Metal Injection Molding (MIM) of components made of Titanium and its alloys
Presentation content

• Introduction to Metal Injection Molding (MIM)

• Technology - explanation

• Products - examples

• Company – brief overview

• Conclusion

• Contact information
Introduction

MIM Production process - schematic

→ secondary Hot Isostatic Pressing (HIP) to eliminate porosity is optional
MIM Utilization

Source: MIM Expertenkreis

Matthias Scharvogel, Managing Director, Element 22
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MIM overview

• Parts are Net Shape → expensive material that are difficult to form / machine
• High quality surface finish possible
• Parts are absolutely clean with no burrs
• Significant cost advantage → high volume production of complex geometries
• Less Energy and Material usage → clean sustainable technology
• Additional design advantages → avoid joining parts
• Additional design advantage → Titanium - Ceramic bond

• Cost driver: Injection molding tool required
• Cost driver: Titanium powder → need for next generation (meltless ?) powder
MIM Titanium feedstock

- Feedstock manufactured in house
- Feedstock can be adjusted according to product design / application
- Ti powder particles shape and size tailored to product design / application
- Several approved sources for feedstock ingredients
- Feedstock homogeneity and repeatability are key!
Titanium MIM Materials

- Commercially Pure (CP) Titanium
- Titanium Aluminum Vanadium alloy: Ti 6Al 4V, Ti 3Al 2.5V, Ti 6Al 4V 0.5B
- Titanium Aluminum Niobium alloy: Ti 6Al 7Nb
- Titanium Aluminides possible e.g.
  Ti 47Al 4(Mn, Cr, Nb, Si, B), Ti 45Al 5Nb 0.2B 0.2C
- Other Ti based alloys possible (e.g. Nitinol)
- Alternative Ti alloys under development
Ti6Al4V
chemical and mechanical requirements


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example: implantable port
complex shape

- Undercut can be achieved
- Parts are “net shape”
- Injection gate not visible
- Parts with varying wall thickness can be achieved

Through hole Ø 0,4mm (0.016”)
example: implantable port system
saving assembly

no 2nd operation needed
surface finish

- Colouring by anodising
- Tumbling
- Shot peening
- Electro polishing
- et al
example: custom screw

- Custom screw with outside thread
- O.D. 3mm
example: custom gear

- Rotating gear
- Light weight
- Complex shape
example: commercial airplane fasteners

- Inside / outside thread possible
- Strength and ductility are key

CAD-animated

"as sintered"

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example: housing for implants

- Many design options available
- Material thickness down to 0.2mm (0.008”)
- Helium leak test → hermetically tight
- Hot Isostatic Press (HIP) optional
example: nozzle with hollow space

→ Element 22 uses several different technologies available for creating undercuts
example: implantable valve ring

- Complex shaped part
- High cost savings
- Challenge: sintering
example: frame & switch

- Complex shaped parts
- High surface finish requirements
small parts: overview

- Small parts in serial production with down to 0.037 gram
- Tolerances depend a lot from the desired geometry of the sinter part
- Tolerances below 0.02mm (0.0008”) can be achieved
- Wall thickness down to 0.1mm (0.004”)
- Inside and outside thread possible

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small parts: screw
small parts: inside thread
advanced Processes
porous structure / coatings

- Different processes available
- Material and porosity can be adjusted

porous structure, spherical powder
porous structure, irregular HDH powder
advanced Processes
Titanium Ceramic bond

- Titanium and Ceramic are co-sintered
- Titanium and Ceramic connected through shrinkage while sintering
- No additives needed to create bond
- Excellent connection

Titanium – Ceramic gear, front view
Element 22 GmbH

• Production facility located in Kiel, Germany – about 100 KM north of Hamburg

• Focus on Medical and Commercial Aerospace Industry

• Core technology is Powder Metallurgy (MIM) of Titanium

• Thin walled Ti6Al4V Super Plastic Formed (SPF) cases in product portfolio

• Running high volume Metal Injection Molding (MIM) production → Net Shape!

• Production facility is dedicated to Titanium and its alloys
Quality and regulations

• QS Certification by TÜV SÜD: ISO 13485 and ISO 9001

• ASTM F2885 published in 2011 for Ti6Al4V for surgical implants

• ASTM F standard for CP Ti targeted for 2012

• Ti MIM parts with approval to implant in Europe, Asia, and South America in 2011

• First Ti MIM part with FDA approval to implant in USA in 2011
overview of tests performed

• Over 1,000 tensile tests - different powders / alloys, surface finish, density, microstructure, gas content

• Chemical composition – many different lots

• Density - different methods like cross section or Archimedes principle

• Fatigue - 4 point bending, different surface, density, microstructure

• Tests on actual components - geometric capabilities, impact resistance on housings, notch impact

• Biocompatibility, toxicity, etc. - CP Ti and Ti6Al4V

• Friction and abrasive - under physiological conditions

• Stress corrosion cracking

• Weldability – several processes

All investigations were carried out in house and close collaboration to reknown Universities, Institutes and laboratories:

• Helmholtz Forschungszentrum GKSS, Geesthacht
• Fraunhofer IFAM, IPA, IWM, Bremen, Stuttgart, Munich
• BSL BIOSERVICE Scientific Laboratories, Munich

• CA University, Kiel
• GFE Fremat, Freiberg
• et al

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conclusion

- Net Shape Titanium MIM process is running in high volume production
- MIM process offers cost, but also design advantages
- Technology transfer and feedstock supply possible
- First ASTM standard for implantable applications published, more to follow
- Challenge: designes to understand design possibilities through MIM process
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