New materials and customizing of properties by powder technology

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OUR PRODUCTS

THIN FILM MATERIALS
Sputter targets with Customized Composition and Geometries
Technology Consulting
Manufacturing Partnerships

POWDER INJECTION MOULDING
Ceramics, Metals and Composites
Manufacturing Partner for in-house Production
Developments along the whole Process Chain

PROCESS AND MATERIAL DEVELOPMENT
from Powder to Bulk
by Fast Hot Pressing, Sintering, Injection Moulding and Additive Technologies
Tailored Processing, Services and Consulting

ADDITIVE MANUFACTURING
3D printer development for XXL Metal parts
Multi-Material Manufacturing
New Materials for printed Ceramics
What is it that materials & music have in common?

In music the base bricks are tones, in materials we count as such the elements of the periodic system. Combining them, we can invent and tune new music or materials!
Our „tones“ used for material developments ...

Not all „tones“ we CAN play on our instruments
Not all „tones“ we WANT TO play
We can combine a big variety of different „tones“
Several „tones“ do not sound harmonic, when played together
Some „tones“ can only played in combination with others. (e.g. O, N,...)
a single element – a row of elements together

- sounds „nicer“

- sounds „well“
For a material to sound excellent we do need in addition?

- The right instrument (process/machine)
- The right timing (speed)

... and now let’s talk TECHNOLOGY!

How to invent customized materials?
Step 1: POWDER MORPHOLOGY

- Gas atomized NiCr 80/20
- Water atomized NiCr 80/20
- Dendritic Cu
- Copper coated W

- Molten and broken Al2O3/TiO2
- Molen, broken and thermally annealed Cr2O3 Powder
- Agglomerated, sintered WC/Co 88/12
- Agglomerated, sintered Molybdänpulver
Step 2: MIXING and MICROSTRUCTURE

W-20wt%Cu „alloy“

Mixture with dendritic (electrolytic) Cu-powder

Mixture with fine, more spherical Cu-powder

CROSS SECTIONS AFTER COLD COMPATION AND FREE SINTERING:
Step 3: MANUFACTURING PROCESSES - „Instruments“

- Hot pressing
- 3D Printing
- Injection moulding
- Sintering
... A brief story about knowledge on instruments

Michael
INFLUENCE OF INSTRUMENTS ON MATERIALS

SLOW

FAST

STRUCTURE:  CORSE  FINE

Besides „pure elements“ we can use combinations like with Oxygen („Oxides“), Nitrogen („Nitrides“), Carbon „Carbides“), …

Applications e.g. „Sputtering targets“
PROCESSING OF MATERIALS BY DIFFERENT PARAMETERS

Influence of the mixing process

Influence of the hot pressing process
COMPARISON OF PROCESSING SPEED: Al-Cu

“Composite Structure”
- Hardness: 104 (HV5)
- Thermal Conductivity: 227 W/mK
- Easy to machine/ “ductile”

“Intermetallic Structure”
- Hardness: 631 (HV10)
- Thermal Conductivity: 83.7 W/mK
- Difficult to machine/”brittle”

Same raw material but different processing conditions (very fast densification vs. slow densification)
„TUNING“ of Material Properties
Matrix and Filler Materials:
- High thermal conductivity: 100 – 250 W/mK
- Customized thermal expansion: 6 – 10 ppm/K
- Easy to machine

Applications
- Housings for electronics
- Structural parts for advanced thermal management
ROTARY TARGETS and XXL PLANAR

Higher yield compared to planar targets
Process for ceramic rings developed
Stable process for high throughput coatings

XXL size targets for display coating

Boron Carbide rings used in special R&D applications like for neutron absorption and neutron reflection

TiB$_2$ Rotary Targets
Google, Samsung plan for the operation of large satellite constellations.

The RHP Module is responsible for Xe gas distribution to the satellite thrusters.

(Partner: AST)
NEW MATERIALS FOR JEWELRY – NIELLIUM

ALLURE
THOMAS HAUSER

NIELLIUM

Partner: Thomas Hauser
EDM CERAMICS

✓ Carbide ceramics modified for EDM machinability.
✓ Special techniques to join ceramics.
✓ Spark erosion and wire cutting is possible.
Metal Matrix Composites

Materials:
- Matrix: Al, Ti, Cu, Ag and their alloys
- Filler materials: Carbon-fibres, nanofibres, nanotubes or particles such as MoS2, WS2, graphite, diamond, SiC, Cu2O, ZrW2O8

Tailorable material properties:
- High thermal conductivity
- Low thermal expansion
- Low coefficient of friction
- Increased wear resistance
- Increased strength/stiffness

Applications:
- Heat sinks for electronic devices
- Self lubricating bearings and slip rings
- Lightweight high strength materials for automotive/aerospace

Cu-carbonfibre MMC  
Cu-Cu2O MMC  
Ti-Boron MMC  
CuSn-MoS2/Cf MMC  
Al-Diamond MMC
CuSn-Teflon composites

- Preparation of mixtures of CuSn+teflon
- Composites with 25, 40 and 50 vol% 
- Densification using 100 and 150 MPa at temperatures between 310 and 360 °C (melting point of teflon is 326.8 °C)
- Densification time: 60 s and 120 s
- Coefficient of friction for 40 vol% teflon: 0.2 (mean value)
CuSn-MoS$_2$ Composites

- Preparation of mixtures of CuSn+MoS$_2$
- Composites with 25, 40 and 50 vol% 
- Densification using 150 MPa at temperatures between 600 and 700 °C
- Densification time: 60 s
- Coefficient of friction for 40 vol% MoS$_2$: 0,18 (mean value)
High temperature oxidation tests of ZrB$_2$ composites

- Reduction of the grain size improves the oxidation resistance
- Reduced grain size results in high hardness of ca 24 GPa and a fracture toughness of 5.2 MPa m$^{1/2}$

Oxidation test at 1.500° C/1 hour

GRAIN SIZE REDUCTION

ZS2

75 µm

ZS1-2

28 µm

ZS3

20 µm
Densification of ZrB₂ based composites

Densification of powder mixtures by Rapid Hot Pressing; cycle time < 1 hour

Microstructure of ZrB₂-composite

Oxidation tests at T > 1.100°C
HOT WIRE EXTRUSION

- Pressing-Sintering (focus on high temperature ceramics)
- Gas Pressure Sintering (up to 2,200°C)
- Direct wire extrusion (up to high temp.)
- Liquid Phase infiltration of porous pre-forms
- Plasma Arc Deposition/Material Synthesis
Ongoing Material Developments

- Quasicrystalline materials
- MAX Phase materials
- High entropy alloys
- Bulk metallic glasses
- Coloured metals and ceramics
- PGM alloys
- Porous materials
SOME MORE INSTRUMENTS
XL SHAPE WELDING

3M System

4M System

ROB4M System

GREEN BODY PRINTING - SINTERING

Filament MEAM

Granules MEAM

Metal/Ceramic STL
MATERIAL DEVELOPMENT, PROCESS OPTIMIZING
4M SYSTEM (WIRE & POWDER ARC)

- in-situ Multi-Materials
- Material-Hybrides

Two compositions part

Ti+B4C

Ti

Stiffrod Ti Multi-Material (RHP)
Outlook: Multi-Material Structures

Hardness of S229

Indentation Height [mm]

Hardness/HV2

S229
4M SYSTEM (WIRE & POWDER ARC)
MATERIAL EXTRUSION AM (MEAM)
MATERIAL EXTRUSION AM (MEAM)

1. Compounding
2. Feedstock
3. Granulation
4. Injection Moulding
5. Green Part
6. Debinding
7. Sintering
8. Final Product
MATERIAL EXTRUSION AM (MEAM)

1. Compounding
2. Feedstock
3. Filament Spool
4. FFF 3D printing
5. Green Part
6. Debinding
7. Sintering
8. Final Product

FEEDSTOCK MIXTURE

FILAMENT OR. GRANULES-EXTRUSION
MATERIAL EXTRUSION AM (MEAM)
POWDER BED - SELECTIVE LASER MELTING (SLM)

Material-Hybrides compounds

source: Ch. Wallis et al. RAPID.TECH 2017
Abb. 3.6: a) erfolgreicher Aufbau einer Kühlstruktur auf einem Cu-MMC mit b) zugehöriger LIMI-Aufnahme der Bindezone Maraging Stahl/Cu-MMC.
LET US SUMMARIZE
SOLUTIONS IN POWDER TECHNOLOGY
MANUFACTURING CUSTOMIZED PRODUCTS

SPUTTER TARGETS
INNOVATIVE CERAMICS
CORE COMPETENCES

FUNCTIONAL MATERIALS AND INDIVIDUAL APPLICATIONS POTENTIAL BY COMBINING THE POSSIBILITIES OF POWDER

- Cu-carbonfibre MMC
- Cu-Cu$_2$O MMC
- Ti-Boron MMC
- CuSn-MoS$_2$/Cf MMC
- Al-Diamond MMC

NIELLIUM
Music only sounds well,

- if all the music and score can be played
- if polyphonical playing is practised
- if all needed instruments are available
- if agogic and musical variations are allowed
- and if you have ...
... musicians, that know their instruments by heart!