Powder Injection Moulding of Multi-Material Devices

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- Two-component-PIM
  - Material combinations
  - Assembly-PIM
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Driving Forces for Multi-Material PIM

Economical Objectives	Technological Objectives
create high value-add products	create innovative products with properties profile
reduction of assembly expenditure	
low costs in large and medium series production	
equipment based on established 2C-machinery	

Multimaterial Devices

=> Multifunctional Products

with complimentary or contradictionary properties, e.g.

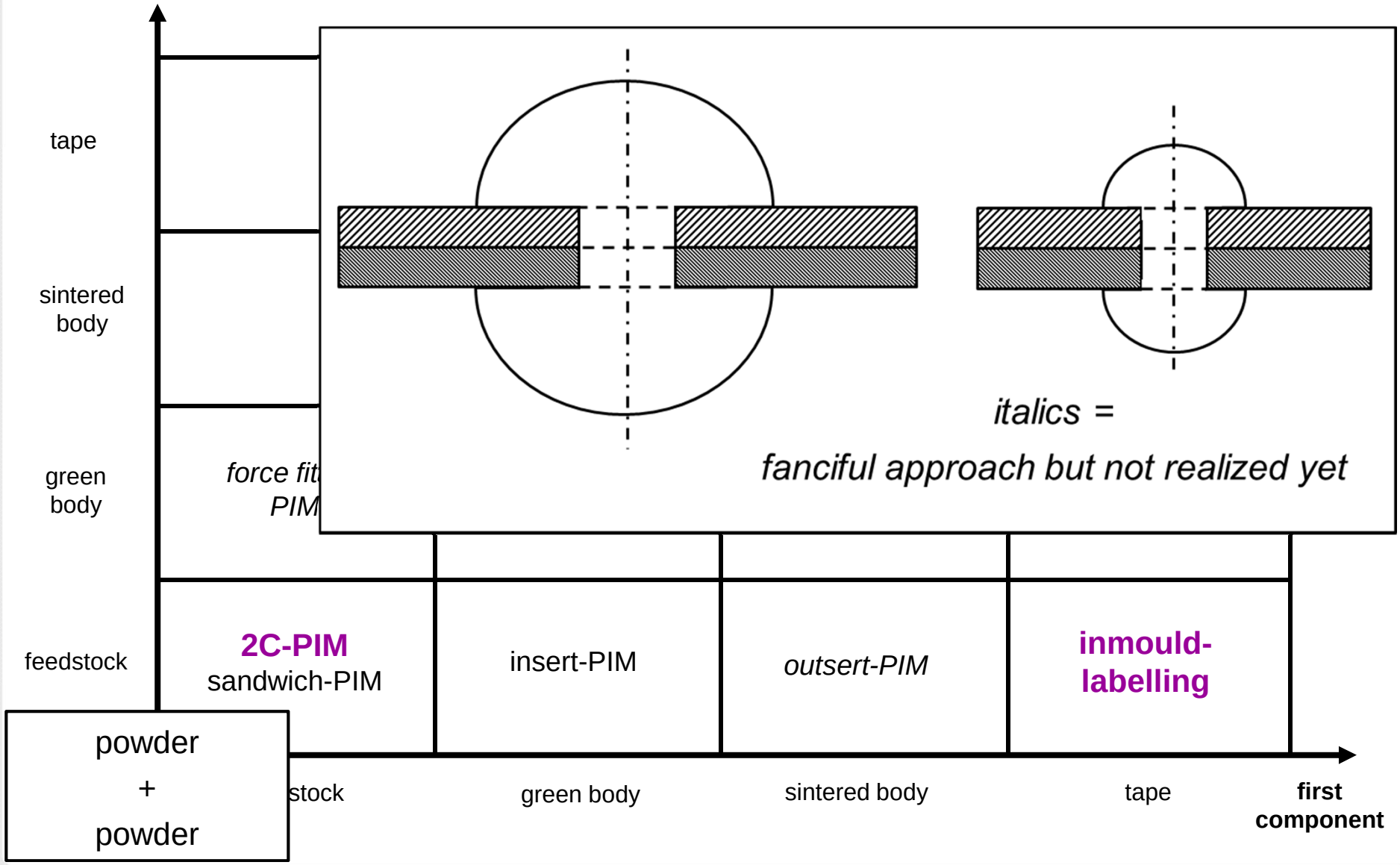
conductive	↔	**insulating**
hard	↔	**tough**
magnetic	↔	**non-magnetic**
hydrophilic	↔	**hydrophobic**
dense	↔	**porous**

etc.

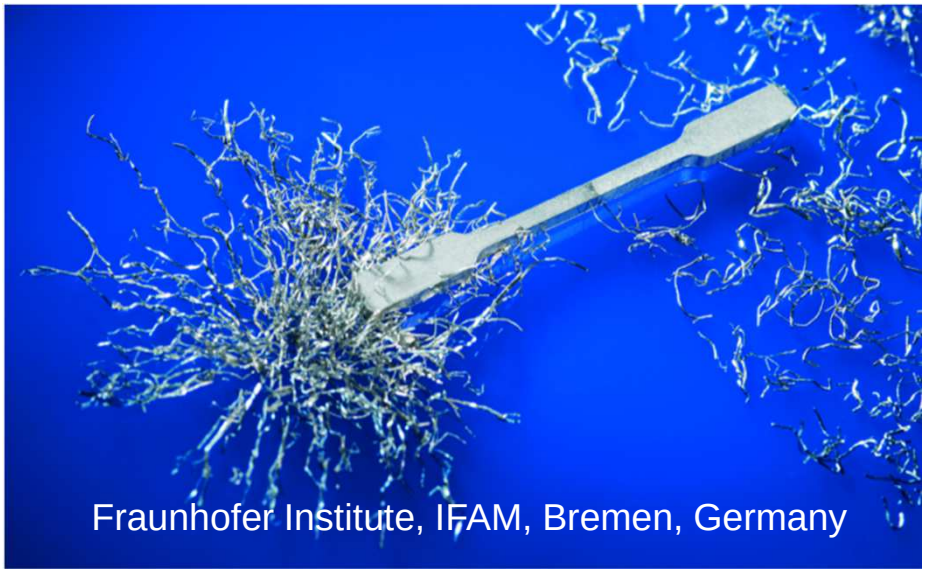
Driving Forces for Multi-Material PIM

Economical Objectives	Technological Objectives
create high value-add products	create innovative products with properties profile
reduction of assembly expenditure	strong and tight material connections
low costs in large and medium series production	several sub-variants of basic process
equipment based on established 2C-machinery	

Multi-Material PIM



2-Component PIM (Overmoulding)

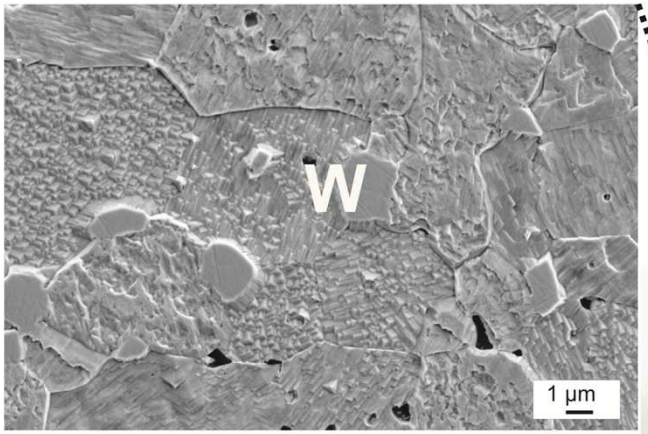


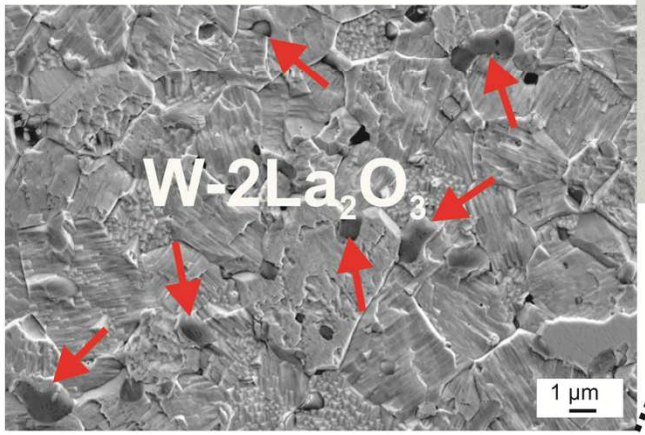
Combination of a magnetic steel (17-4PH)
with a non-magnetic steel (316L)

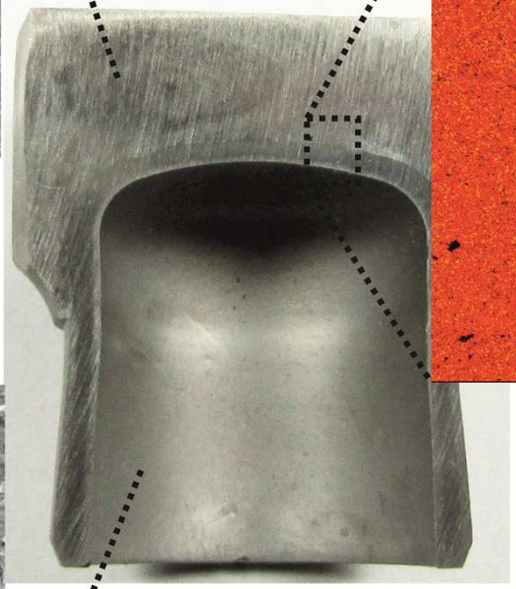
Hard metal WCxCo with different
Co-contents (16% and 6%)
ARBURG

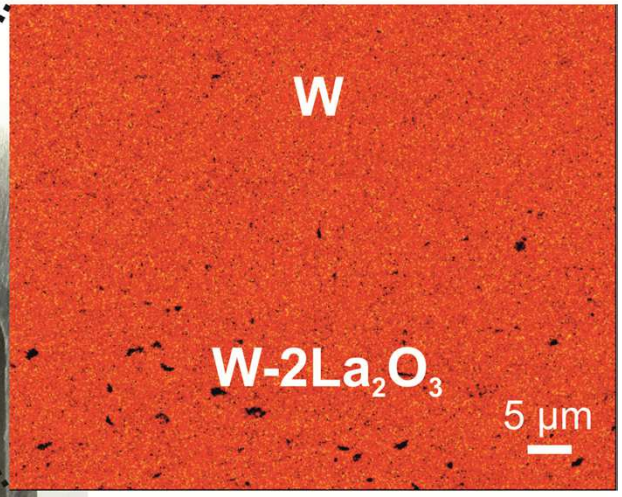
2-Component MIM, steel
AMT, Singapore

2-Component Tungsten PIM (2C-WPIM)









AES Map

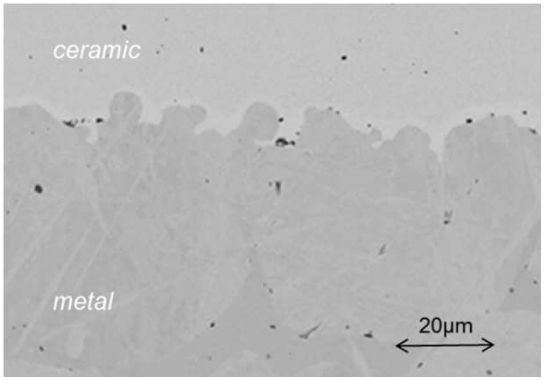
black: La_2O_3
red: W

Only presintering!

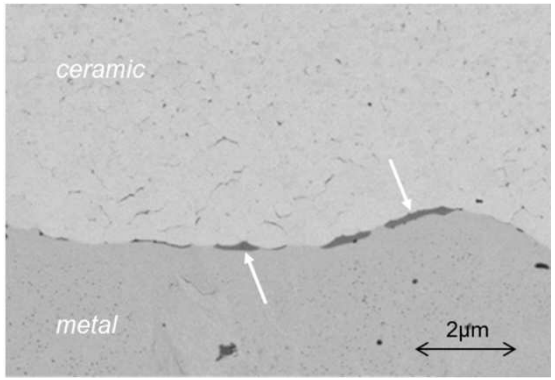
Combine different Material Classes

Fixed connection of metal (steel 430L) and ceramic (ZrO_2)

BSEM images of the interface of ceramic (ZrO_2) and metal (steel 17-4PH) samples
Courtesy of Fraunhofer Institute IKTS, Dresden, Germany

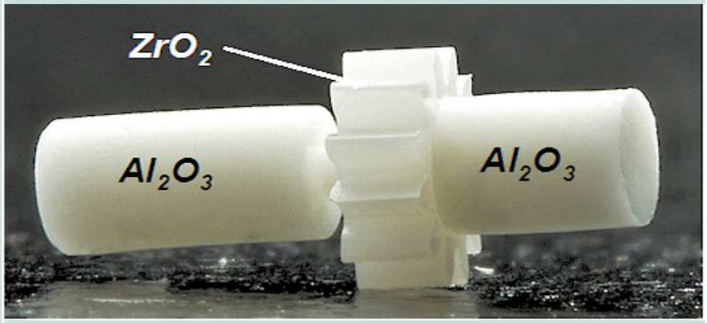
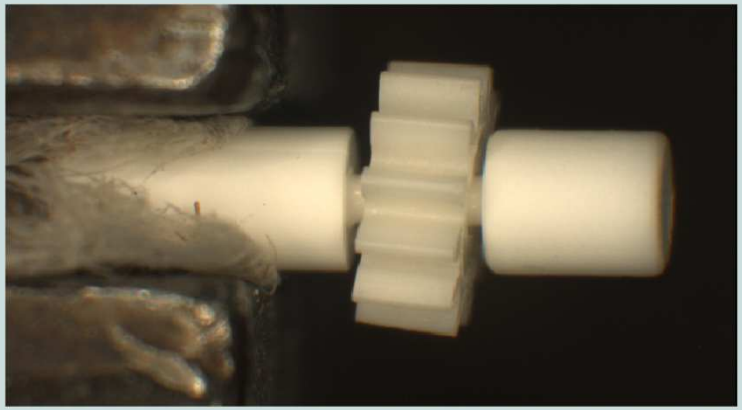


microscopic interlocking structure supported by a partial material bond



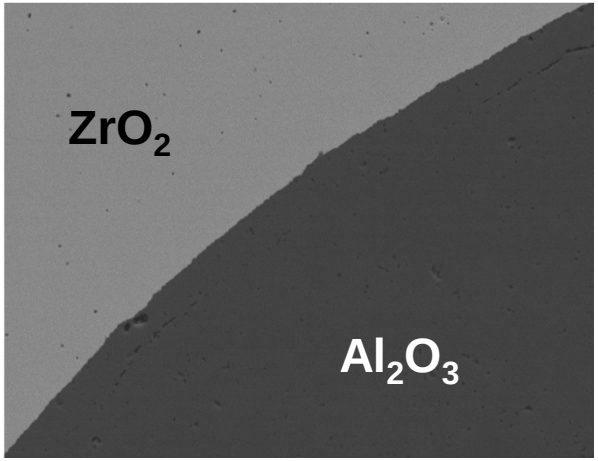
intermediate phase can be detected (white arrows)

Assembly Powder Injection Moulding

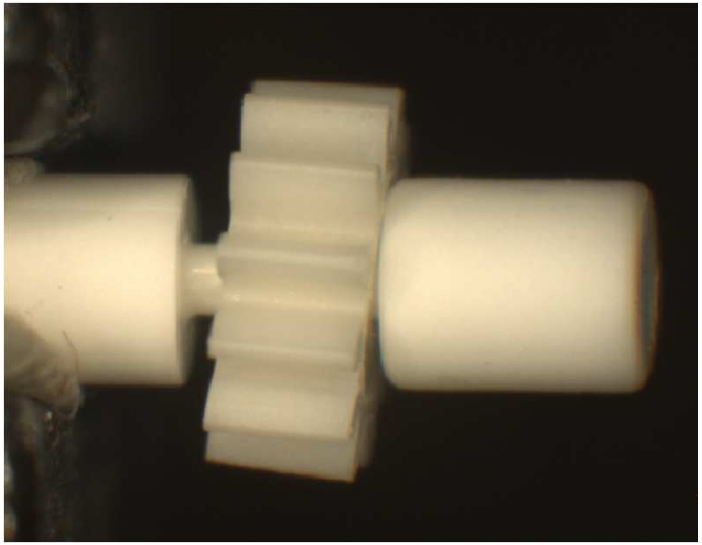
connection	fixed	movable
binders	compatible	not relevant
powder loading	nearly equal	$\varphi_{outside} > \varphi_{inside}$
sintering-T	nearly equal	$T_{outside} > T_{inside}$
CTE	nearly equal	nearly equal
		

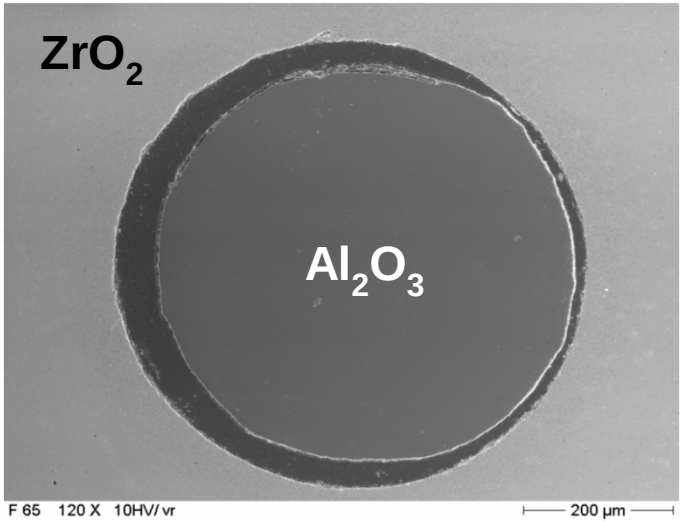
Assembly Powder Injection Moulding

Fixed connections of different ceramics



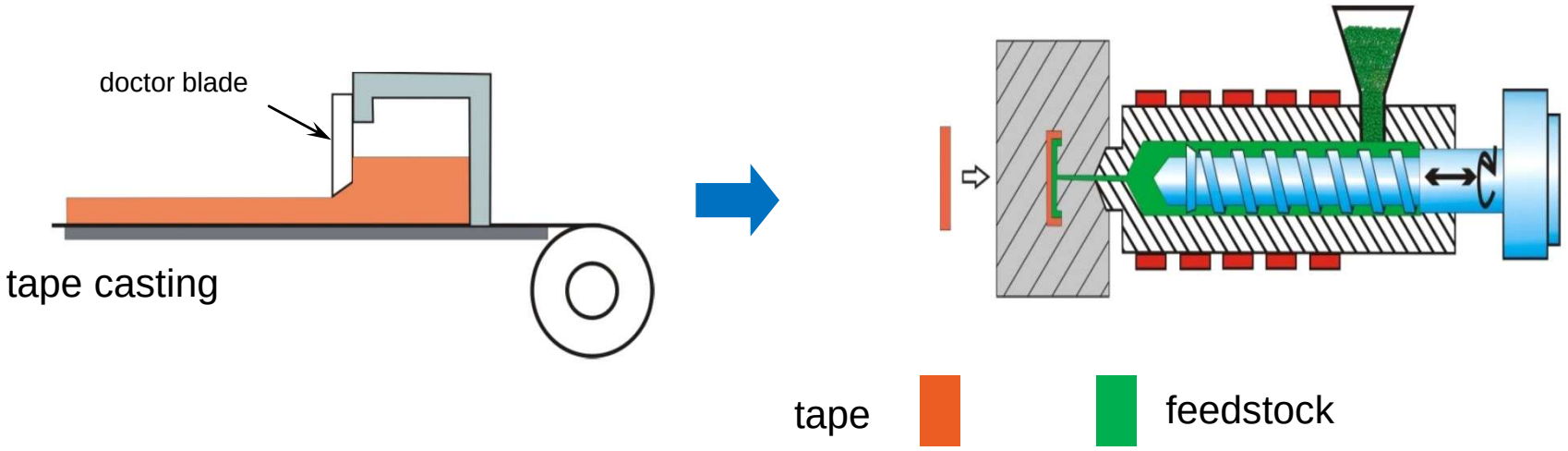
Realisation of movable connections





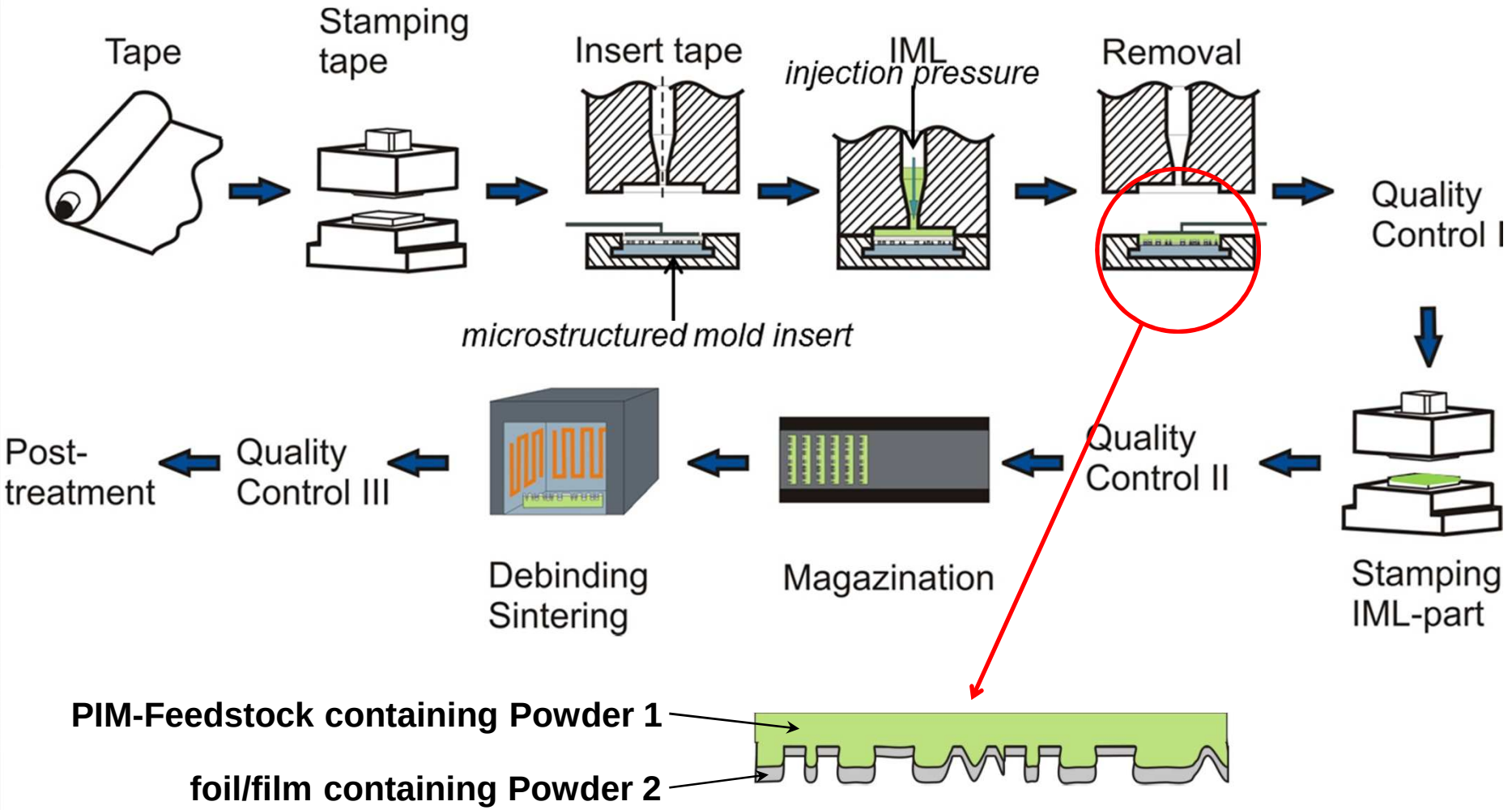
PIM green bodies + non-PIM green bodies

Powder Inmould-labelling (IML-PIM)



EU Project No. FP7-NMP4-2007-214122

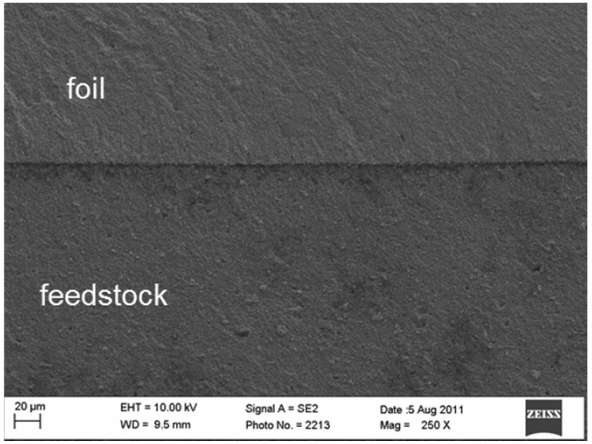
Micro Powder Inmould-labelling



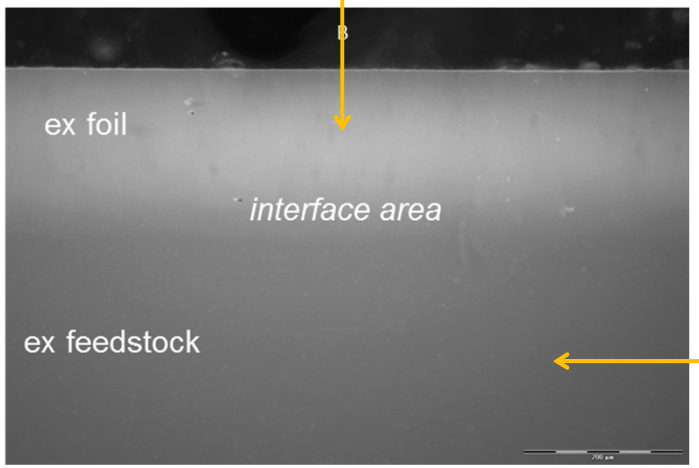
Powder 2: functional or nano-particles applied on the structured surface

Investigation of samples

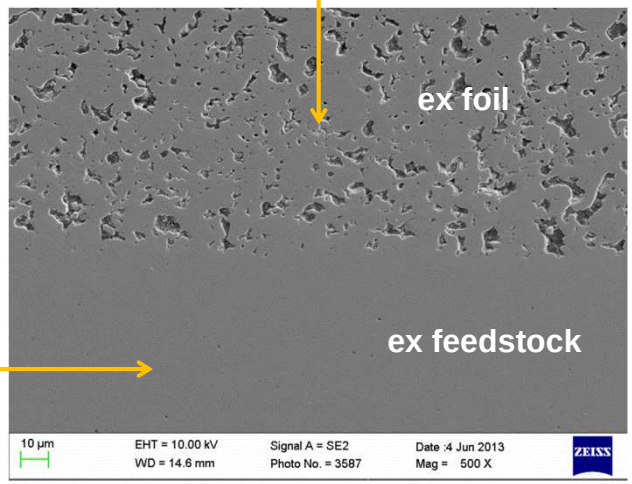
green body



ca. 53Vol% ZrO_2
70nm



ca. 50Vol% ZrO_2
40nm



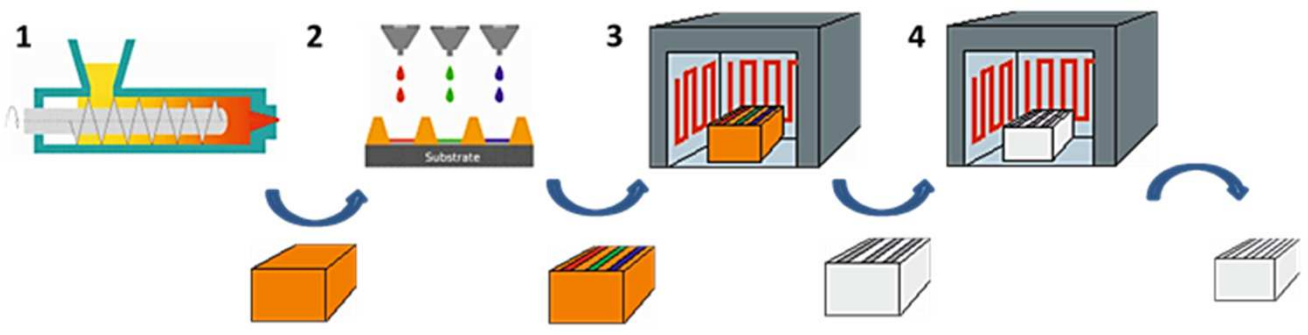
ca. 50Vol% ZrO_2
440nm

Hybrid Process Combinations

PIM green bodies + non-moulded materials

PIM + Additive Manufacturing

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



Combining the advantages of

PIM (high throughput) + AM (customized complex parts)

Summary and Outlook

- **Benefits of Multi-Material PIM**

  economical and technological

- **Possibilities of Process Combinations**

  ideas and realized approaches

- **Examples for Material Combinations**

  2C-WPIM, metal/ceramic joints

- **Current focus on Two-component PIM**

  inmould-labelling PIM

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