Examinations on
Precision Powder Injection Molding

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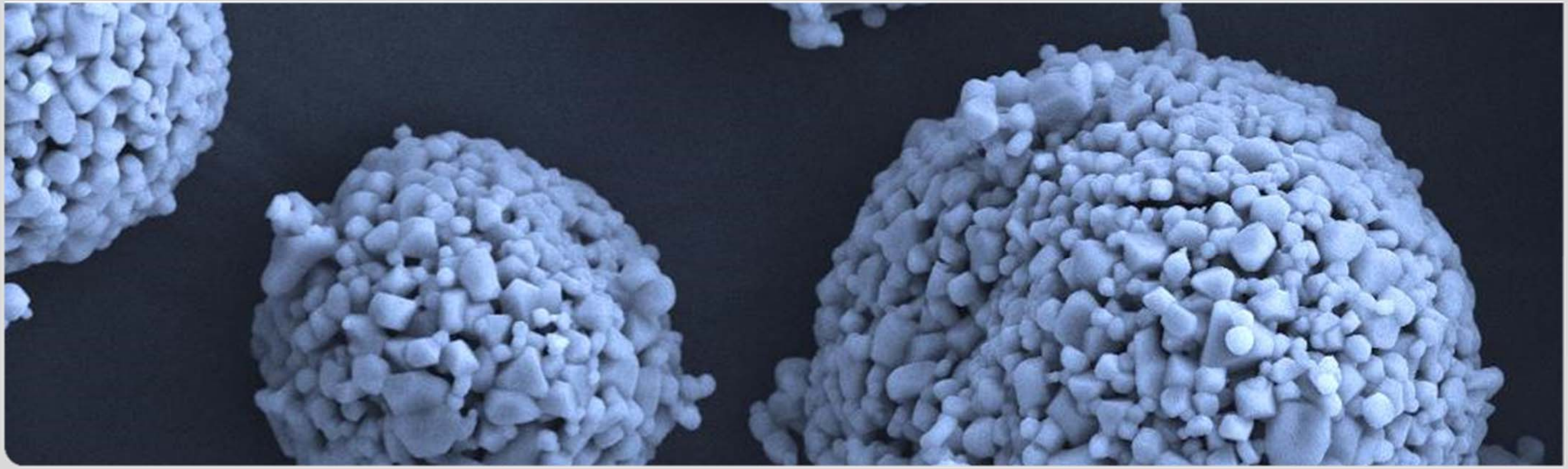
INSTITUTE FOR APPLIED MATERIALS - (IAM – WK)



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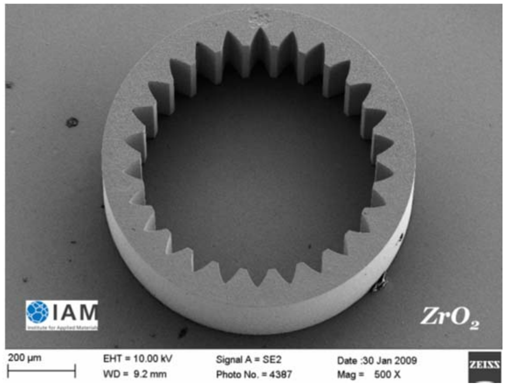
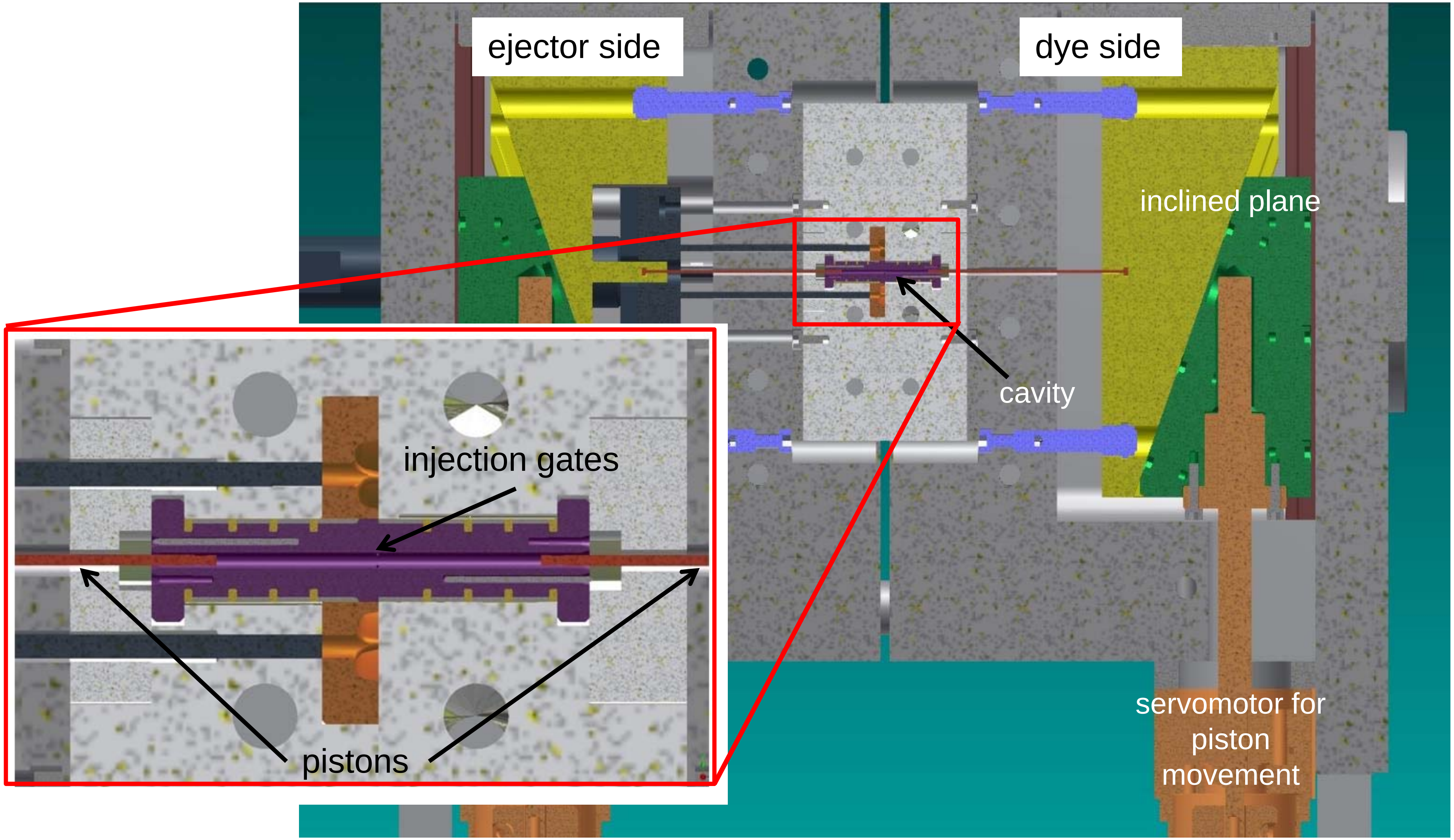


Scheme of twin-piston tool



PIM Accuracy

measuring positions

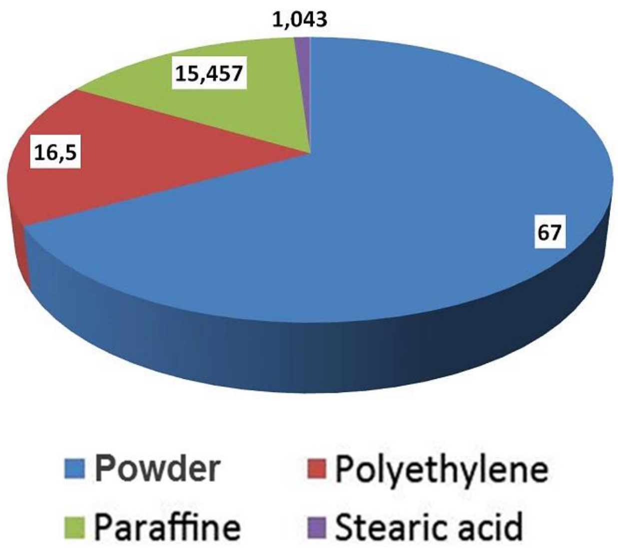
First demonstrator:

Cylinder Ø = 2.015mm

gate position: dye side / middle

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

Feedstocks:

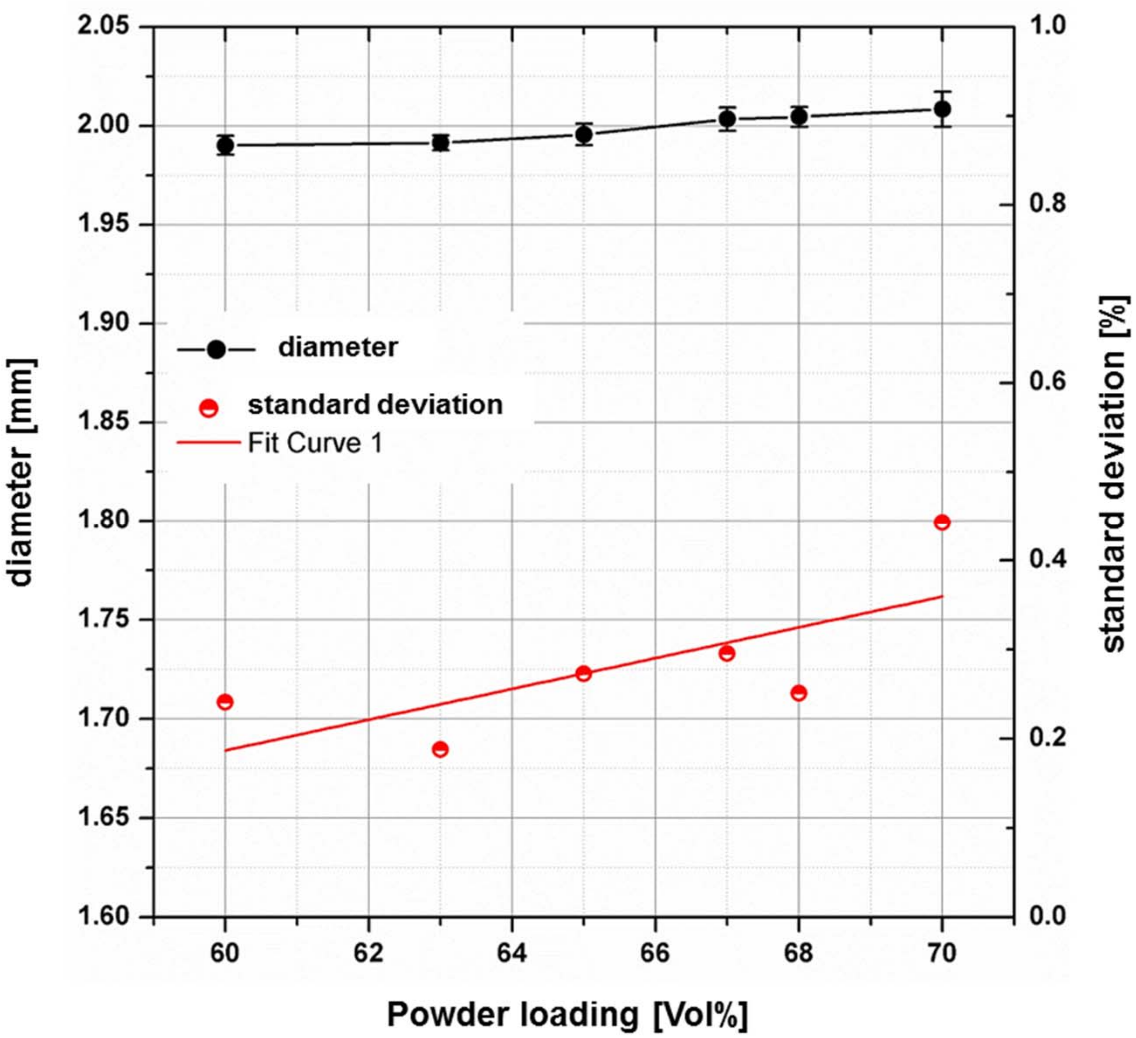


Powder: 17-4PH Osprey 1.4542

D_{50} ca. 4µm

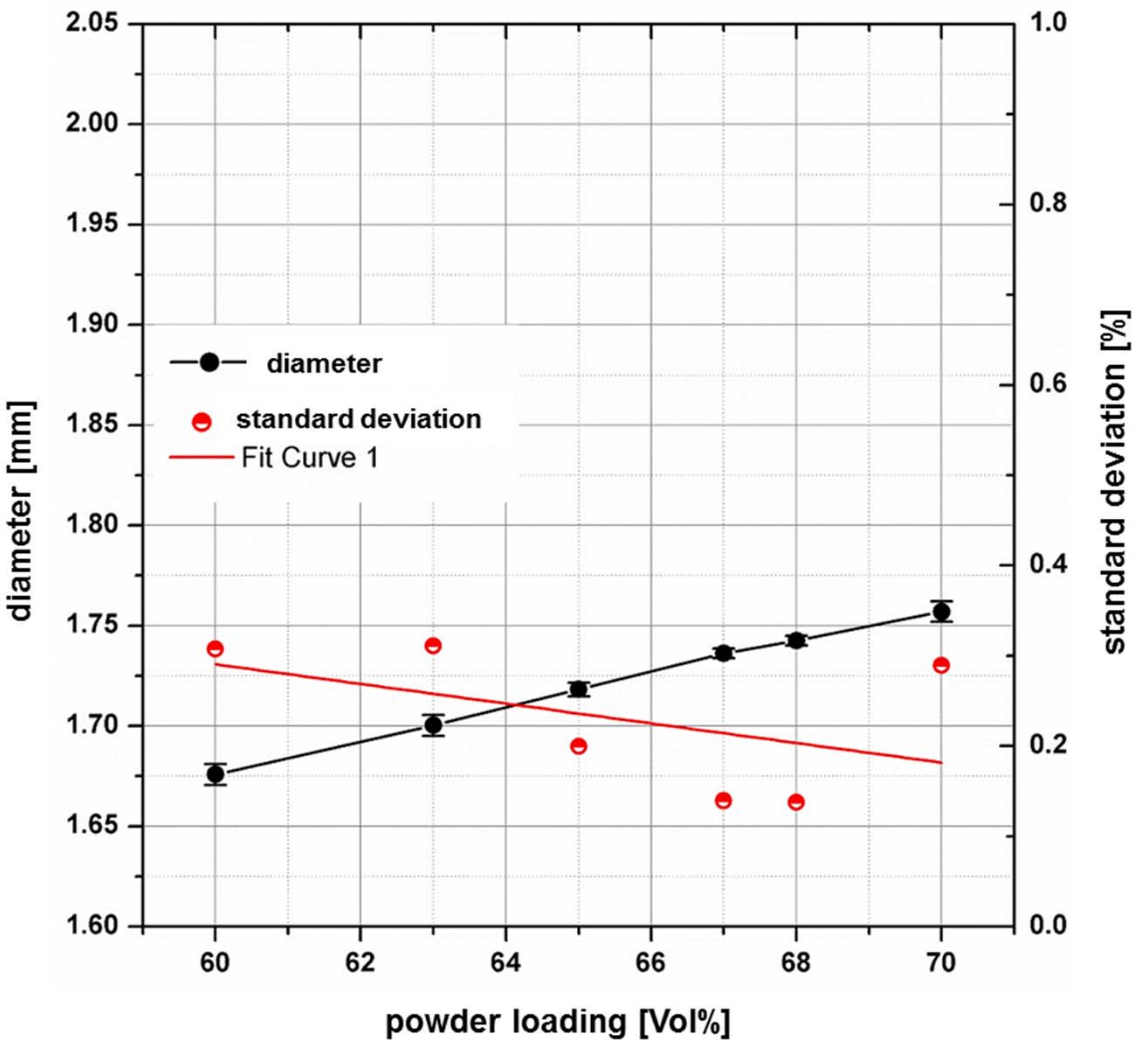
PIM Accuracy

Green bodies

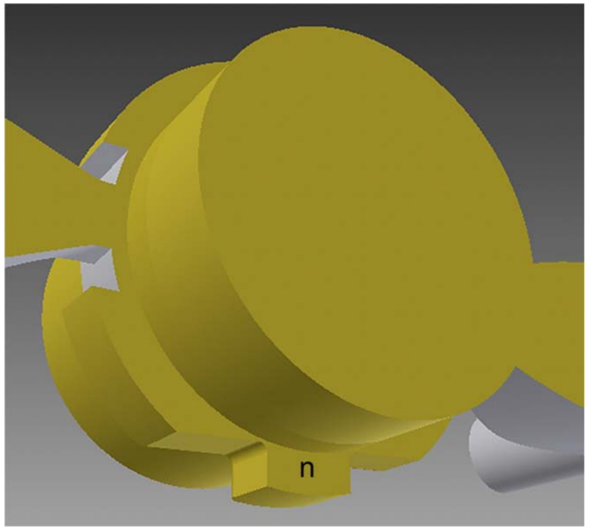


PIM Accuracy

Sintered parts

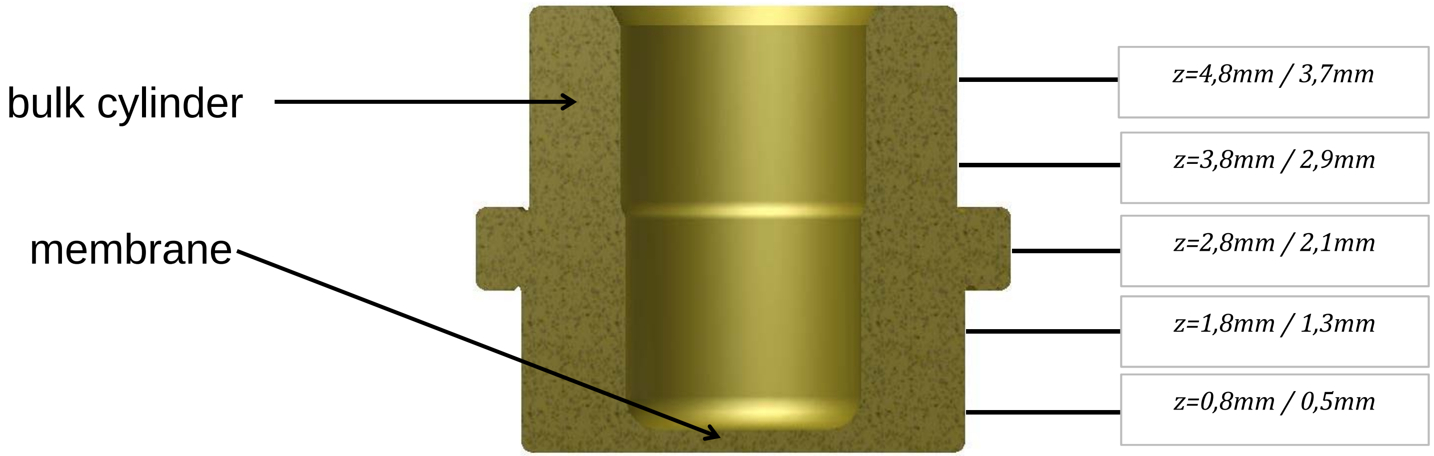


Parts with considerable thickness variation



Creation of demonstrator:

Membrane carrier



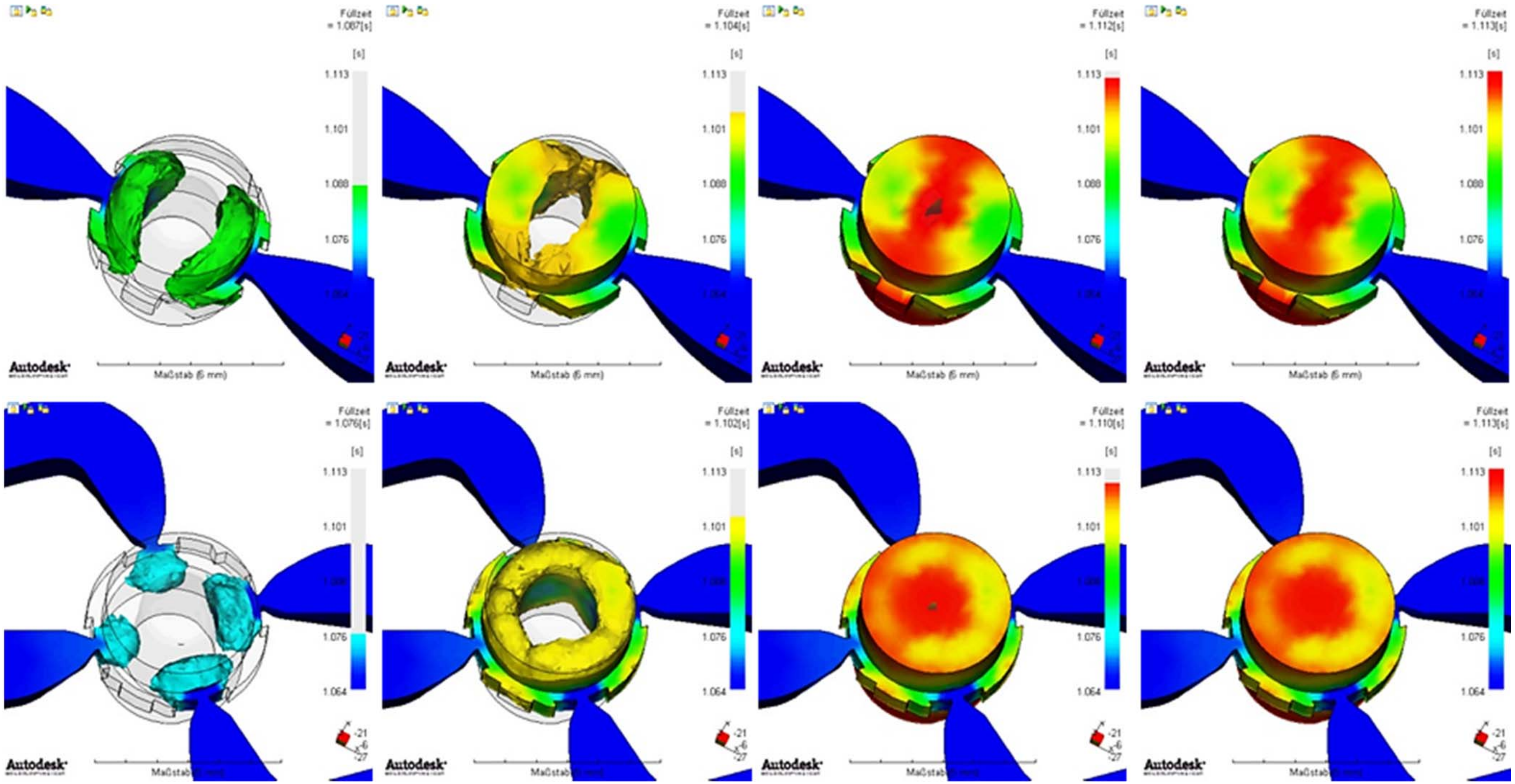
Process conduct

Process 1: Unaltered powder injection molding

- 63Vol% 17-4PH feedstock
- filling simulations
- constancy of cylinder diameter

Filling simulation

Evaluation of most suitable runner system



verified by short-shot studies

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HELMHOLTZ GEMEINSCHAFT

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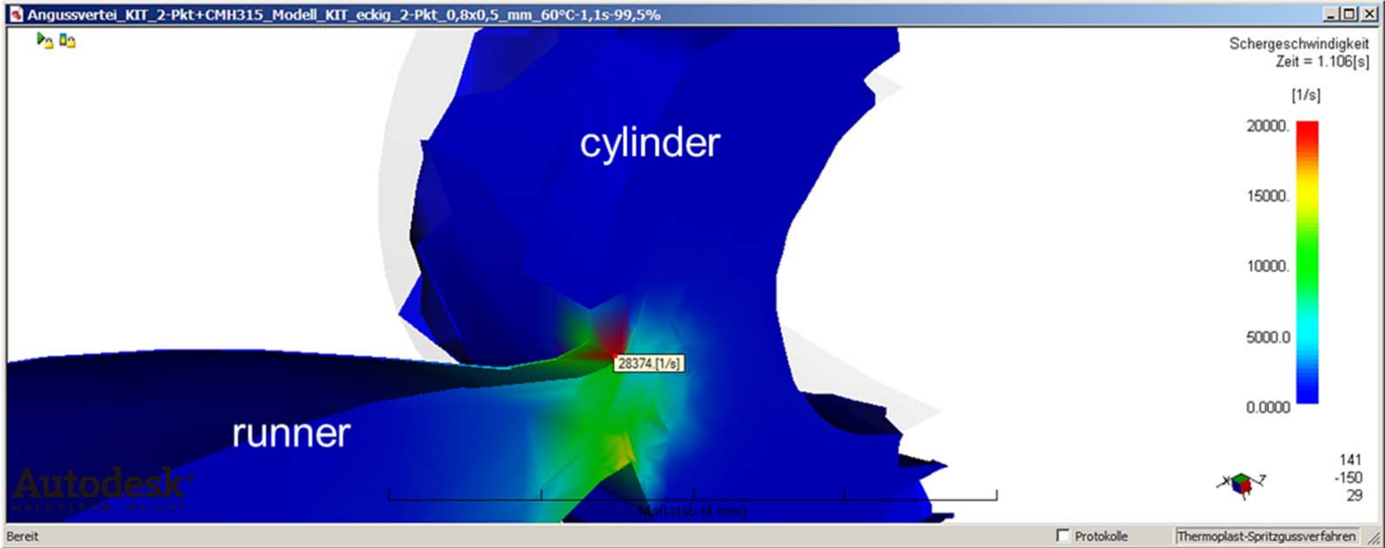
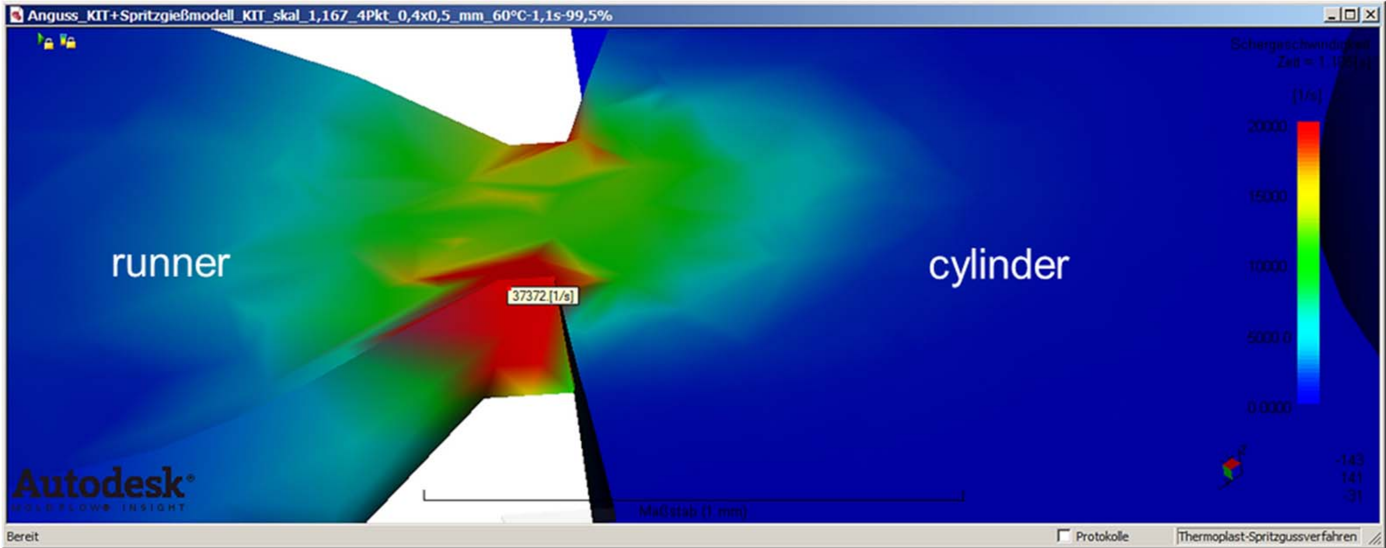
Filling simulation

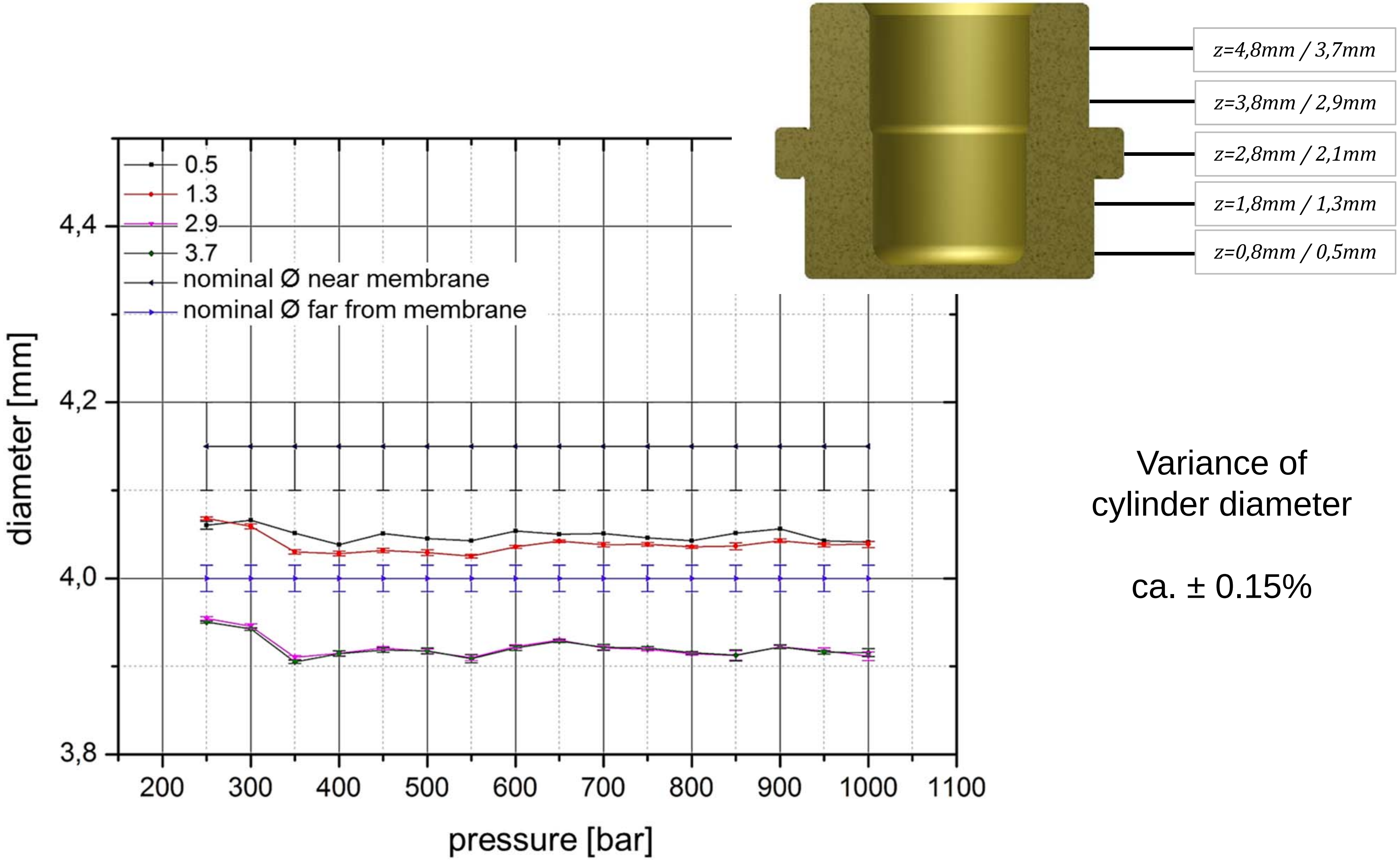
determination of critical shear rates





→ acceptable shear rates

Accuracy of unaltered PIM



Variance of cylinder diameter

ca. ± 0.15%

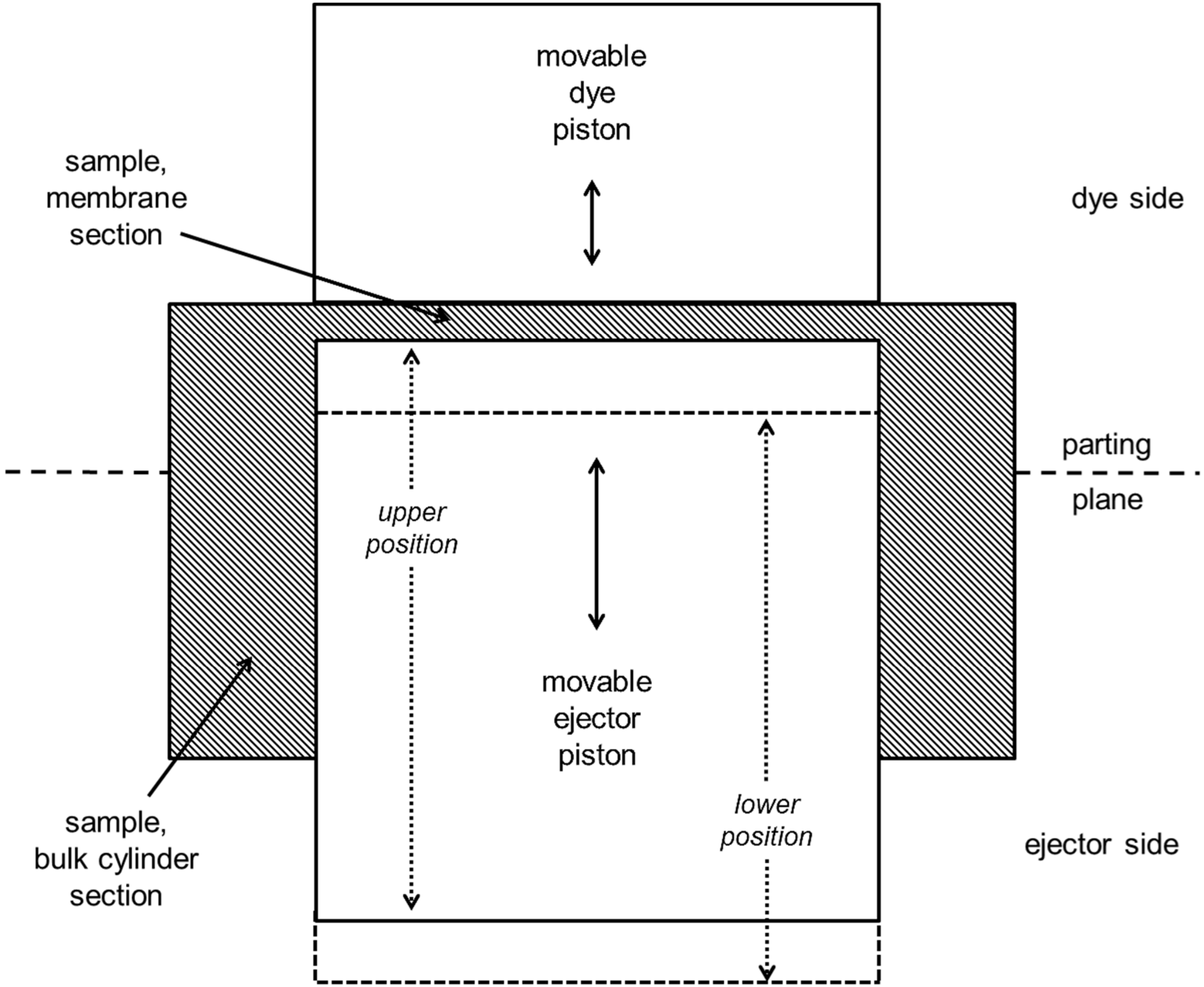
Process conduct

Process 1: Unaltered powder injection molding

- 63Vol% 17-4PH feedstock
- filling simulations
- constancy of cylinder diameter ca. ± 0.15%
- minimum membrane thickness ca. 400µm

Process 2: Powder injection molding + embossing step

» *pull back the pistons*
» *filling this cavity by injection of feedstock*
» *push the pistons forward up to final membrane thickness*

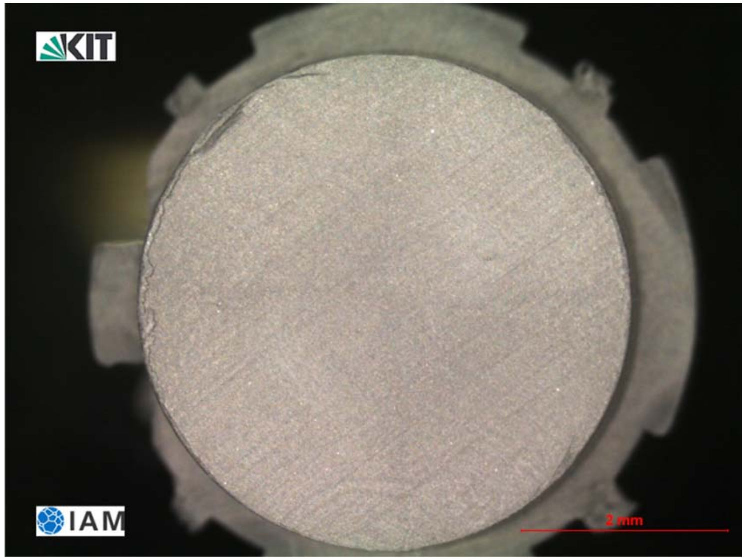

movable
dye
piston
sample,
membrane
section
dye side
parting
plane
upper
position
movable
ejector
piston
lower
position
sample,
bulk cylinder
section
ejector side

Minimum membrane thickness

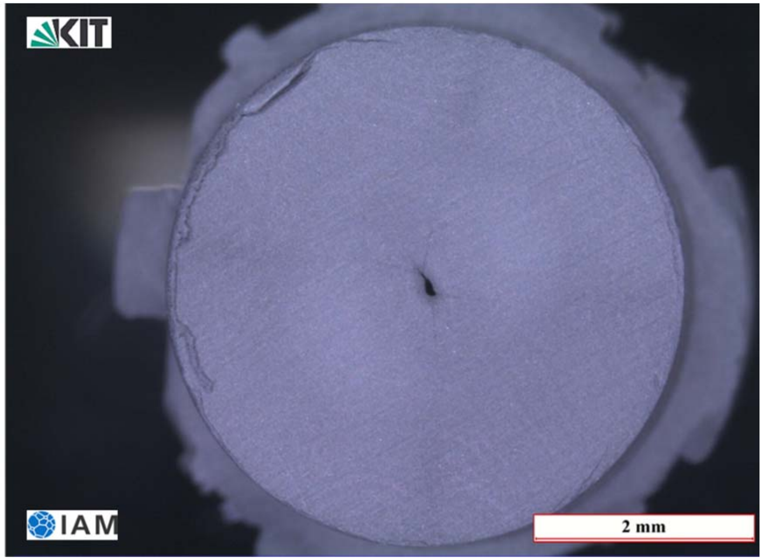
Reduction of membrane thickness due to PIM + embossing process

Variation of main parameters: embossing force, gap width,
and embossing delay time

Classification (from 1 to 5) of molded membrane carriers



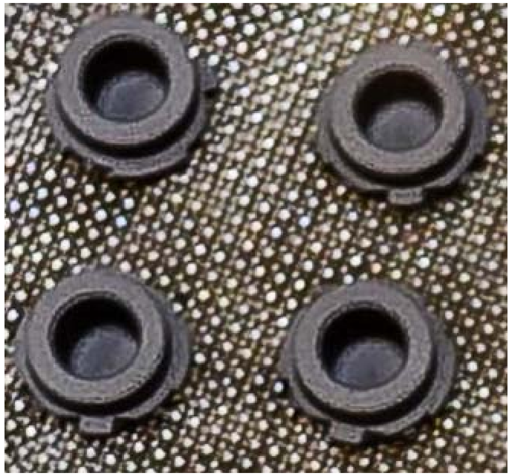
Class 1 sample: no visible failures



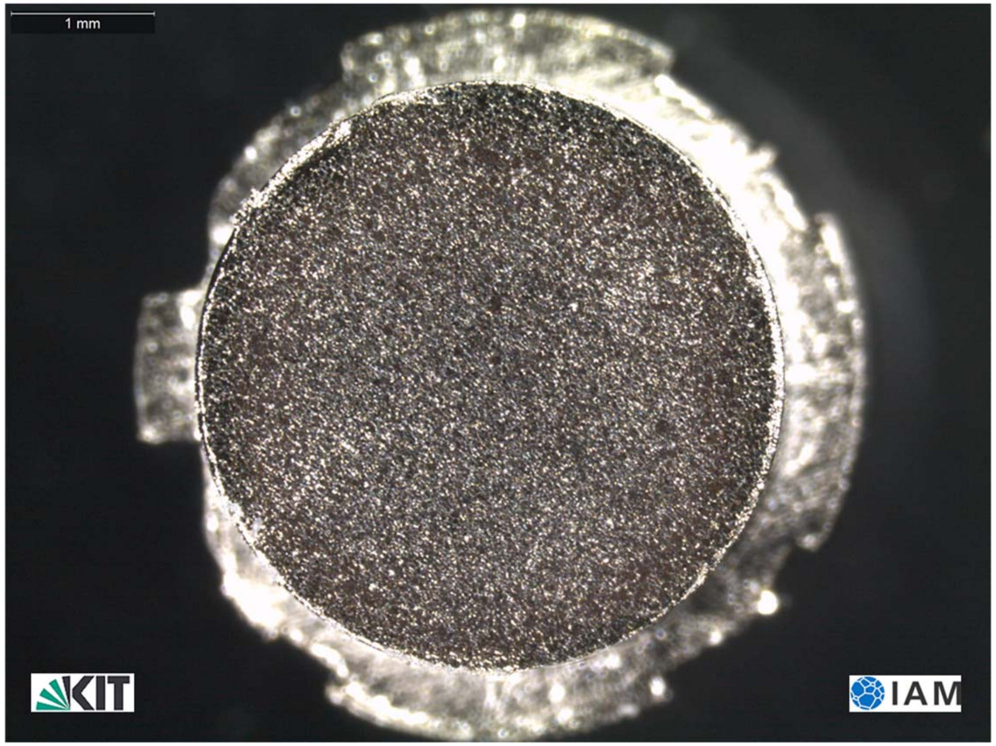
Class 5 sample: clearly visible voids

Thermal treatment

membrane carriers before debinding



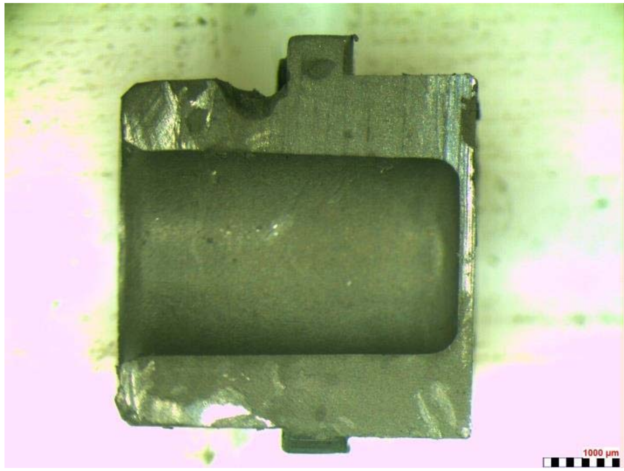
class 1 sample after sintering



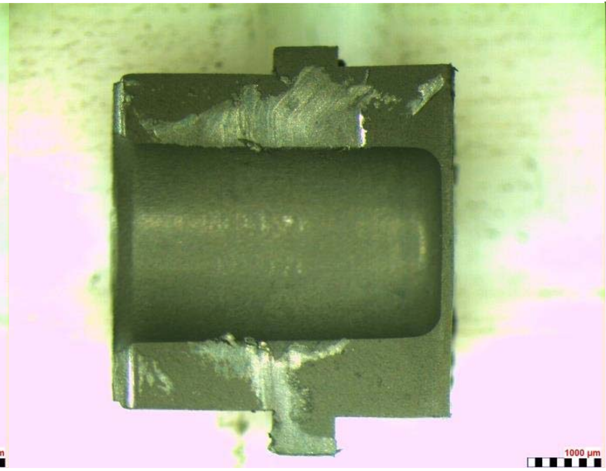
Minimum membrane thickness
≤ 200µm

Constancy membrane thickness
± 0.4%

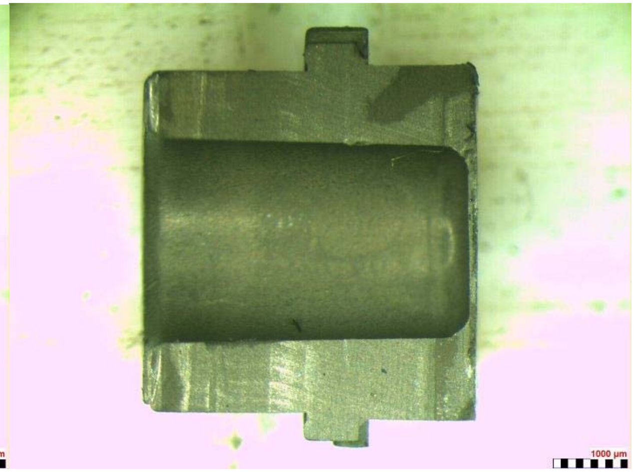
Further reduction of membrane thickness



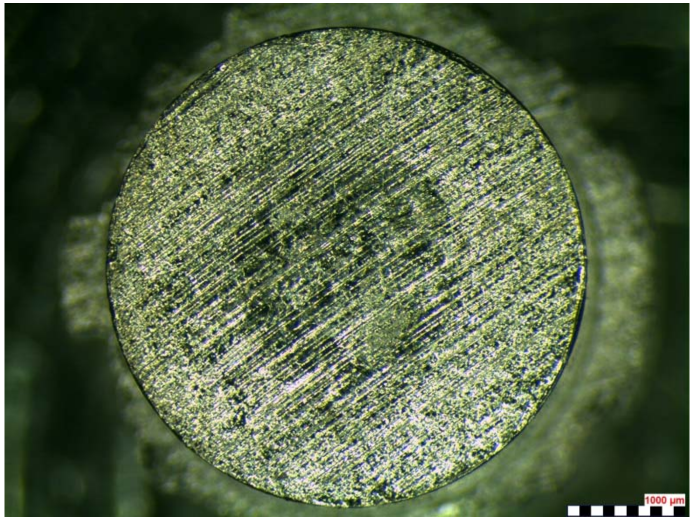
200µm



150µm



100µm



Sintered sample
thickness ca. 90µm
feedstock sticks on piston top

Outlook

PIM + embossing process

- increase powder loading → 67Vol%
- improve powder composition (bi-modal)
- improve piston movement
- avoid feedstock-wall adhesion

Simulation of PIM

- jetting, powder-binder segregation etc.
- simulation of embossing step ↔ powder pressing

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Forschungszentrum Karlsruhe
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Thank you !