Powder Injection Moulding of Multi-Material Devices

V. Piotter, E. Honza, A. Klein
T. Mueller, K. Plewa

Karlsruhe Institute of Technology (KIT)
Institute for Applied Materials (IAM-WPT)
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<tr>
<th>Economical Objectives</th>
<th>Technological Objectives</th>
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<td>create high value-add products</td>
<td>create innovative products with properties profile</td>
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Multimaterial Devices

=> Multifunctional Products

with complimentary or contradictory properties, e.g.

- conductive $\leftrightarrow$ insulating
- hard $\leftrightarrow$ tough
- magnetic $\leftrightarrow$ non-magnetic
- hydrophilic $\leftrightarrow$ hydrophobic
- dense $\leftrightarrow$ porous
- etc.
# Driving Forces for Multi-Material PIM

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<td>create high value-add products</td>
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<td>reduction of assembly expenditure</td>
<td>strong and tight material connections</td>
</tr>
<tr>
<td>low costs in large and medium series production</td>
<td>several sub-variants of basic process</td>
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Multi-Material PIM

force fitting PIM

2C-PIM sandwich-PIM insert-PIM outsert-PIM inmould-labelling

powder + powder

powder

first component

tape

sintered body

green body

feedstock

italics = fanciful approach but not realized yet
2-Component PIM (Overmoulding)

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

Fraunhofer Institute, IFAM, Bremen, Germany

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

2-Component MIM, steel
AMT, Singapore
2-Component Tungsten PIM (2C-WPIM)

Only presintering!

AES Map
black: La$_2$O$_3$
red: W
Combine different Material Classes

Fixed connection of metal (steel 430L) and ceramic (ZrO₂)

BSEM images of the interface of ceramic (ZrO₂) 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

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<th>connection</th>
<th>fixed</th>
<th>movable</th>
</tr>
</thead>
<tbody>
<tr>
<td>binders</td>
<td>compatible</td>
<td>not relevant</td>
</tr>
<tr>
<td>powder loading</td>
<td>nearly equal</td>
<td>$\varphi_{\text{outside}} &gt; \varphi_{\text{inside}}$</td>
</tr>
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<td>sintering-T</td>
<td>nearly equal</td>
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![Image of assembly powder injection moulding](image-url)
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)

dr. blade

tape casting

tape

feedstock

EU Project No. FP7-NMP4-2007-214122
Micro Powder Inmould-labelling

- Tape
- Stamping tape
- Insert tape
- IML injection pressure
- Removal
- Quality Control I
- Quality Control II
- Quality Control III
- Post-treatment
- Magazination
- Debinding Sintering
- PIM-Feedstock containing Powder 1
- foil/film containing Powder 2

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

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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- All colleagues at KIT

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