In-mold Labeling Micro Powder Injection Molding: Large Scale Production of Micro Structured Two-component Parts

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multi layer

MIM 2012

Outline of the talk

I. Introduction and Motivation
II. In-mold Labeling Micro Powder Injection Molding (IML-µ-PIM)
III. Performing of IML-µ-PIM
IV. Reproduction of micro structures
V. Debinding and Sintering
VI. Summary and Outlook

Introduction and Motivation

Advantages of multi component shaping methods:

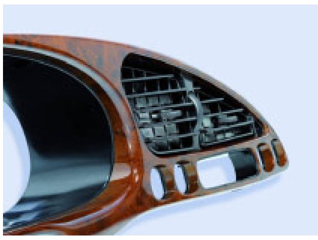
- Reduction of handling and assembly expenditure
- Reduction of plant costs
- Combination of different materials, for example:
  - → multi colour products
  - → electrical conductivity/electrical insulation
  - → hardness/toughness
  - → magnetic/non-magnetic
  - → fixed/movable connection
- Many possible applications in different sectors (bio-/medical, IT, micro system technology, etc.)

Introduction and Motivation

In-mold labeling (IML) process well known in packaging industry

Ice packaging
source: www.plastech.biz

Yoghurt cup
source: Volpini Verpackungen GmbH Austria

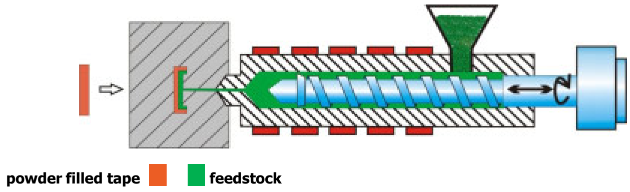


automobile industry
Control penal
source: HOFMANN innovation group

E. Honza - In-mold Labeling Micro Powder Injection Molding

Introduction and Motivation

Combination of IML Technique with Powder Injection Moulding (PIM)

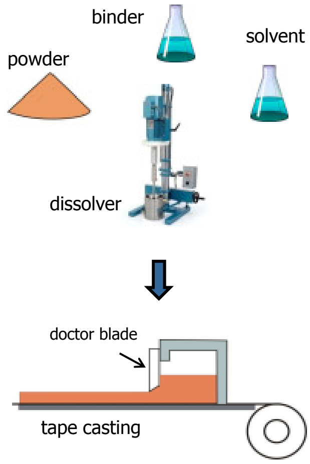


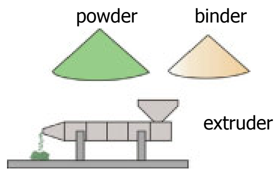
Possible application of colored and/or structured ceramic IML-parts:

- For additional structuring and/or refining of surface
- Haptic reception, resistant to abrasion, durable parts
- Nano-particles applied on the structured surface:
  better contour accuracy,
  higher surface quality,
  functional properties etc.

In-mold Labeling Micro Powder Injection Molding

Production of tapes and feedstock



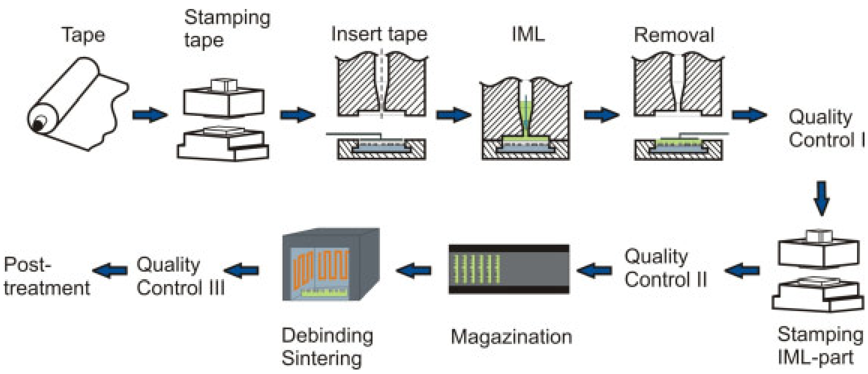


Requirements for multi component ceramic parts:

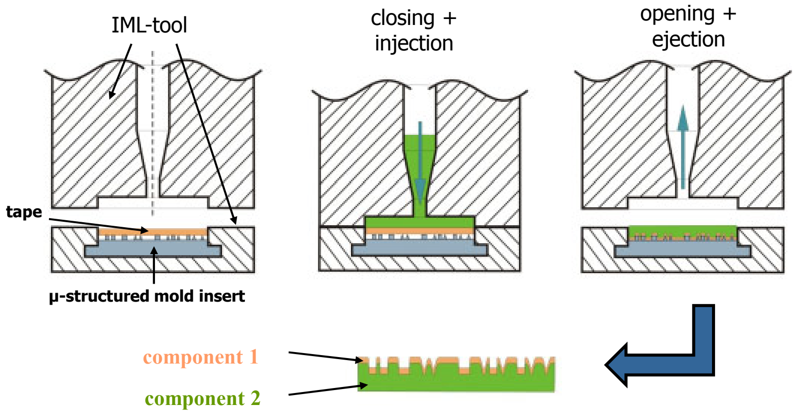
- Compatible binder systems with comparable thermal expansion behaviour
- Selected powders with similar sintering behaviour:
  → Comparable absolute shrinkage values and rates during sintering
  → Comparable sintering temperatures and gas atmosphere

In-mold Labeling Micro Powder Injection Molding

→ Process chain contains several challenging fabrication procedures

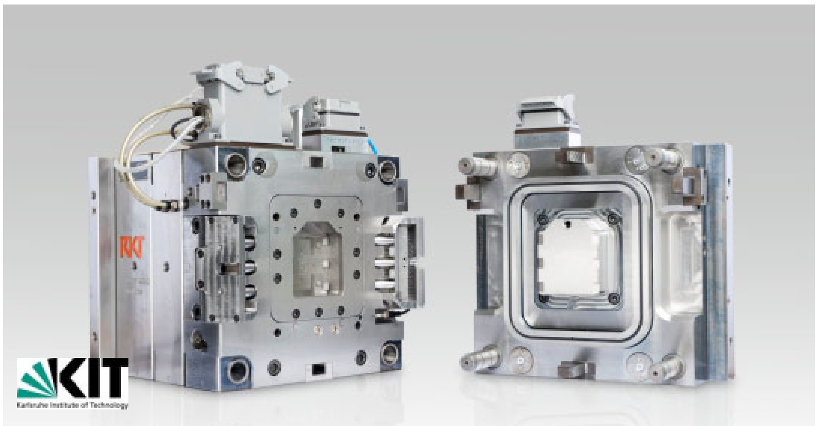


In-mold Labeling Micro Powder Injection Molding



Performing of IML-μ-PIM

Tool concept combines Powder Injection Molding (PIM) with micro replication features (e.g. variothermic process control) and IML-process

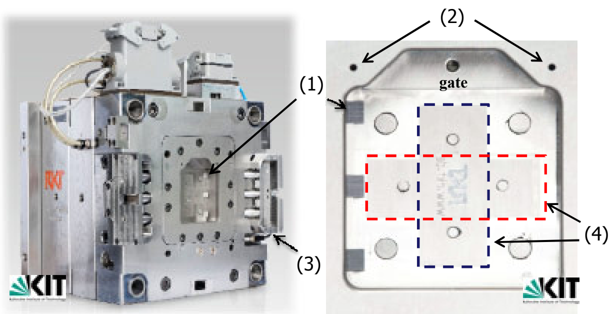


Performing of IML-μ-PIM

Features of the tool:

(1) Fixing of tapes/labels with blank holders
(2) Vacuum system
(3) Variation of tape thickness between 0.1 and 1mm
(4) Variation of mould insert position (parallel & cross to flow direction)

➢ In addition: three different thicknesses of the parts (1.5 mm, 1.9 mm and 2.4 mm)



Performing of IML-μ-PIM

- Filling study (PE-tapes and PE as molding compound)

Good results without defects and good analogy to pure injection molding

- ZrO_2 tapes (thickness: 300μm) and ZrO_2 feedstock

Ceramic IML- parts with size of 80x80mm² and thickness of approx. 1.8 mm

Performing of IML-μ-PIM

The selection of appropriate process parameters is critical for the realization of defect-free IML-μ-PIM parts

- Injection speed: with low injection speed deformation of parts and air entrapment between tape and feedstock

Performing of IML-µ-PIM

Tool temperature:

- Increase of the tool temperature results in adhesion between tool and tape and in (partial) damage of the parts
- Decrease of the tool temperature results in better planarity of parts

Tool temperature: 60 C

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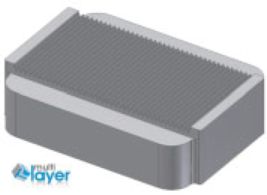
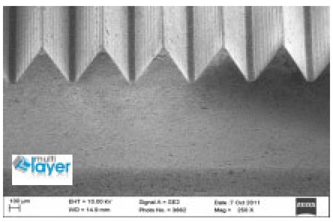
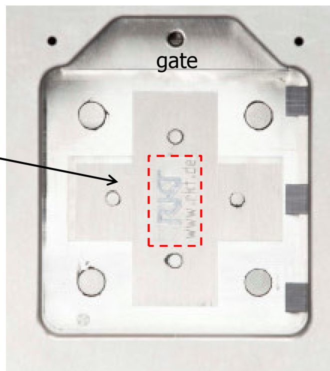
Reproduction of micro structure

Micro structured tool insert







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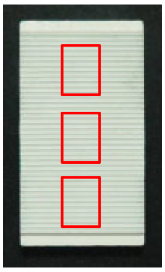
Reproduction of micro structure

Investigation of the influence of process parameters on the reproduction accuracy:

Process parameter	value
Tool temperature [°C]	40-50-60
Injection speed [mm/s]	48-52-56
Holding pressure [bar]	430-550-650-850



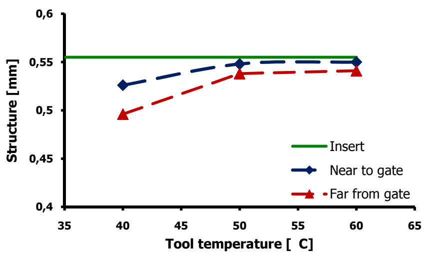
Measuring of reproduction accuracy:

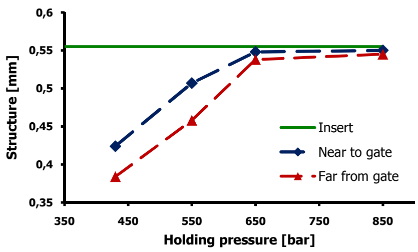
- Near to the gate
- Far from the gate
- Middle of structure

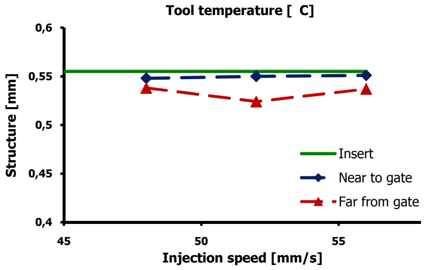
Reproduction of micro structure

Measuring of reproduction accuracy:

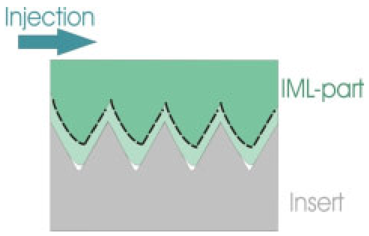
- Near to the gate good reproduction
- Decline of structure accuracy with distance from the gate



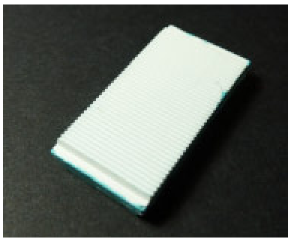


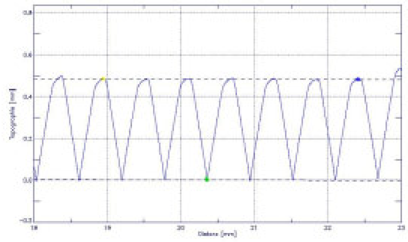


Reproduction of micro structure



Flow behavior of the feedstock and the behavior of the tape especially away from the gate identifiable





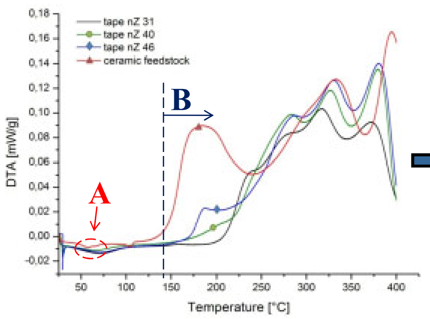
Debinding and Sintering

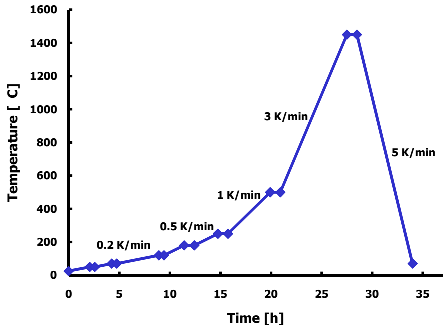
Preparation of debinding routes:

- Debinding process quite often combination of solvent and thermal debinding
- Thermal analysis (DSC, TG, DTA) provide the necessary data for several binder components

<u>The final debinding route has to consider the thermal behaviour of the components</u>

Debinding and Sintering





DTA investigations → Search for suitable process parameters:

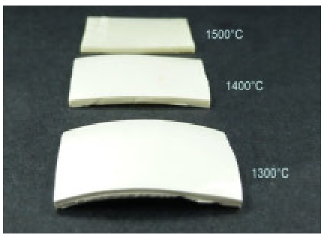
- Melting point of wax between 50 to 70 C (**A**) → low heating rates
- At a temperature of approx. 150 C the decomposition of the remaining binder components starts (**B**) →increasing of heating rates

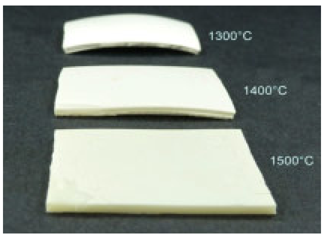
Debinding and Sintering

Sintering routes:

- Starting with materials of similar shrinkages at comparable temperatures

  → avoid the deformation of parts



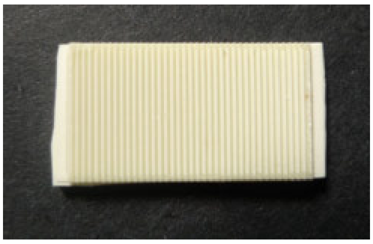


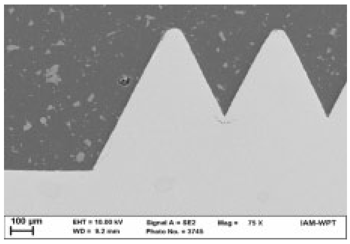
- Starting with materials of similar thermal behaviour (thermal expansion coefficient)

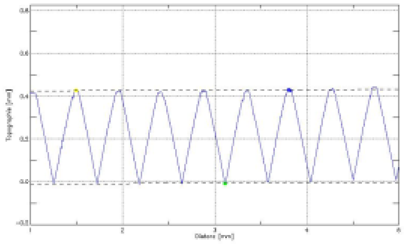
  → production of crack free multi component parts

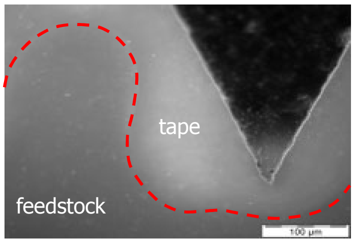
Debinding and Sintering

Shrinkage of structure ~ 21%









Summary and Outlook

- Realisation of IML-µ-IML technique using powder materials is possible
- Combination of materials with different properties
- Adjustment of materials essential
- Further investigations of process parameters and of accurate reproduction of complex structures

- Presented investigations part of Large-scale integrating project MULTILAYER (Grant agreement no.: 214122-2)
- Acknowledgement: Fraunhofer Institute for Ceramic Technologies and Systems(IKTS) in Dresden (provider of ceramic tapes)