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Selbstschmierende Metallmatrixcomposite aus der Weltraumforschung für Kugellager in der Luftfahrt

(Self-lubricating Composites)

General manager: Dr N. Gamsjaeger
Head of testhouse: Dr. A. Merstallinger

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History of AAC

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Spin-Off

- **Reorganisation of AIT in 2010**: Spin-Off of the business field „Aerospace and Advanced Composites“ into a SME
- Objective: Keep **Competence in Aeronautic and Space** in Austria

AIT Austrian Institute of Technology

Mobility **Energy** **Health** **Security** **Policy** Materials

- ...
- LKR

AAC	PTC	PIM	SPA	ADG
SME (Shareholder also AC2T)	SME	Pim-Tech, SME	Dept. of Applied Wr Neustadt	Uni Montan Uni Leoben

COMPANY PROFILE

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Company data

- **Founded August 2010**
- **Headquarters: Wiener Neustadt, Viktor-Kaplan-Straße 2 (business location „Technology Park Seibersdorf“ until June 2012, then TFZ Wiener Neustadt)**
- **Shareholders: Staff members, AC^{2}T research GmbH**
- **19 scientific und technical staff members**

Mission statement

AAC is positioning itself as the only commercial provider of research, development and testing in the field of composite materials for aerospace and terrestrial applications in Austria

DIVISIONS & THEIR SERVICES

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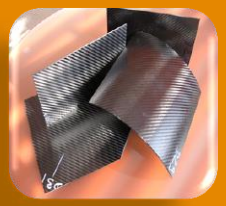

Polymer Composites

- Development of coatings, adhesives and surface modifications
- Nano composites
- Process modeling and verification of resin infusions
- Structural Health Monitoring

Inorganic Composites

- Development of ceramic nano particles
- Functional inorganic composites and coatings
- High temperature ceramics

Materials & Components Testhouse

- Microstructure – Material analysis and support
- Materials & Components tests under extreme environments
- Virtuel testing

Global services in the value-added chain of costumer:
Research – Development – Prototypes

Space Materials Testhouse

under ESTEC-contract (TRP)

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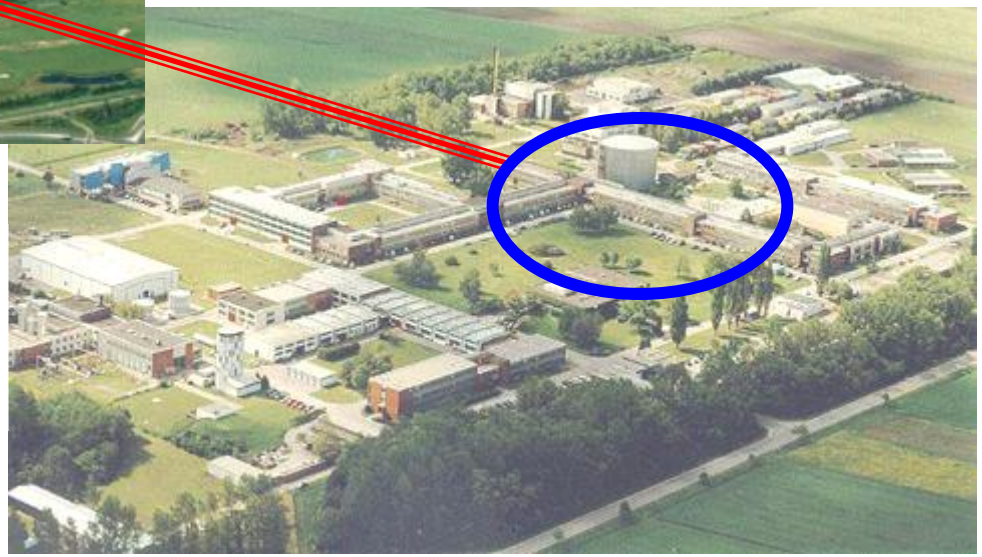
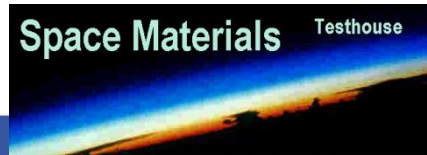
Objectives of the Testhouse

Assistance to ESTEC by characterisation and qualification of materials and processes of industrial suppliers



esa ESTEC

- **Cooperation since 1989 by frame contract**
- **Cooperation partner at ESTEC:**
  - **QM materials & processes division**



Objectives of CuMMC-Development for space applications

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- Material Development
  - Metal Matrix Composites (CuMMC) with
  - Embedded dry Lubricants (MoS_2)
- For Environments of
  - Vacuum, inert gases, air (humid)
  - High Temperatures of up to 300°C
- For high temperature Tribo-Applications
  - Bushes or cages for bearings
  - Slip-rings (electrical)
- Advantages
  - Dry lubrication embedded in a metal
  - Usage temperature (>) 300°C
  - Unique products made in Europe !

Environment – Restraints - Products

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Environment	Solid lubricant	Matrix	Manufacturing restraints	Available products
Ground (RT,air)	Grafit, PTFE	Polymer, Metal		"Many" "Many"
Vacuum (RT)	MoS_2 , PTFE Lead only Bronze, PTFE	Polymer, Metal Polymer with fibres		"Many" Few Few
Vacuum (HT)	MoS_2 MoS_2	Polyimides (max 300° C) Metal	MoS_2 reacts	Tecasint None !

Advantage of metal- to polymer composite at vacuum & high temperature:

- ➔ Higher Stiffness (up to high temperatures)
- ➔ Radiation resistance
- ➔ Thermal expansion close to steel (bearings)
- ➔ Good electrical & thermal conductance

Disadvantage

➔No products

Environment and it‘s impact on Composition

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Conventional materials show limitations …

Targets for space (elevated temperatures)	Conventional MMC offer	Conventional PolyMC offer
➔ Solid lubrication (no liquids)	➔ Yes	➔ Yes
➔ Lubrication by MoS_2 or similar	➔ No (grafite!)	➔ Yes
➔ High stiffness for small bearings	➔ Yes	➔ Lower
➔ Good machinability	➔ No	➔ Partly
➔ Not degradable by Radiation	➔ Yes	➔ No
➔ High temperature (mechanical)	➔ Partly	➔ Partly (Polyimides)
➔ No volatile (outgassing or sublimation)	➔ Partly (sublimation)	➔ Partly

CuMMC (by AAC) offers all these targets

➔ MoS_2 can now be combined with bronze …

Processing – Selection of composition

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Selection of composites and processes:

Process based on powder metallurgy

➔ Powder pre-treatment ("CP")

➔ Hot compaction *

Compositions (examples)

Designation	Type	Composition Fillers in v%
Cu12Sn-5M	Cp	5 v% MoS_2
Cu12Sn-25M	Cp	25 v% MoS_2
Cu12Sn-40M	Cp	40 v% MoS_2
Cu12Sn-12M15CfP	Cp	12 v% MoS_2 15 v% Carbon fibres
Cu12Sn-25M15CfP	Cp	25 v% MoS_2 15 v% Carbon fibres
Cu12Sn-35M15CfP	Cp	35 v% MoS_2 15 v% Carbon fibres

** Hot compaction process in cooperation with* RHP TECHNOLOGY

Ball bearing with CuMMC cage

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ESR Technology
Engineering, Safety & Risk

Bearing tests

- Ball bearings angular contact type
- Races: Cronidur, partly MoS_2 coated, with Balls Si_3N_4
- Testing at 100rpm up to 250.000 revolutions, at RT and 300°C

Results – post examinations after 300°C

- Races and balls in good condition with lubricant transfer
- No significant wear in cage (5-10µm depth)
- No dimensional changes of cage !!

Ball bearing with CuMMC cage

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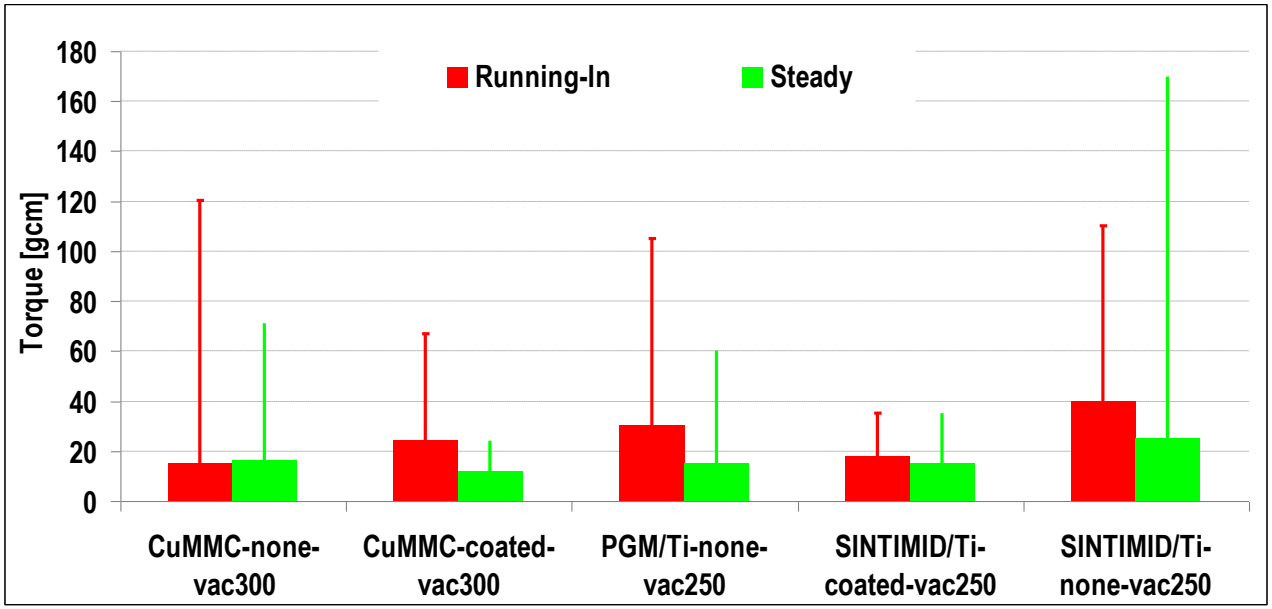
Comparison to references at high temperatures

- References data from published plots (no values available) for up to 250.000 revs
- Temperature: CuMMC at 300°C, references only at 250°C !!

➢ **Torque comparable to competitors**
➢ **Advantage: CuMMC as full cage** possible due to low CTE (polymer inserts in Ti-frame)



Long Ball bearing tests – CuMMC as cage

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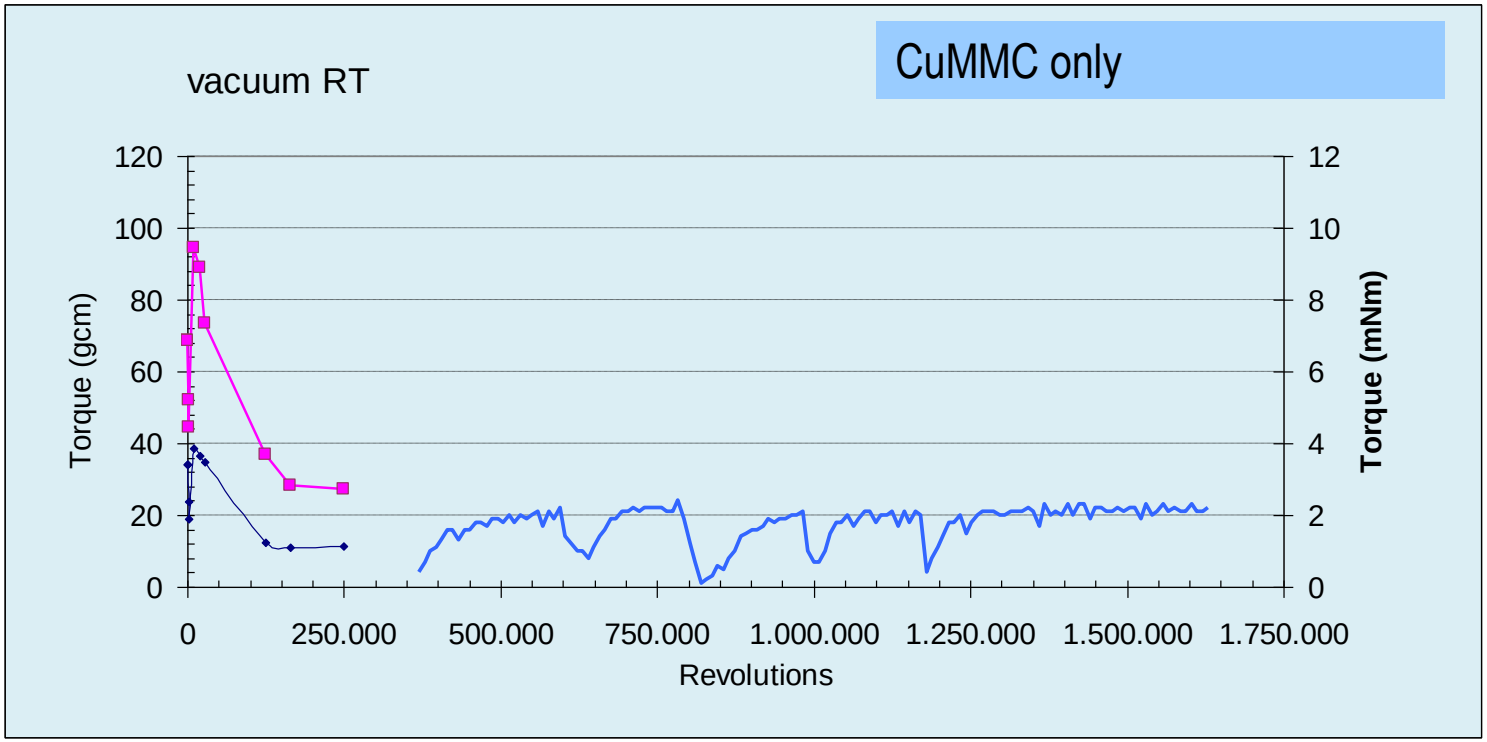
Results – re-assembled bearing after 1 year storage in air

- Typically: solid lubricant materials degrade when running and stored in air
- CuMMC cage only (no additional coatings)

➢ Despite of storage in humid air, torque afterwards is similar to testing in „new stage“



Conclusion

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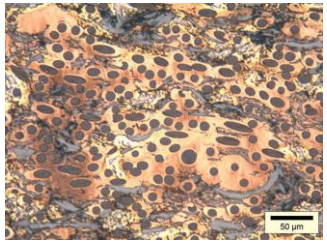
- A New self lubricating material is available
  - Metal based composite (CuMMC made in europe)
  - Main data necessary for space applications is available (tribo, mechanical, CTE, dimensional stability, machinability)



- Ball Bearing tests (CuMMC as cage)
  - Cages dimensionally stable, almost no wear
  - Good performance at 300°C with add. coatings (competitor materials up to max 250°C)
- Journal bearing tests (CuMMC as bush)
  - Bushes no measureable wear
  - Low torque (comparable to PoD)

- Slip-Rings (CuMMC as disc)
  - Reasonable low resistance and noise at 2,5A and 300°C

Spin-Off - Applications

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- Advantages
  - Dry lubrication embedded in a „metal“
  - Vacuum, inert gases, air (humid)
  - High Temperatures of up to 300°C (optional to 450°C)
  - Bushes or cages for bearings
  - Thermal expansion similar to steel
  - No creep (compared to polymers)

- Possible applications
  - Ball bearings for aircraft (high temperaures, dry), e.g air bleed systems
  - Joints and gaskets for high pressure compressors or high temperature vacuum equipment

Thank you !

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Acknowledgement

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Aerospace & Advanced Composites GmbH