Karlsruher Institut für Technologie

Micro and Precision Powder Injection Molding - Materials, Variants, Opportunities

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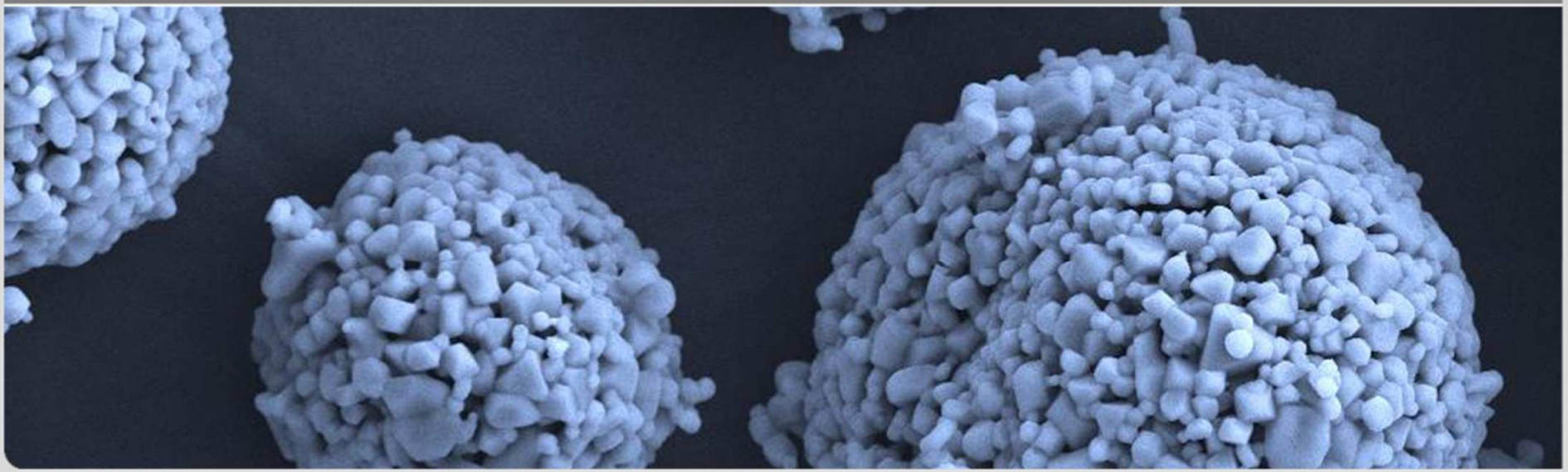
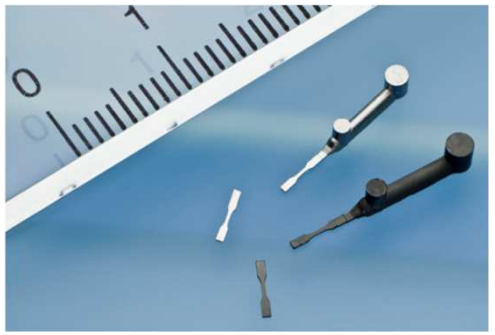
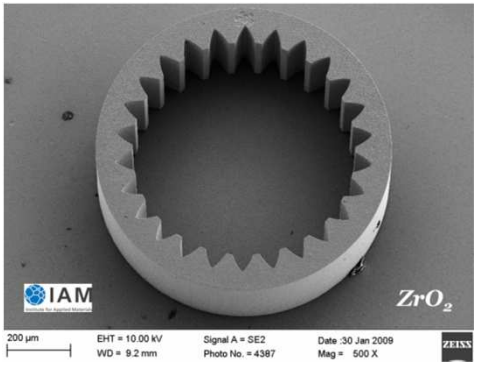
INSTITUTE FOR APPLIED MATERIALS - MATERIALS PROCESS TECHNOLOGY (IAM – WPT)



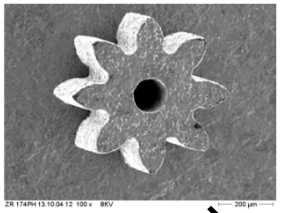
Contents

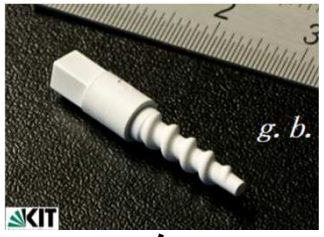


- Powder Injection Molding in micro dimensions (MicroPIM)
- Accuracy considerations on MicroPIM
- PIM of tungsten and tungsten-alloys
- Micro Inmold-labeling using PIM-Feedstocks
- Outlook



Micro System Technology





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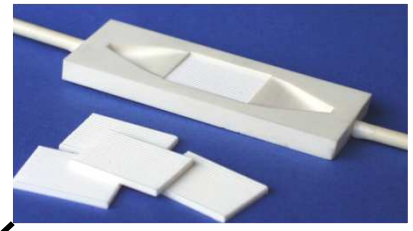
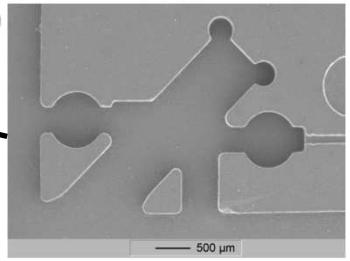
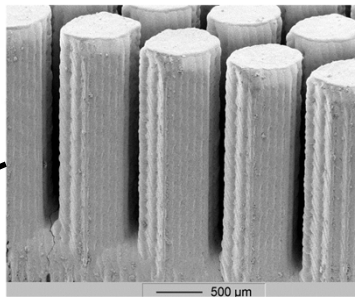
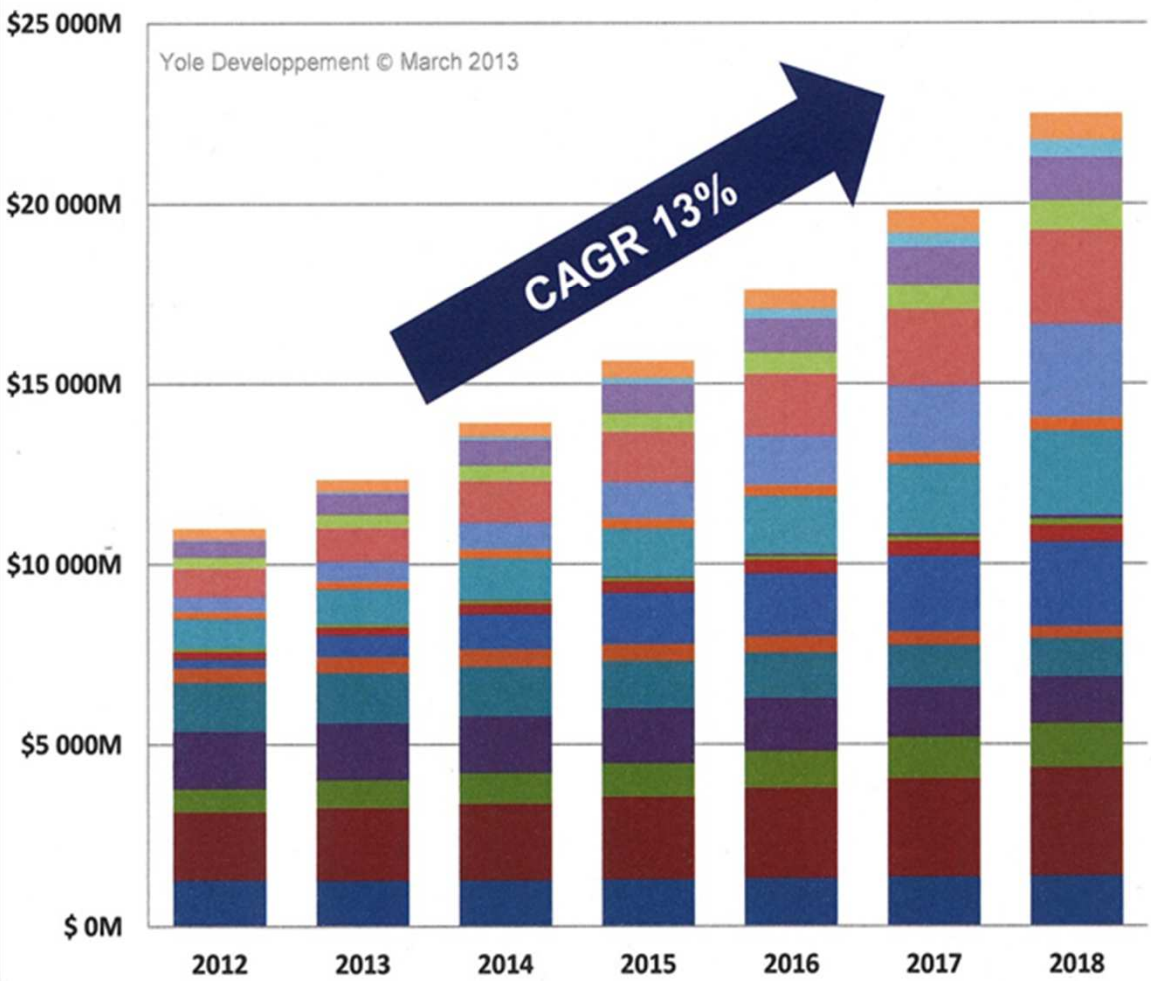
Source: Yole Development, March 2013

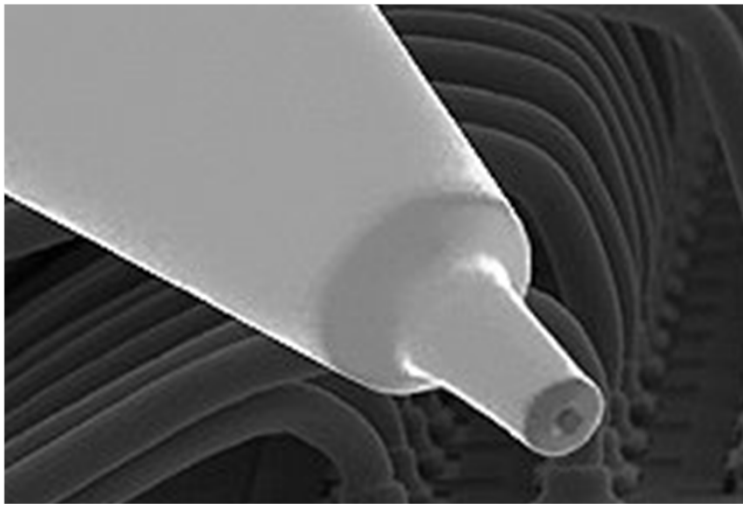






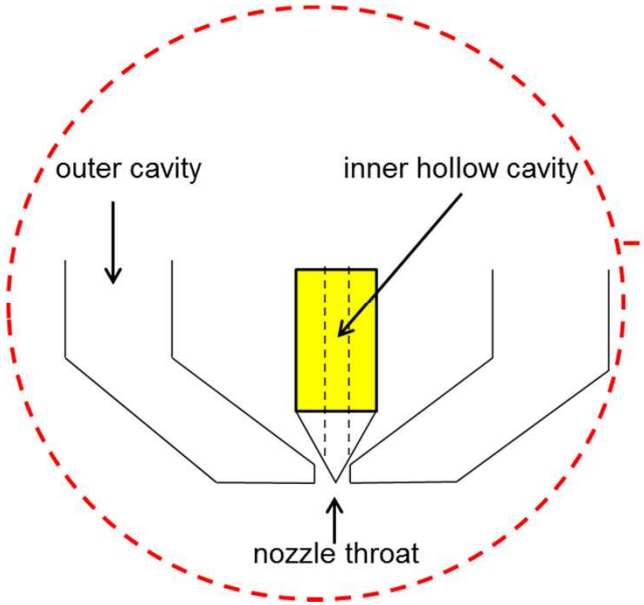


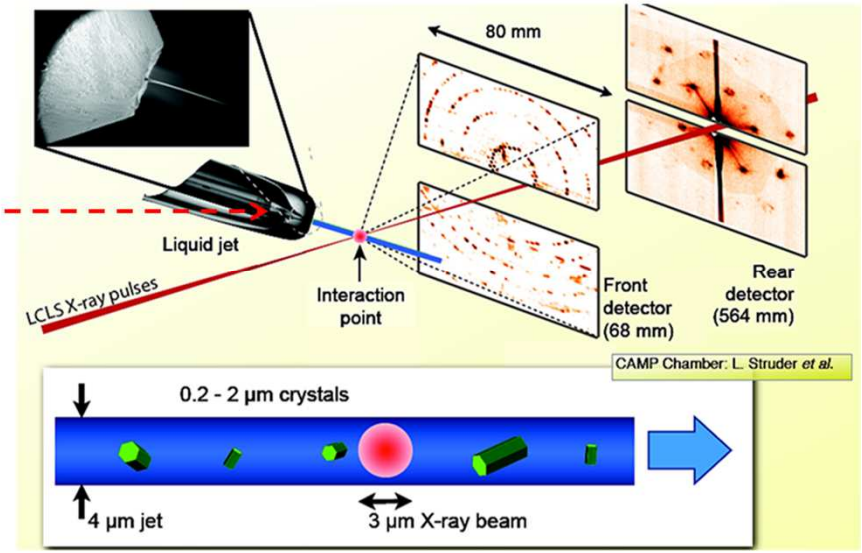
MicroPIM



Capillary for fine pitch bonding
tip-Ø=45µm, hole-Ø=19µm
SPT Roth Ltd., CH

Scientific application: liquid jet nozzles for CFEL
collaborative project between DESY and KIT





Accuracy in (Micro-)PIM

SoA: (± 0.05%) ± 0.1% - ± 0.5%

Determination of explanantory variables, e.g. tool/runner concept

Design and construction of experimental tool

- 2 movable pistons
- position of injection gates variable
- vacuum system
- pressure sensor
- 6 heating elements near to cavity

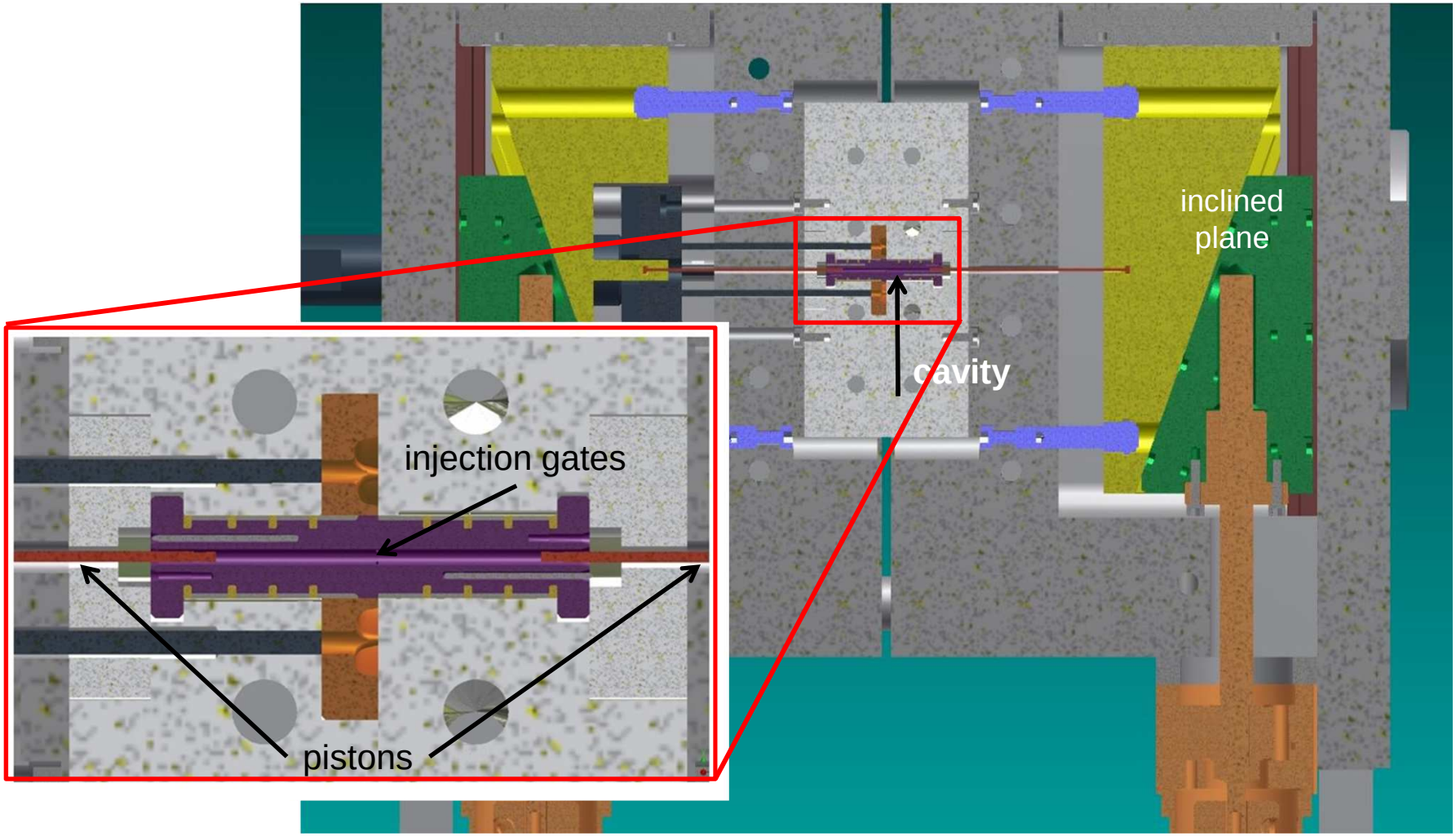
Three ways of process conduct: Injection

- into empty cavity
- against pressureless pistons
- against pressurized pistons

Accuracy in (Micro-)PIM

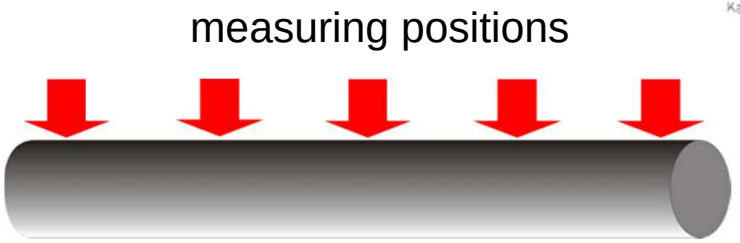
ejector side

dye side



Accuracy in (Micro-)PIM

Sample for initial trials
Ø = 2.015mm

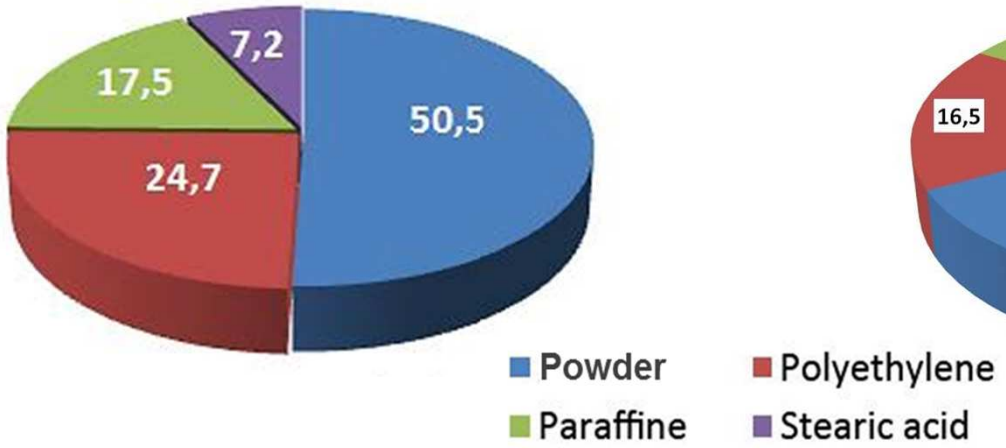


gate position: dye side / middle

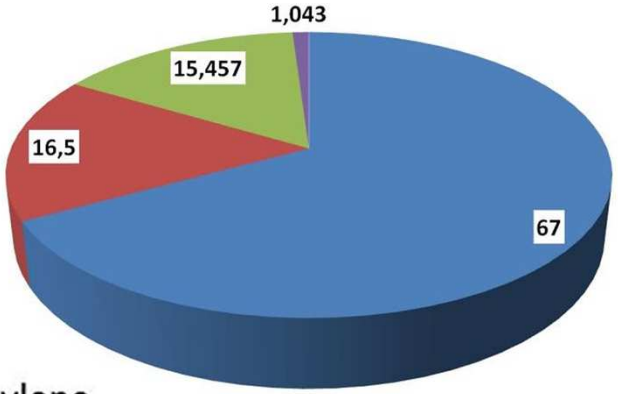
piston pressure: 5.8% / 19.5% of $P_{max, motor}$

Two feedstocks:

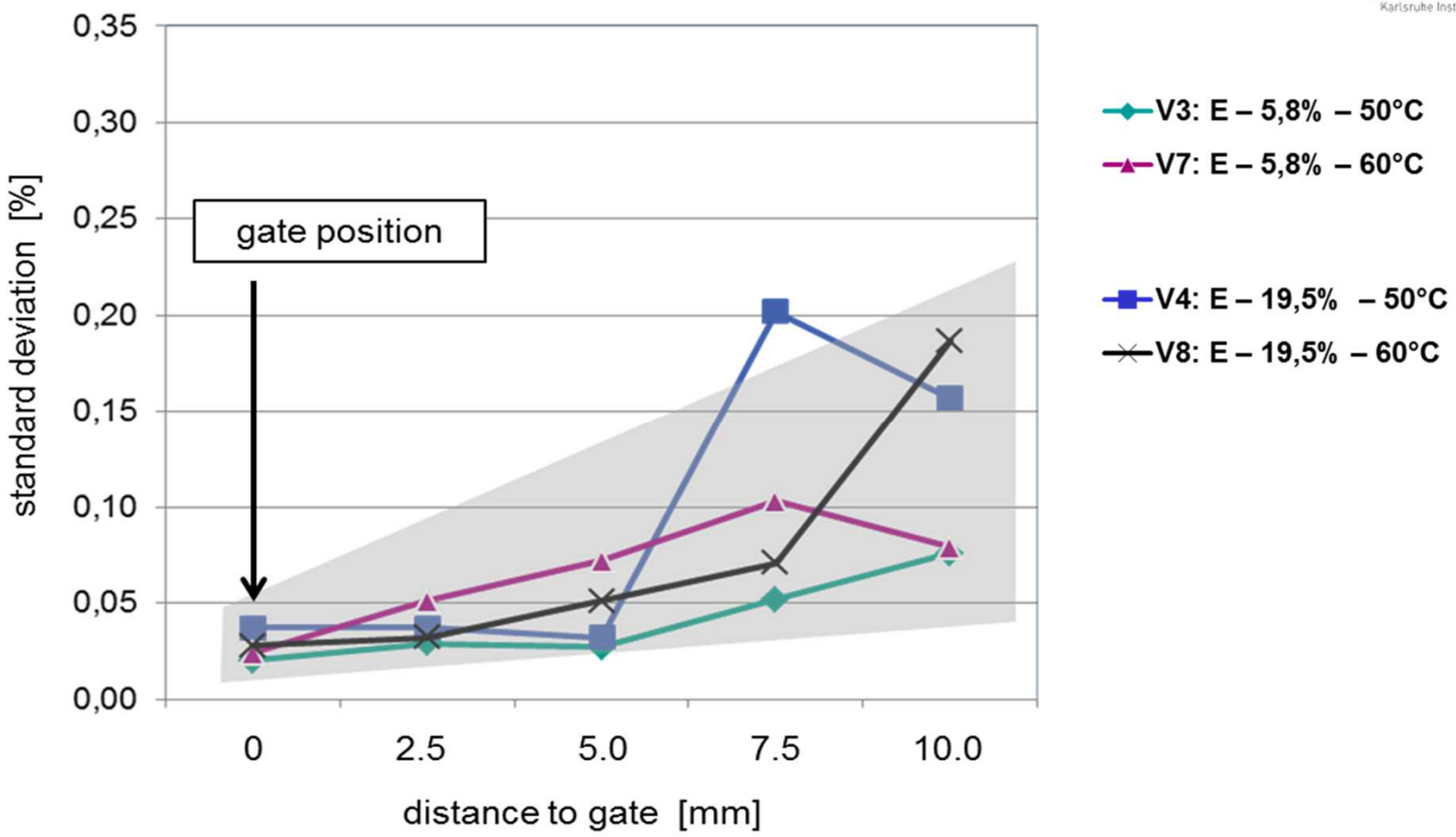
- ZrO_2 Tosoh TZ-3YS-E



- 17-4PH Osprey 1.4542



Accuracy in (Micro-)PIM

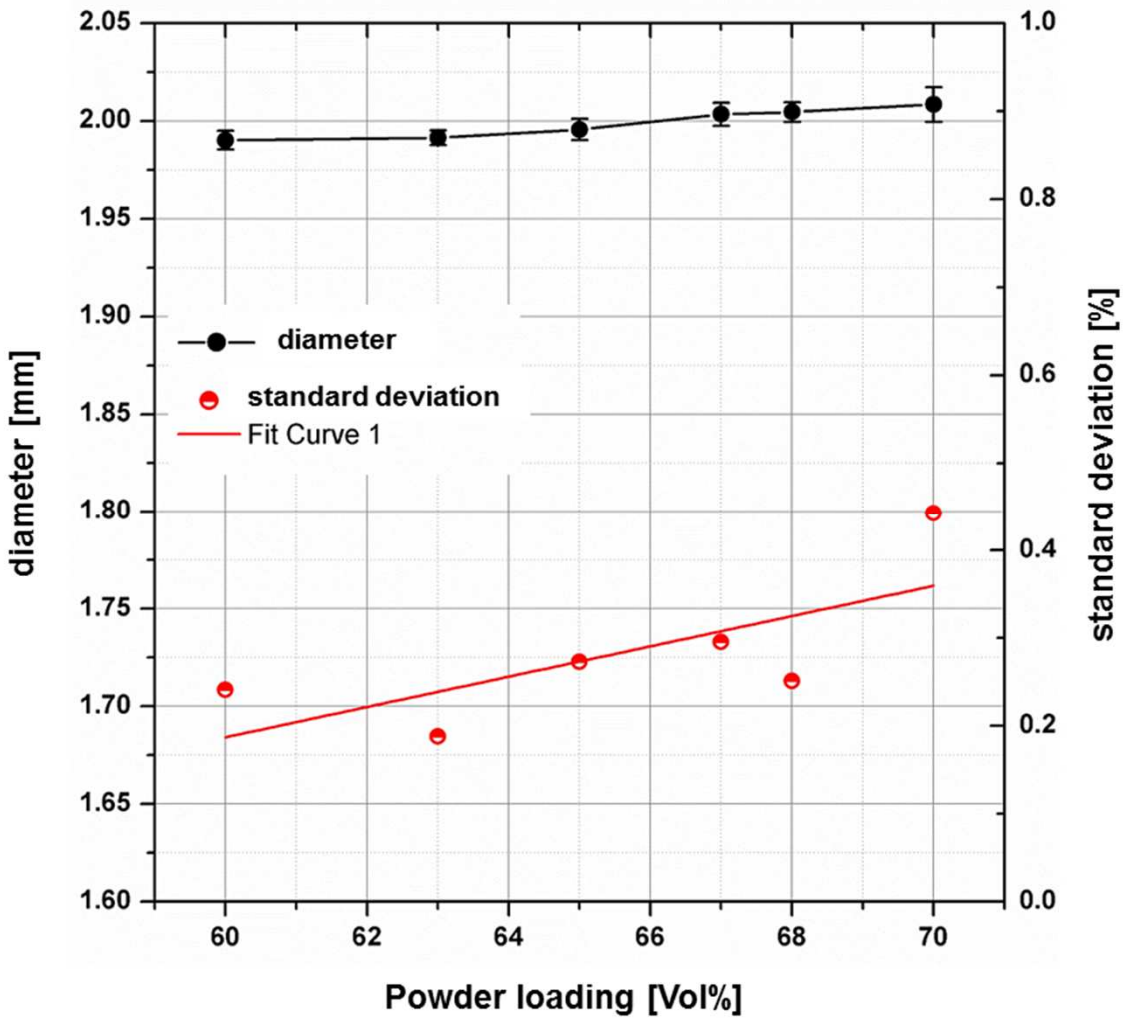


→ **best accuracy for nearly zero counterpressure i.e. quasi-balanced force state**

→ **standard deviation increases with distance to back pressure insertion**

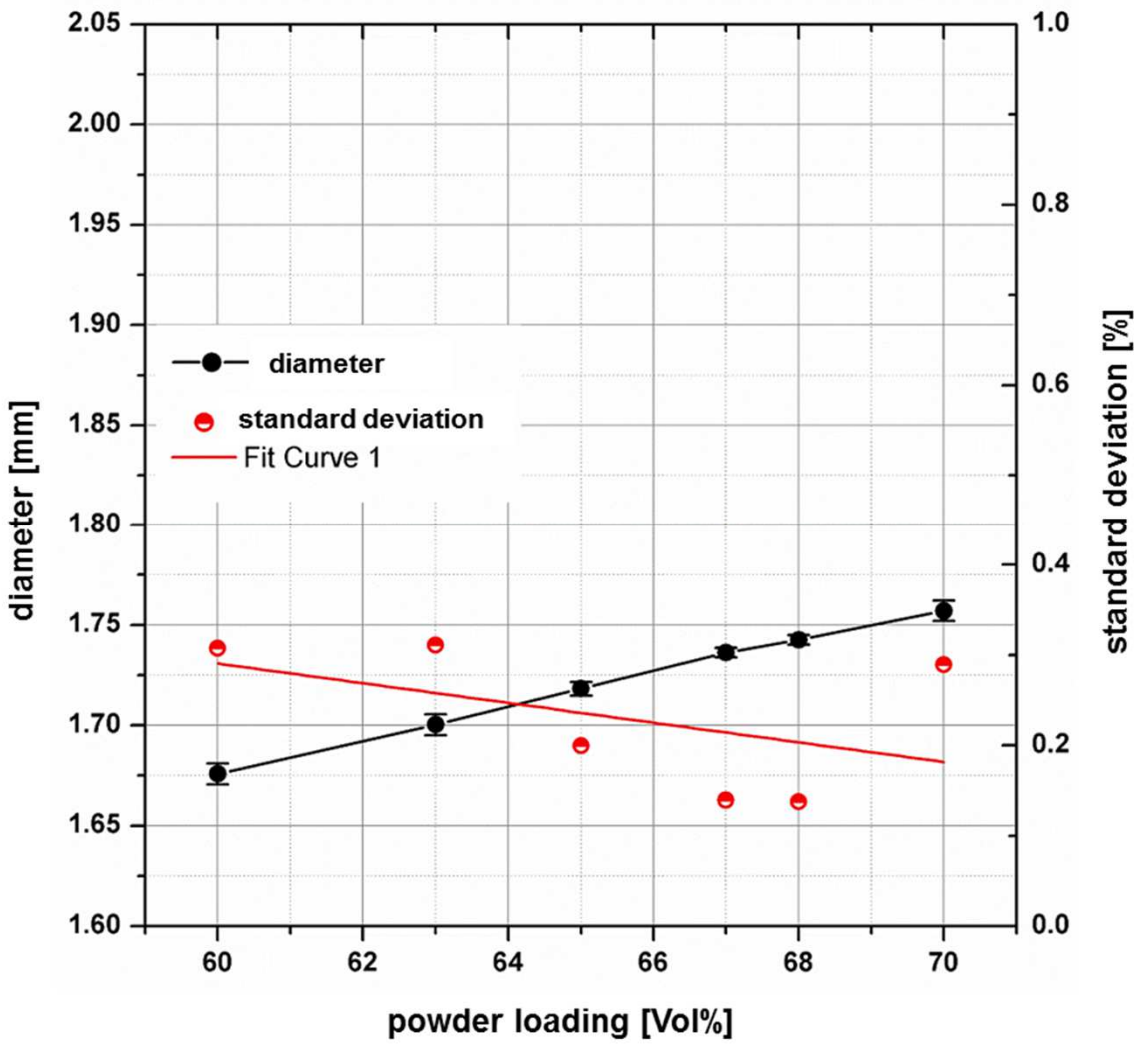
Accuracy in (Micro-)PIM

Green bodies



Accuracy in (Micro-)PIM

Sintered parts



Micro Injection Molding – General Data

Materials	min. lat. Dimension [µm]	min. Detail [µm]	Aspect Ratio [isolated walls]	Tolerance [± %]	Roughness ** R_{max} / R_a [µm]	Materials tested
Plastics	**10**	**≤0.08**	**>20 (200*)**	**0.05**	**0.05 / <0.05**	**Thermoplastics, TPE**
Metals	**50**	**10**	**>10**	**< 0.5**	**7 / 0.8**	**17-4PH, 316L, Cu, W, W-alloys**
Ceramics	**<10**	**<3**	**<15**	**(0.1***) / 0.3**	**<3 / <0.3**	**ZrO_2, Al_20_3, ZTA, Al_2O_3/TiN, Si_3N_4**

* flow length to wall thickness ratio

** depending on mold insert

*** after thorough process optimization

Tungsten PIM (WPIM)

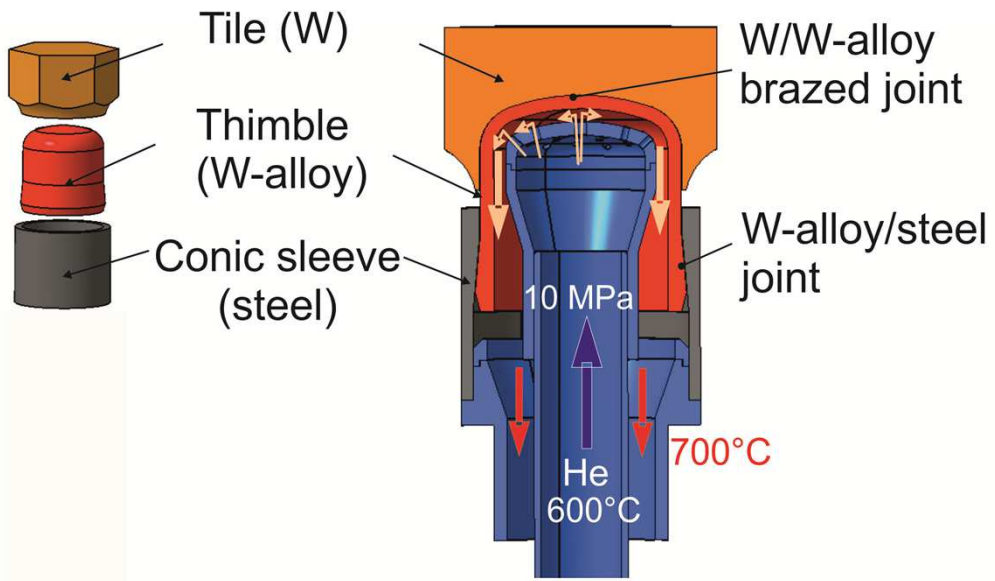
Divertor components for FUSION reactors

DEMO reactor:

- **nearly 300.000 devices**
- **lifetime nearly 2 years**

1 Finger-module:

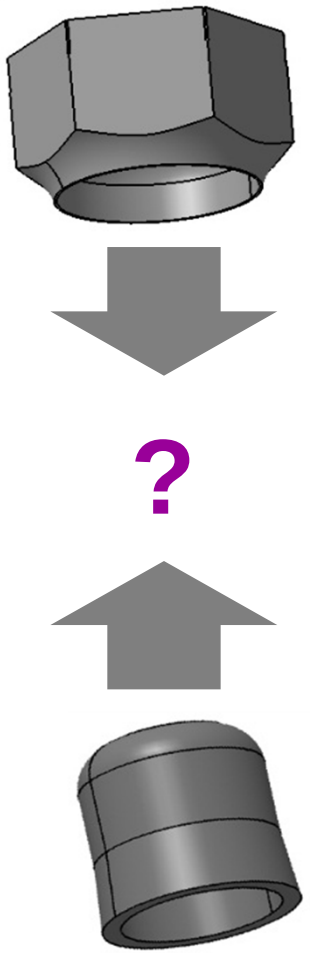
- **3 main parts**
- **2-3 materials**
- **2 brazed joints**
- **assembly …**



1 finger-module

2-Component Tungsten PIM (2C-WPIM)

Needed: Joining method for thimble and tile



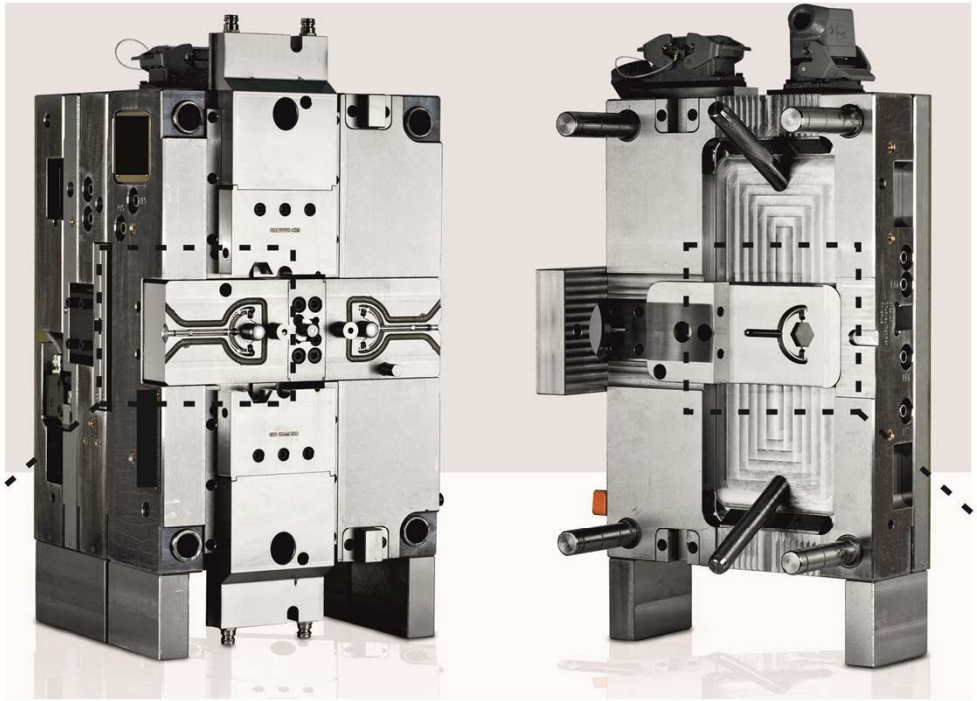
⇒ **production of both parts as one unit in one cycle**

⇒ **effective fabrication by reduced assembly efforts**

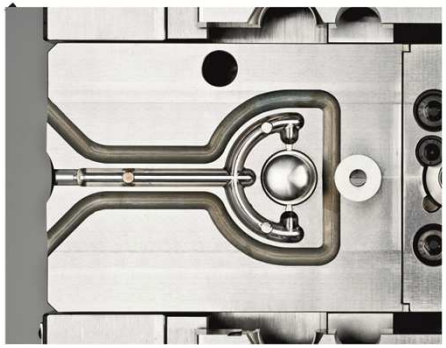
⇒ **saving of brazing steps**

New fully automatic 2C-WPIM tool

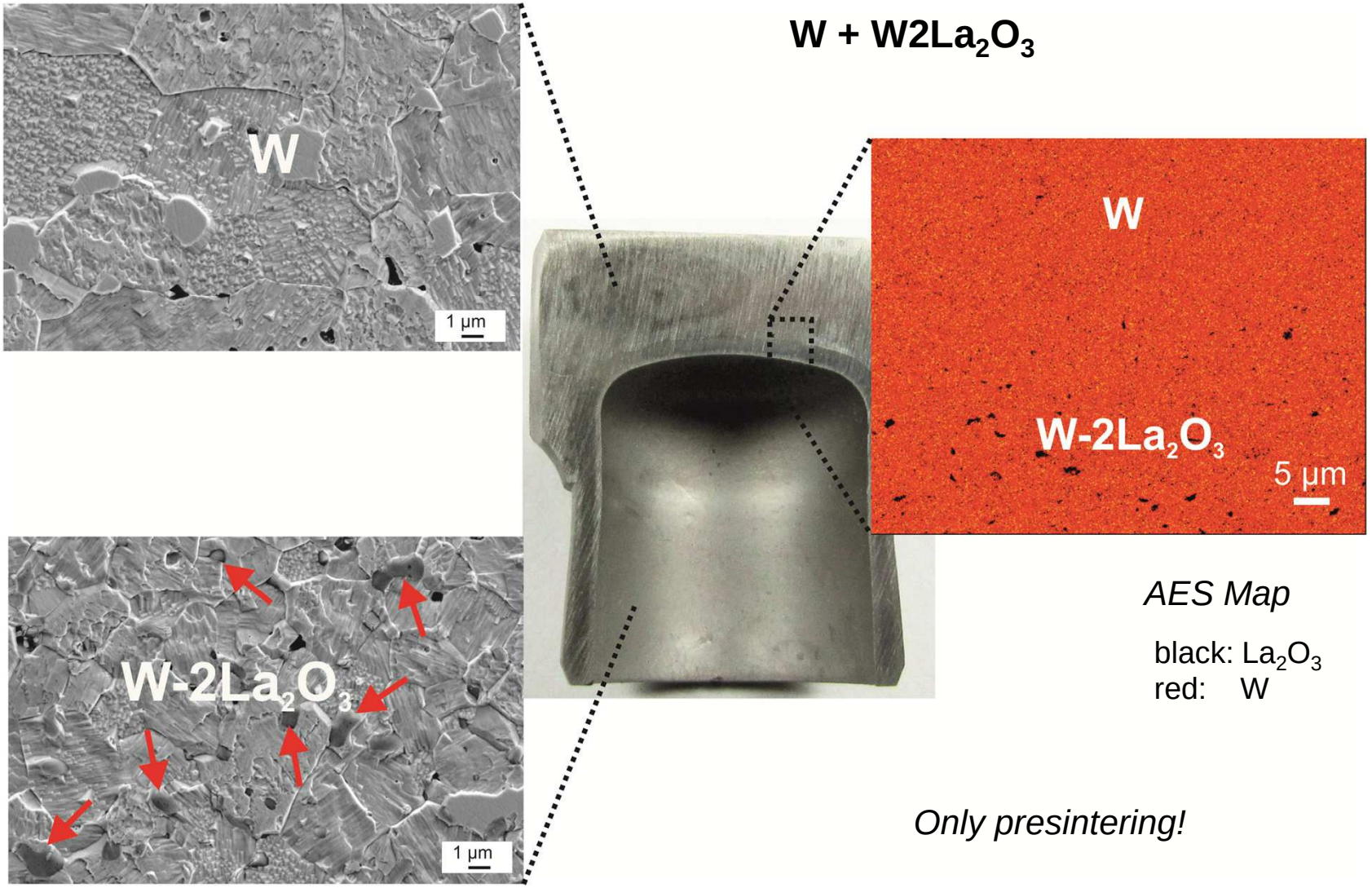
Ejection side



Nozzle side



2C-WPIM



AES Map

black: La_2O_3
red: W

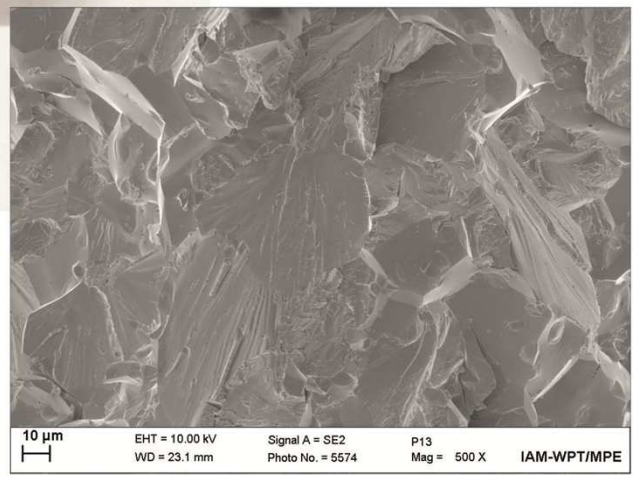
Only presintering!

Tungsten PIM (WPIM)

Needed: really heavy components

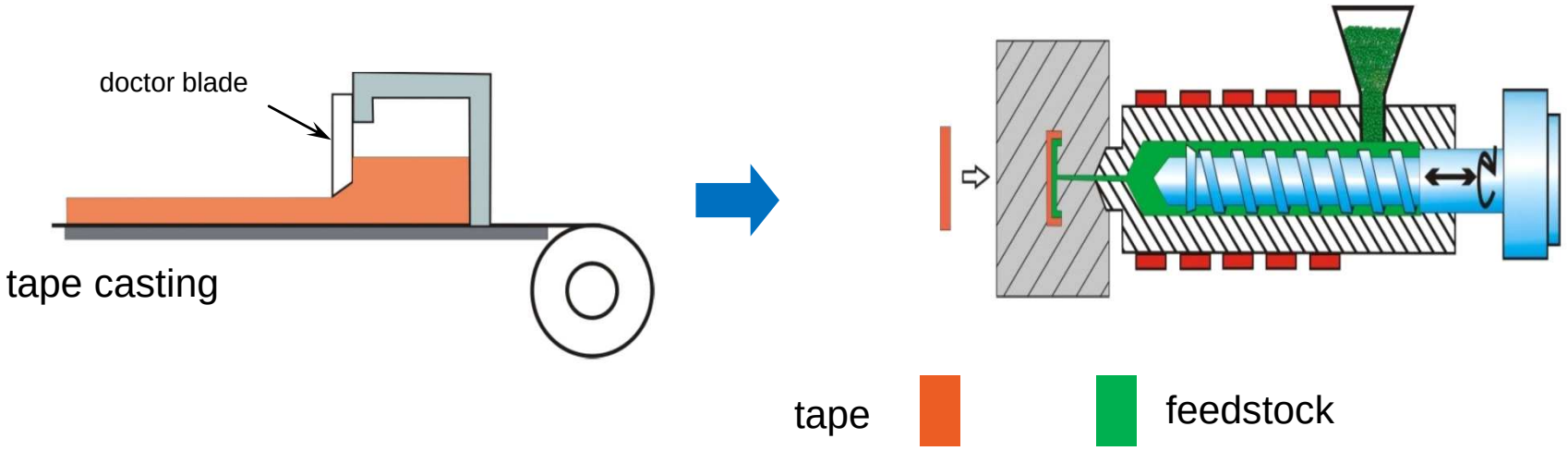
green body

sintered part



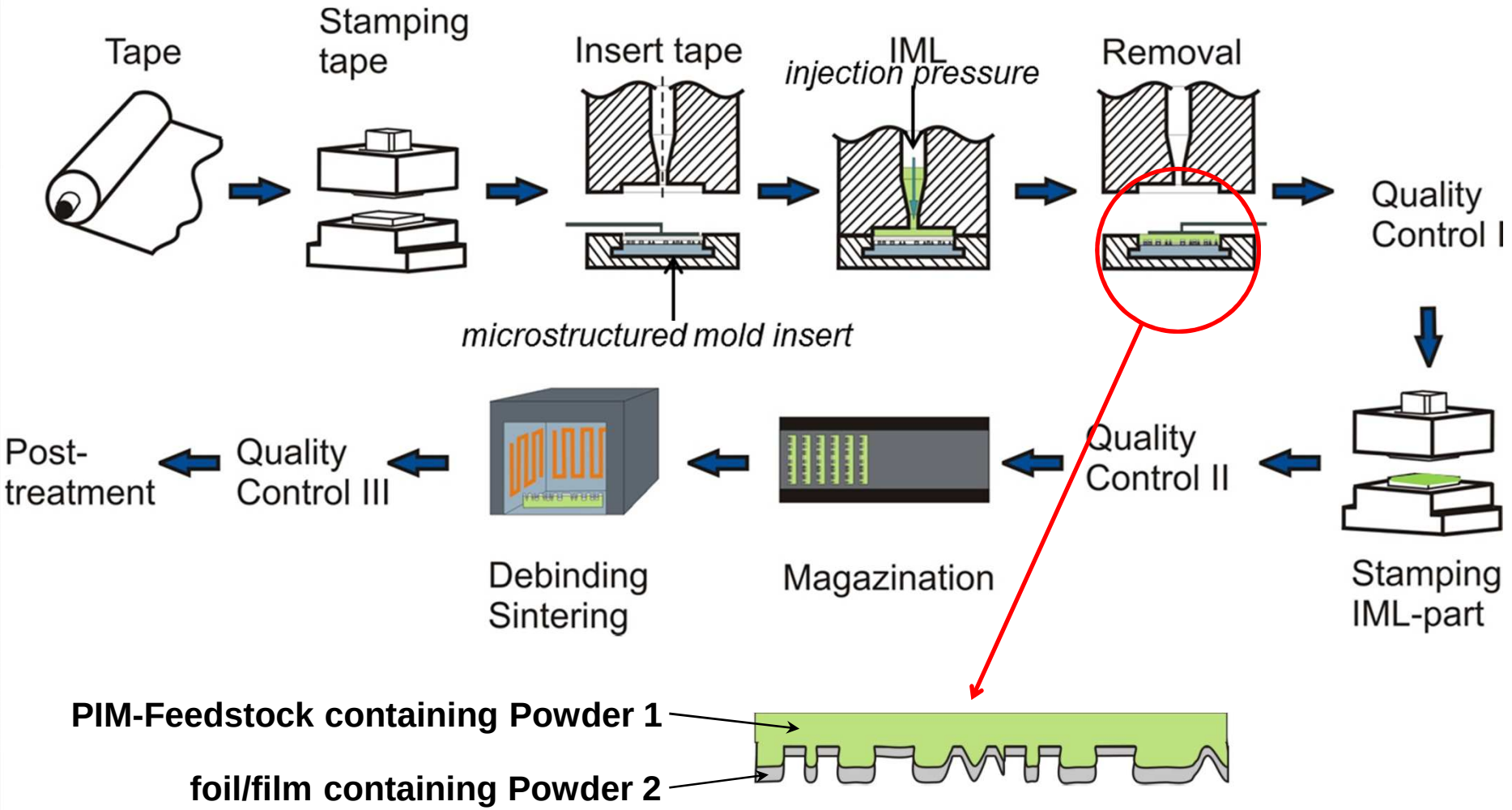
Micro Powder Inmold-labeling (IML-MicroPIM)

- combining the advantages of two shaping methods …



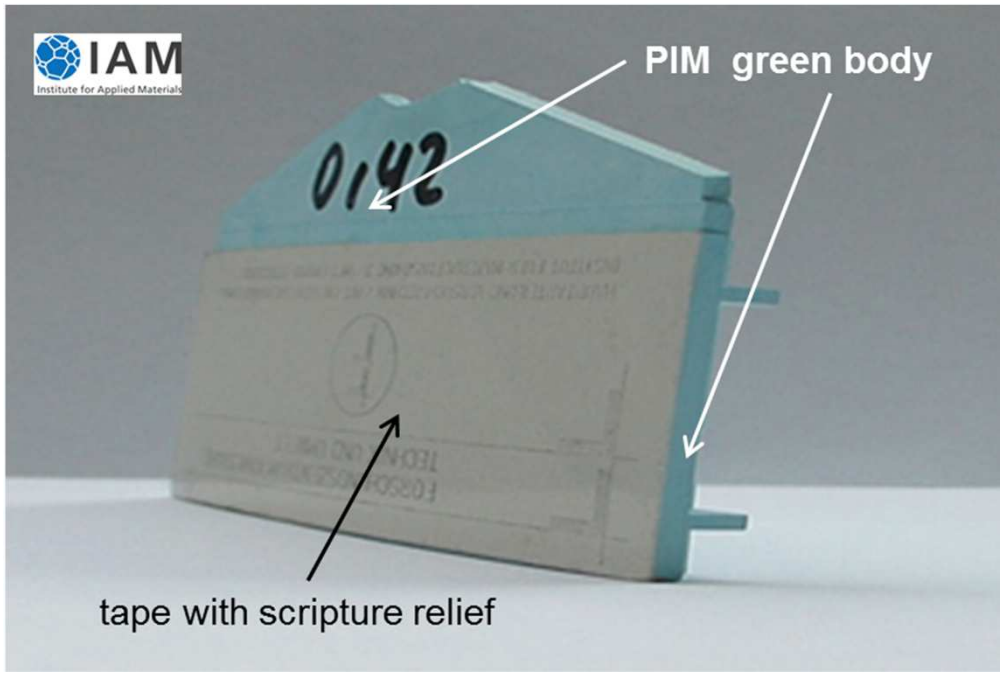
EU Project No. FP7-NMP4-2007-214122

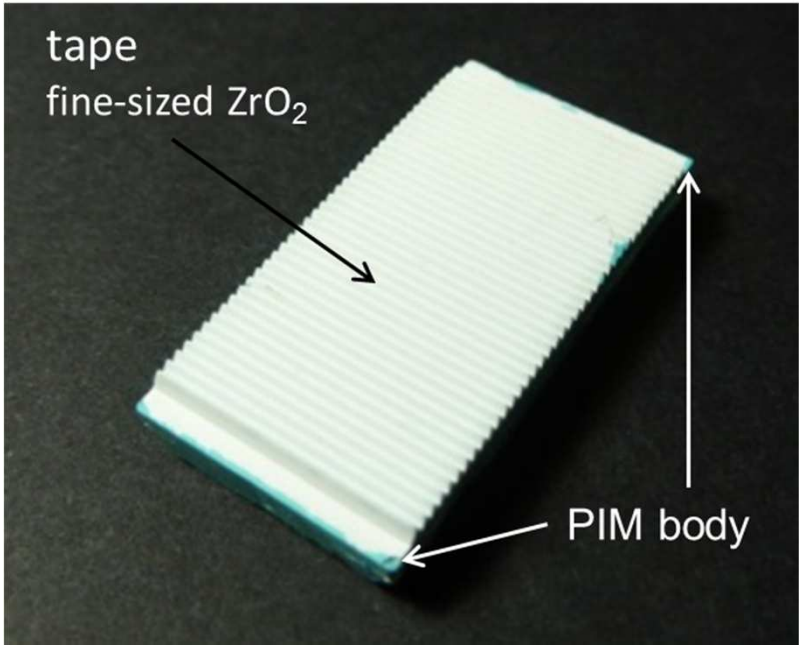
Micro Powder Inmold-labeling



Powder 2: functional or nano-particles applied on the structured surface

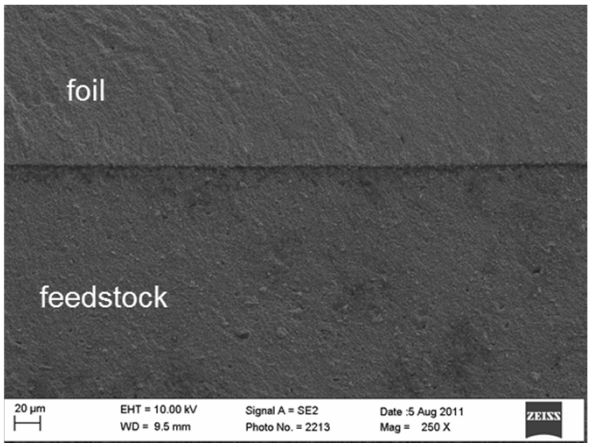
Production of green bodies



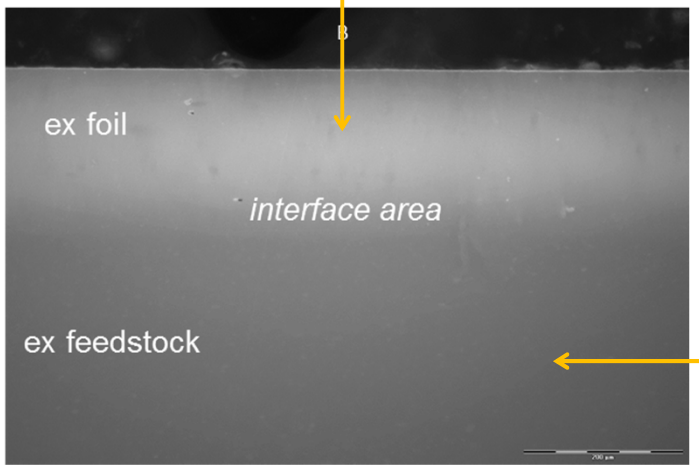


Investigation of samples

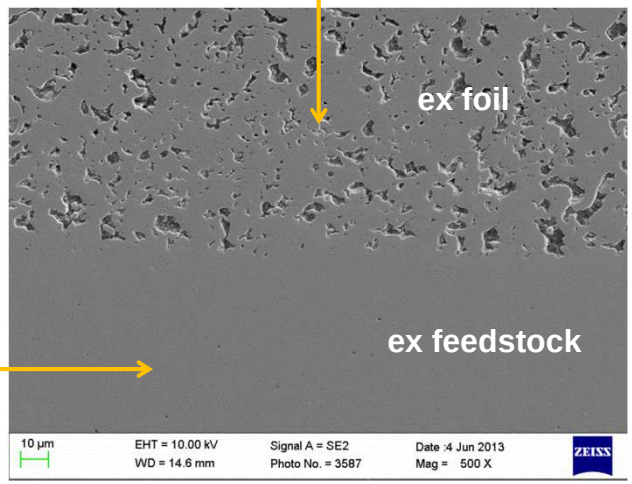
green body



ca. 53Vol% ZrO_2
70nm



ca. 50Vol% ZrO_2
40nm



ca. 50Vol% ZrO_2
440nm

Outlook

- Enhancing technical performance

  improve dimensional accuracy and surface quality

  larger variety of materials, e.g. nanopowders

  improve simulation/predictability

- Extended use of multi-component variants

  micro inmold-labelling using nanopowders

  two-component micro injection moulding

  sinter-joining of PIM green bodies

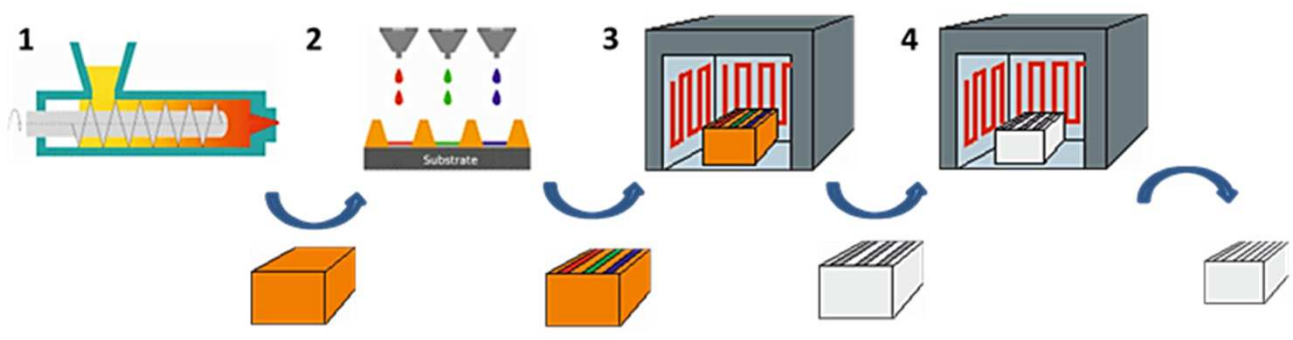
Outlook

- **Hybridization of micro processing technologies**

  3D-MID and variants

  PIM + Additive Manufacturing

1. Micro PIM
2. 3D inkjet printing
3. Debinding
4. Sintering



Highest geometrical degree of freedom ↔ maintain mass fabrication capability

Acknowledgment

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Thank you !