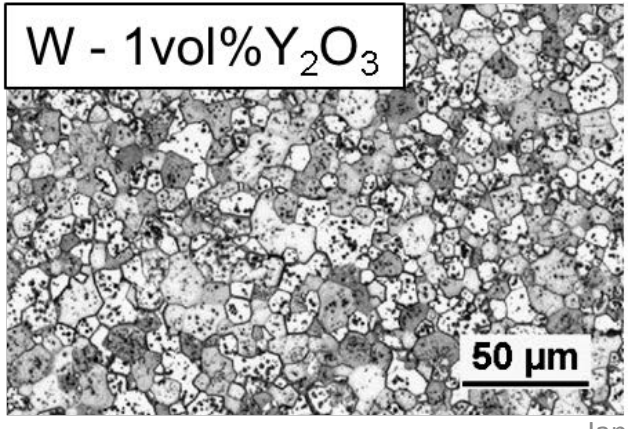
Fine structures possible

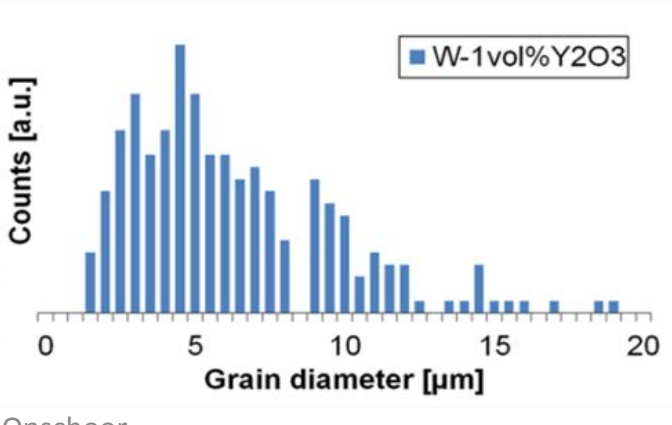
Tensile test component

Microstructure control

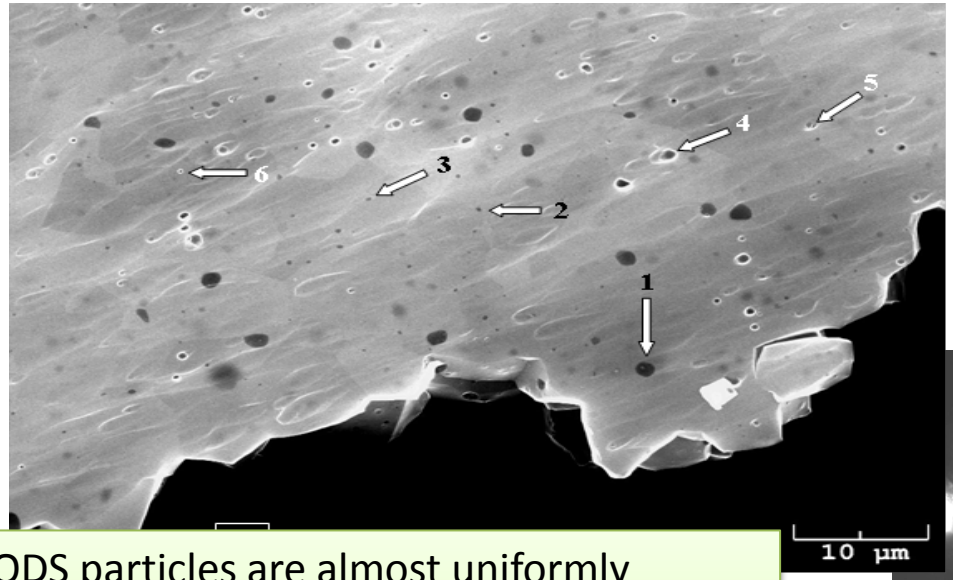




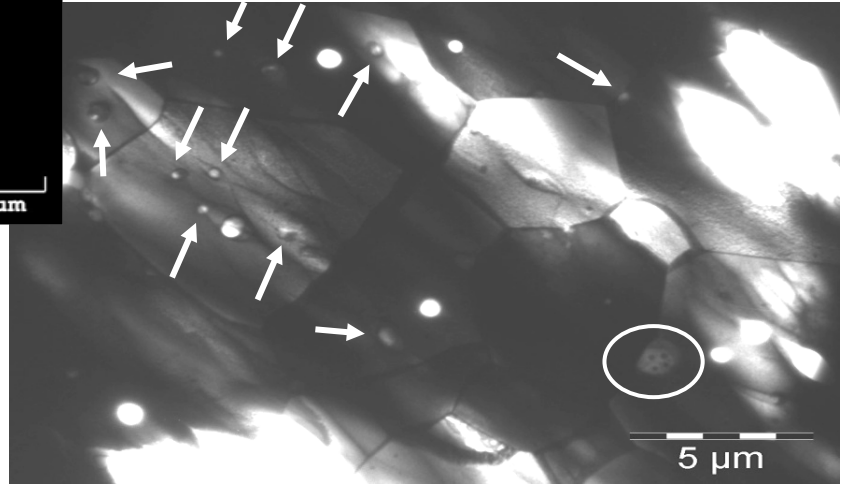




TEM of W doped with 1 vol.%Y_2O_3

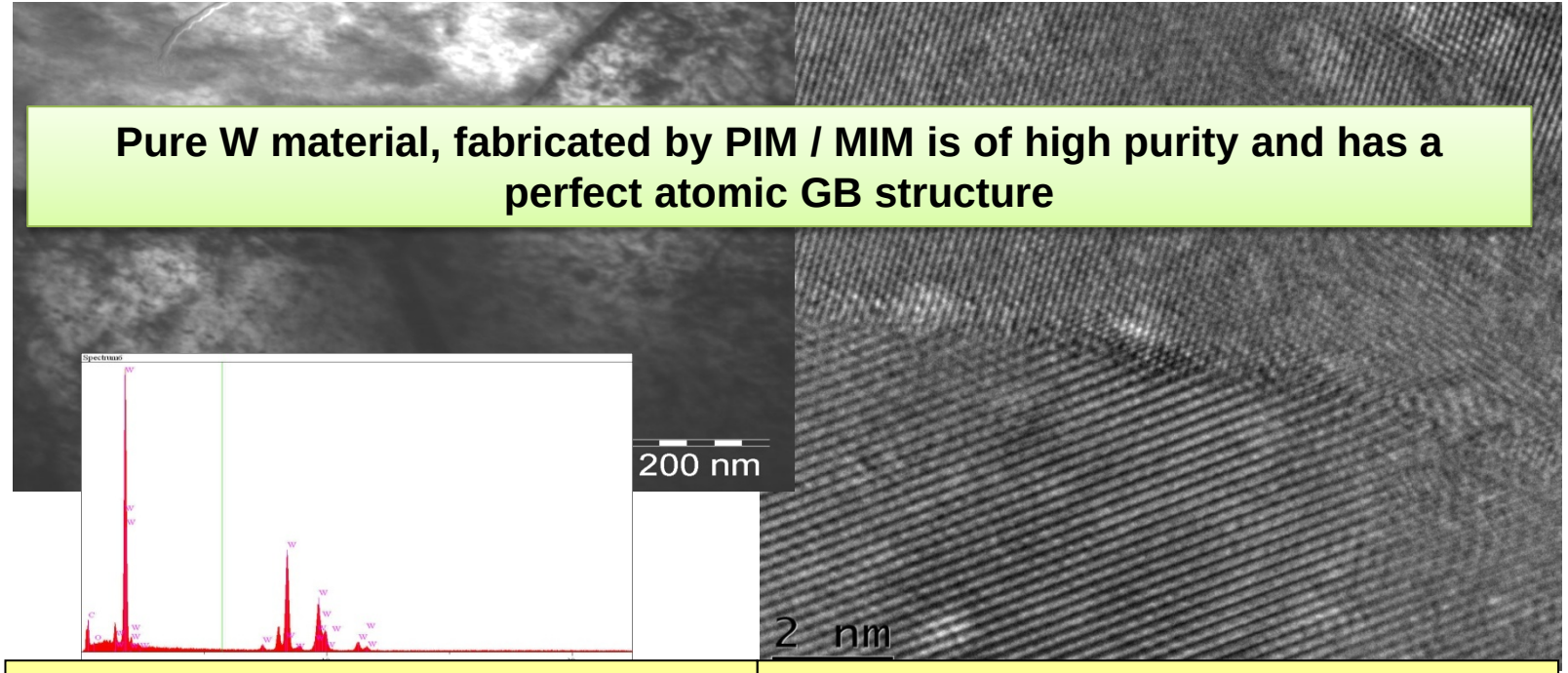


1,2,3 => ODS particles
4,5,6 => pre-existing pores



- ODS particles are almost uniformly spread inside the material volume, mainly as inclusions in the W grains
- W grains containing more than one oxide inclusion are observed everywhere

HRTEM of pure W

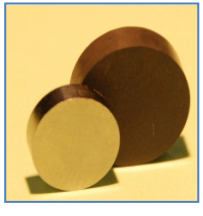


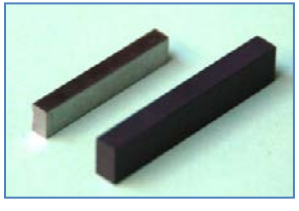
Triple junctions (TJs) and grain boundaries (GBs) analysed by contrast in HRTEM and by X-EDS.

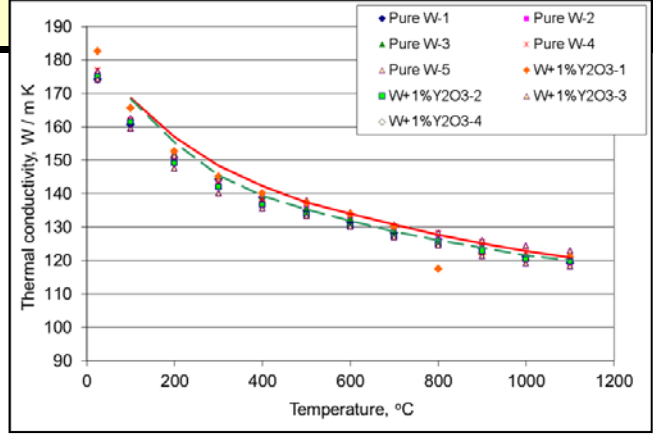
representative observed atomic structure of a GB in the material. No impurity atoms or amorphous phase are seen on these GBs.

Pure tungsten

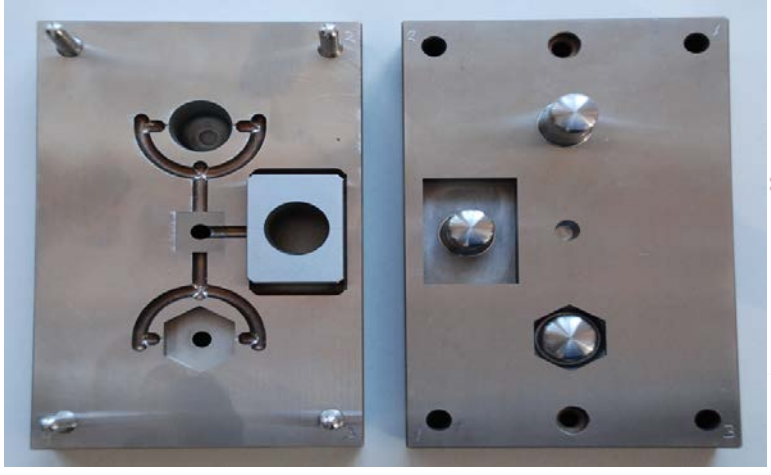
Density bars	**98,8**	**%**
Density squares	**99,0**	**%**
Thermal conductivity (25°C)	**177,2**	**$Wm^{-1}K^{-1}$**
Hardness	**376**	**HV_{30}**
Grain size	**17,2**	**µm**

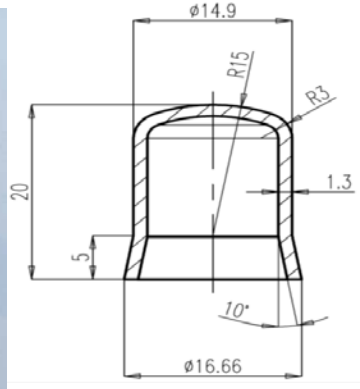


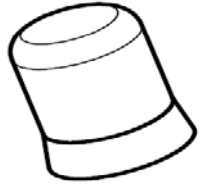




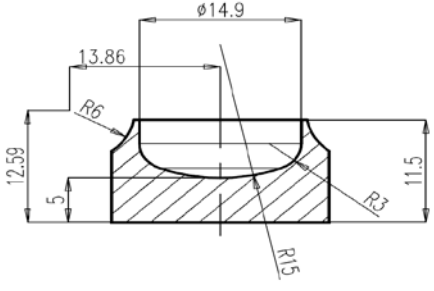
2-component MIM mock-up production

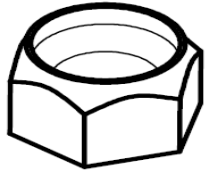






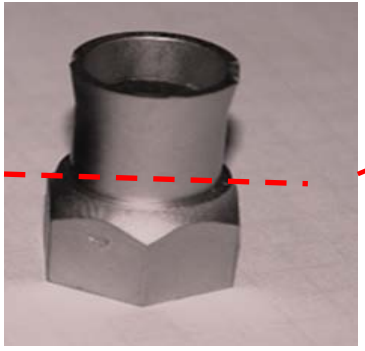
thimble

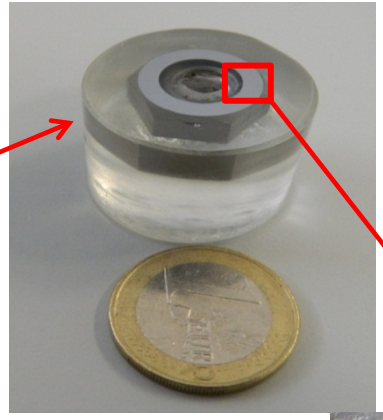


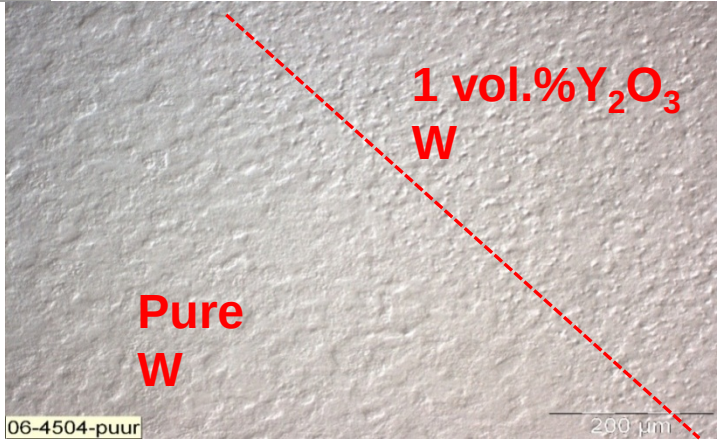


tile

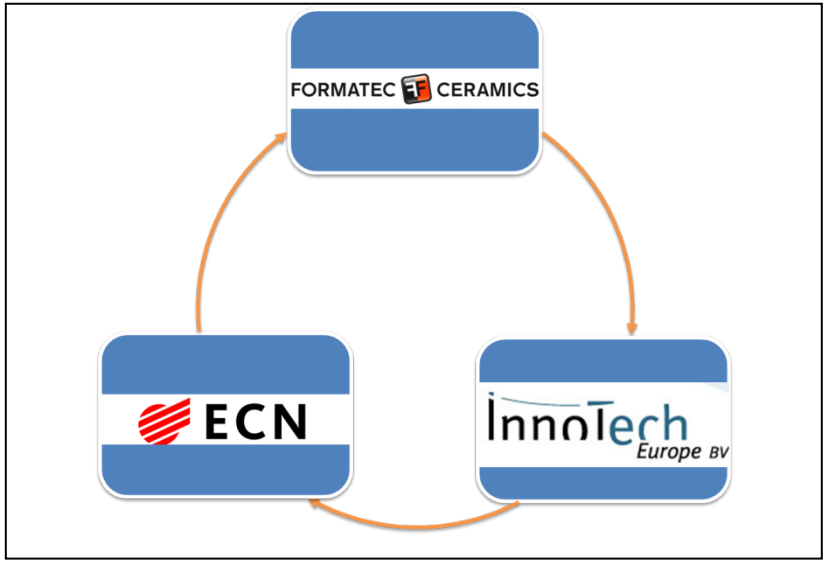
2-component MIM mock-ups production





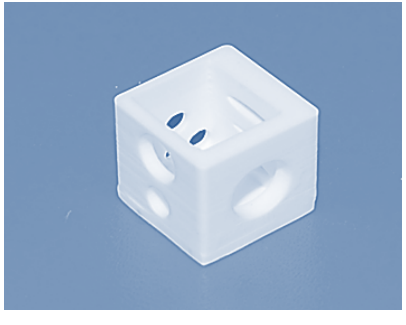


Additive Manufacturing (AM) of ceramics



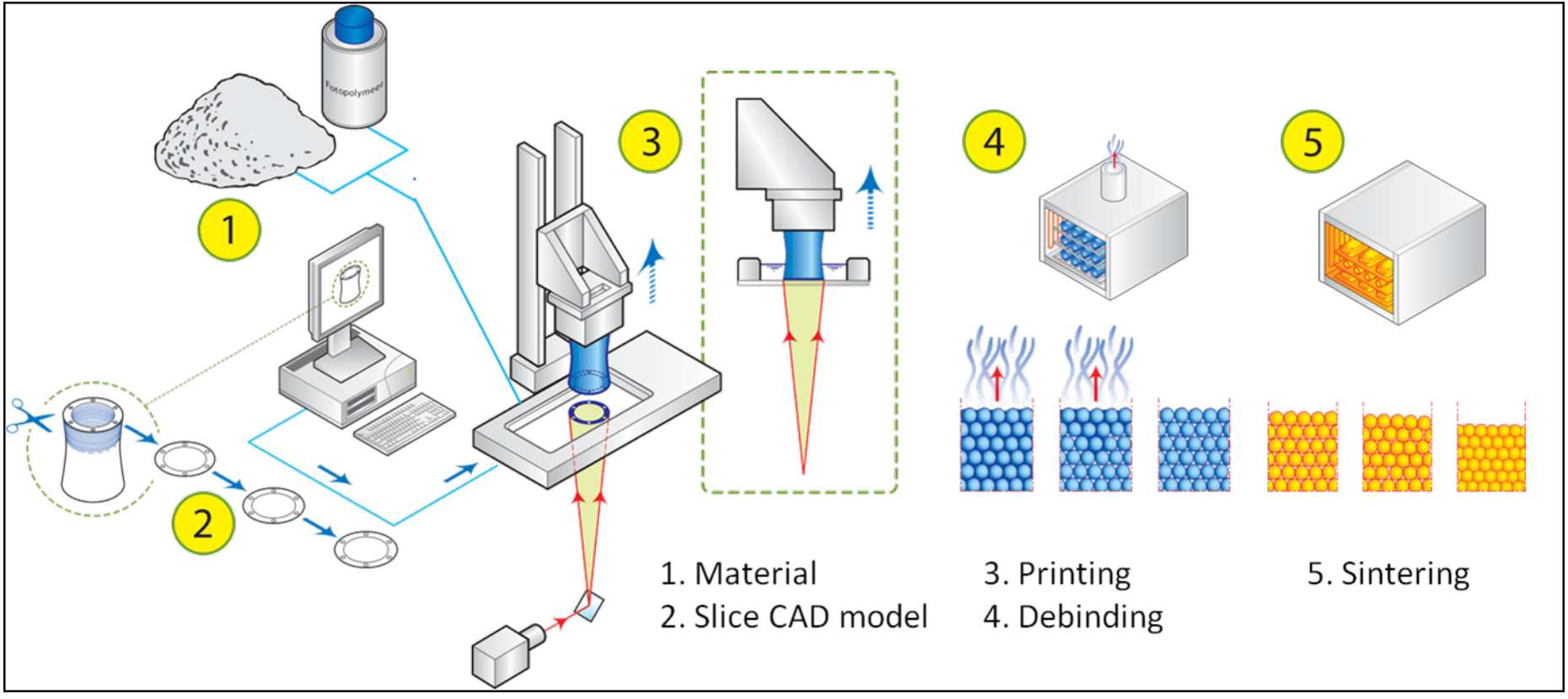
- Project started January 2013
- November 2013: ADMATEC founded
  - Delivers printed components
  - Formatec at booth 118

- Role ECN
  - Slurry / Process development
  - Characterization

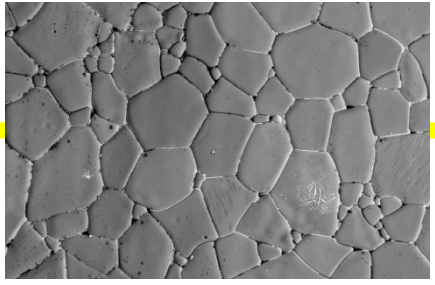


Thursday 15:35-16:00 Genderfoyer
Waar keramiek printen een plek vindt in de markt van keramische producten
Michiel de Bruijcker, Formatec Ceramics BV

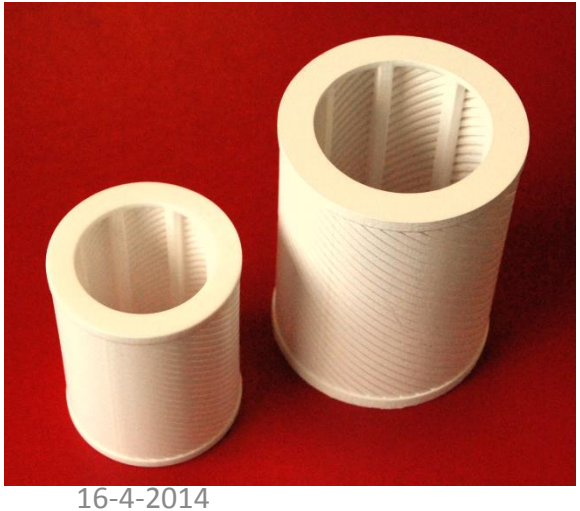
DLP type printing (slurry based technology)

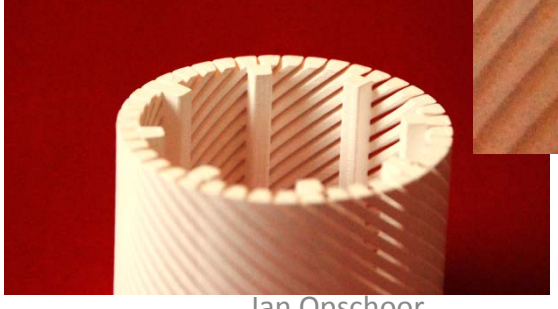


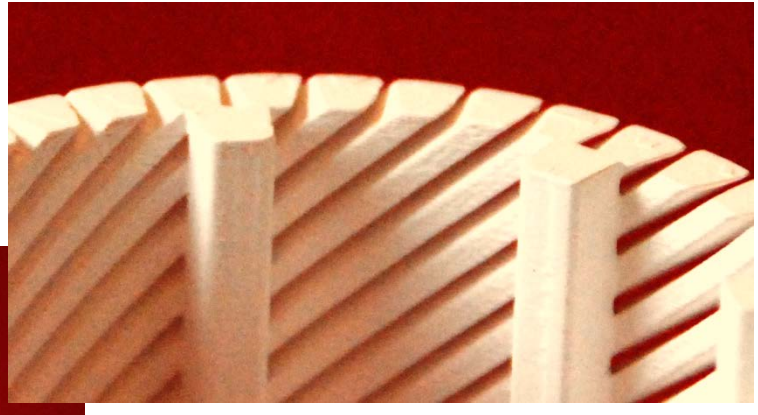
Results AM ceramics



- Materials: Alumina and Zirconia
- Developed 98% dense alumina having wall thicknesses up to 1 cm.







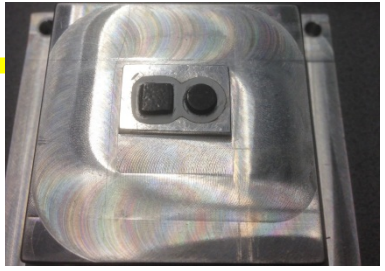
Additive Manufacturing (AM) of metals

and other light absorbing materials

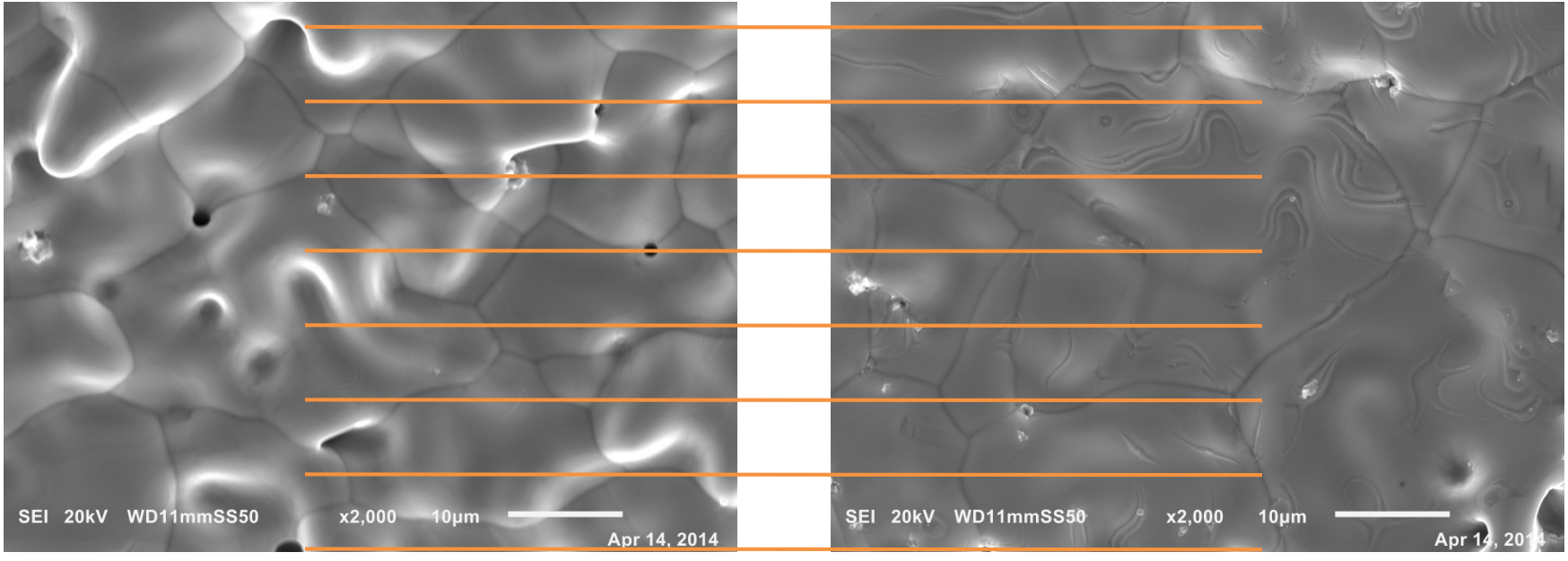
- Slurry based technology
- Digital Light Processing (DLP) type printing
- Started with 316L
  - Severe light absorption
- Optimal alignment between
  - Used metal powder (e.g. grain size)
  - Resin
  - Additives
  - Curing radiation

Improved density
microstructure
roughness
No de-gassing

Microstructure of printed 316L steel



- First results:
  - Printed body of several hundreds of layer



What does ECN offer You?

- A route to your 3D shaped and precise products in ceramics and metals
- Small scale production of your 3D shaped and precise products in metals
- Optimization of your production/manufacturing process
- Characterization of your material to improve your quality
- Adaptation of your design due to the new product quality

- A warm welcome and more information at ECN booth no 58

Materials

Solutions by knowledge and analysis

- Material characterisation
- Failure analysis
- Product optimisation
- Production development
- Joining technology
- Powder metallurgical material processing

Engineering & Realisation

Solutions beyond the state of art

- Process
- Mechanical
- Electrical
- Software
- Commissioning
- HAZOP studies

Metal Injection Moulding

Products of extreme materials

- Netshape manufacturing
- Refractory metals up to 3000°C
- No residual stresses
- No recrystallisation

Thanks for your attention

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