NOVEL CERAMIC FOAM-SCAFFOLDS FOR PERSONALIZED BONE REPLACEMENT

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Challenges approached

- Increase in life expactency
- Need for bone replacement materials also due to:
  - Bone destructing diseases
  - Defects from accidents
- Solutions to date:
  - Endogenous (natural) bone graft substitutes
  - Synthetic bone graft substitutes (BGS)
    - dense and porous
      - Metal (Ti, Ti-alloys)
      - Polymers (PEEK, PA)
      - Ceramics (ZrO_2, Al_2O_3, Hydroxyapatite (HAp) or TCP)
- demand of an ideal BGS: biocompatible, bioresorbable, osteoconductive, osteoinductive, **structurally similar to bone**

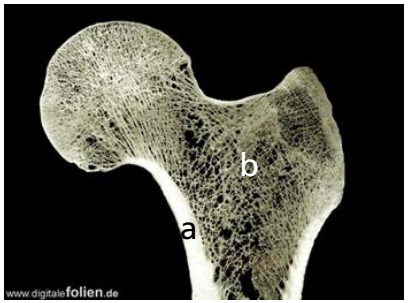
State of the Art ⇔ Innovation

- Ceramic bone graft substitutes:
  - Various geometries (bricks, prisms, granules, balls)

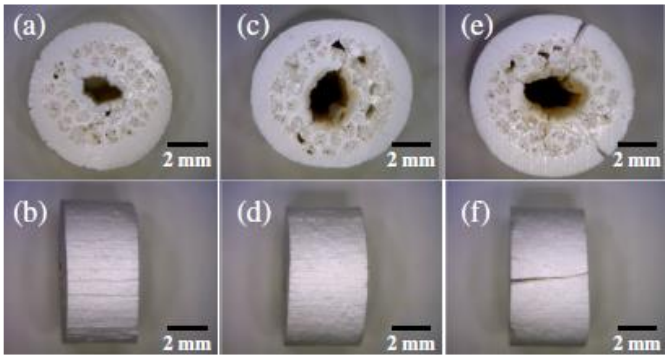
BGS HAp/TCP by Ceramisys

Orbital implants by Ceramisys

  - Complex shapes in terms of dense shell (*cortical bone*, a) and porous filling (*cancellous bone*, b), like a real bone?



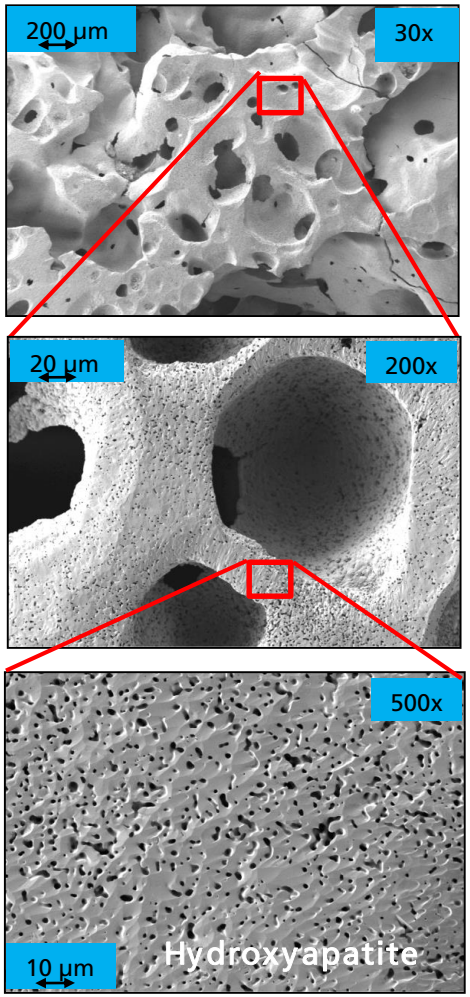
  - First approaches:
    - ZrO_2 shell/porous HAp filling
    - Use: for small bone defects (segments of finger bones)
    - **Unresolved:**
      - Complex outer shape
      - Larger specimen



Dong-Woo Jang et al.: Microwave sintering and in vitro study of defect-free stable porous multilayered HAp–ZrO2 artificial bone scaffold; Sci. Technol. Adv. Mater. 13 (2012) 035009 (9pp)

Porous parts + dense & complex part producing methods

Freeze Foam

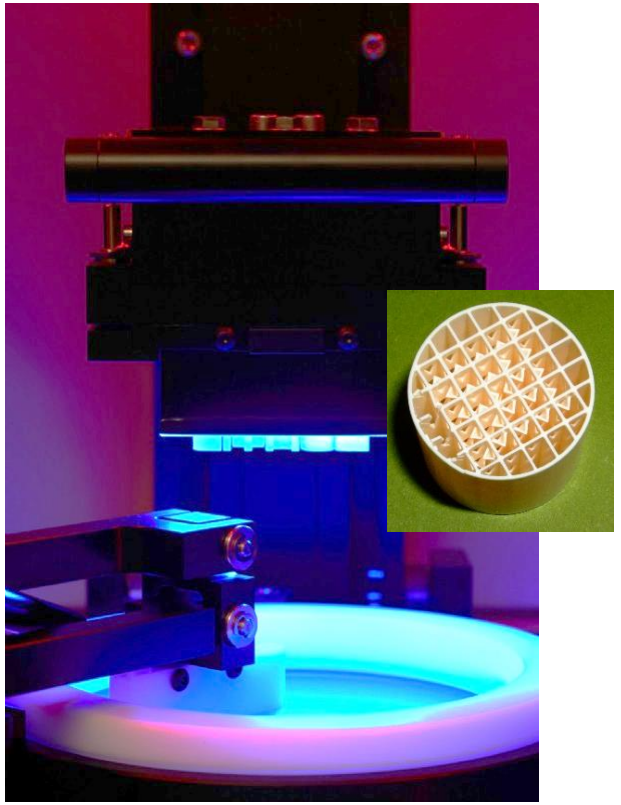


Highly porous biocompatible scaffolds

Process: **Freeze Foaming**
DE 10 2008 000 100

Highly complex 3D-structures

LCM (Lithography-based Ceramic Manufacturing), CeraFab 7500, Lithoz GmbH



Next-generation Bioceramics

LCM + Freeze Foaming

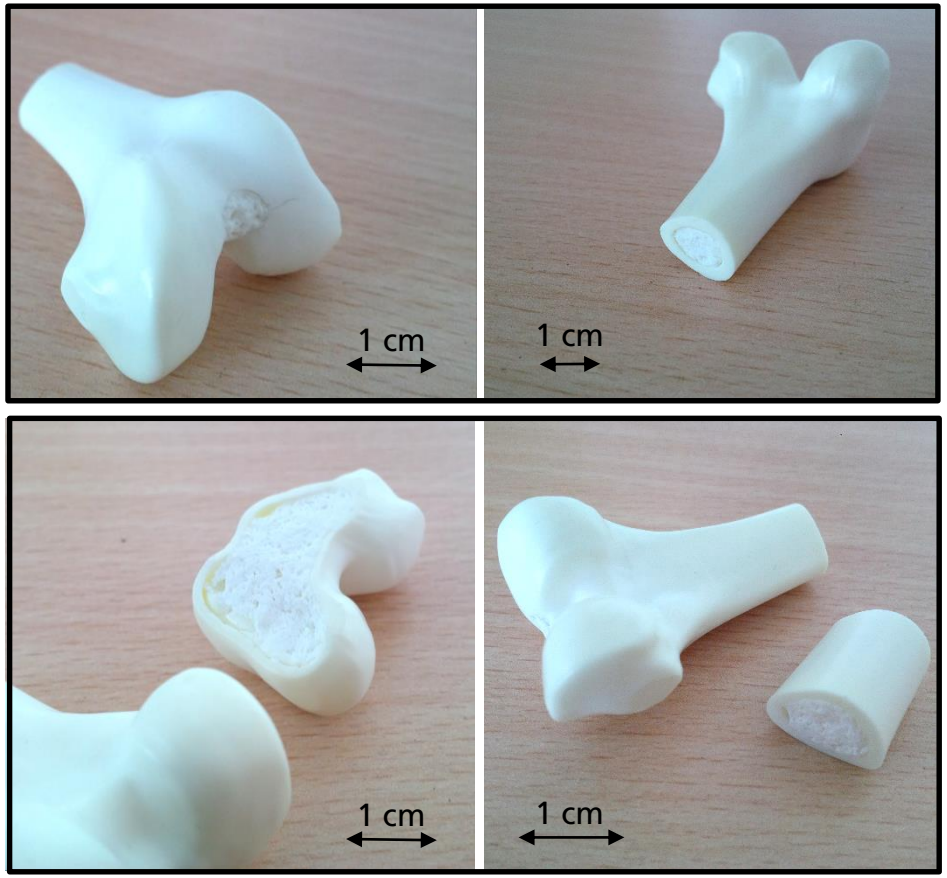
- Demonstrator
  - LCM-manufactured femural bone model (shell, zirconia)
  - filled with a Freeze Foam (zirconia)

LCM

Günther, P.; Master's Thesis, 2015

1. Partial sintering (LCM Part)
2. in-situ Freeze Foaming
3. Co-Sintering

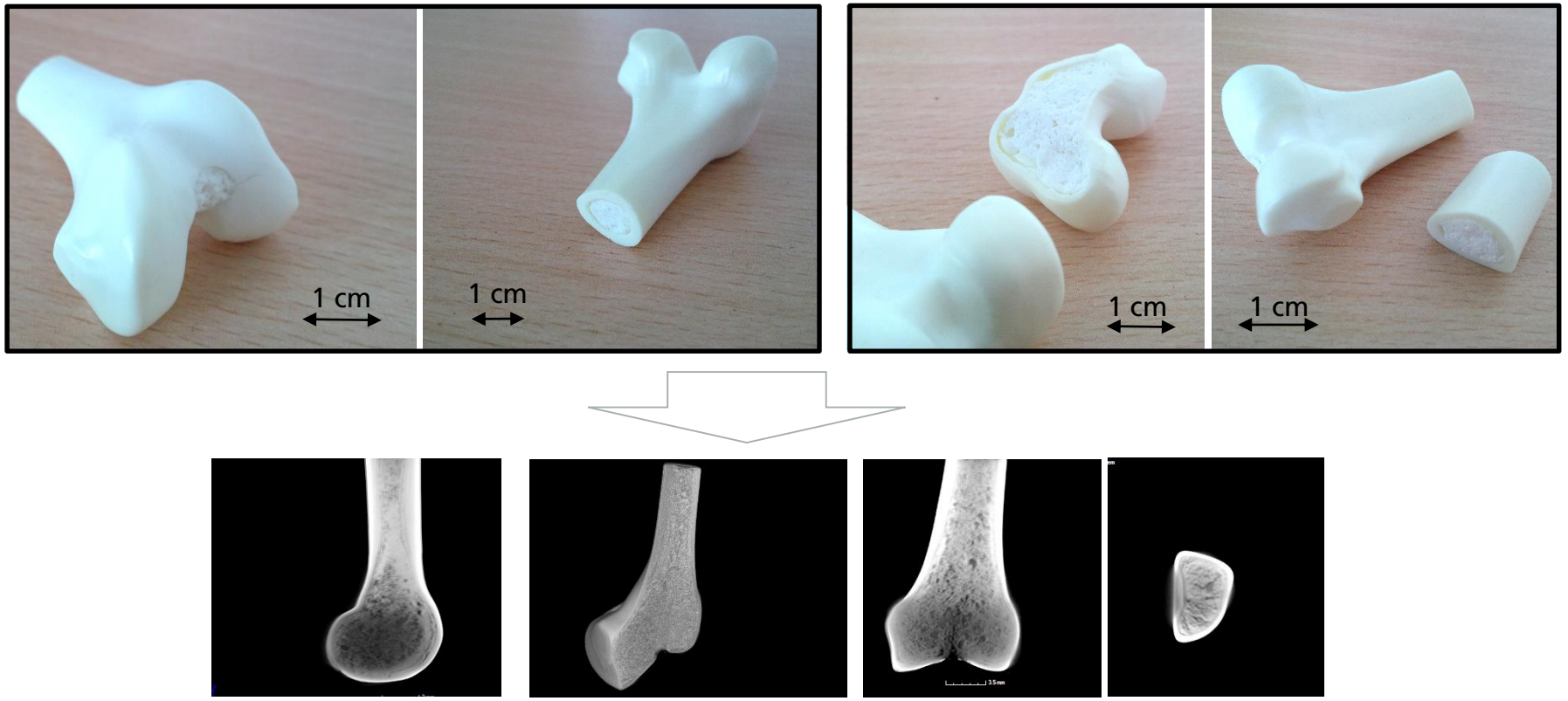
Femural head composite structure.



3. Next-generation Bioceramics

LCM + Freeze Foaming

- Computer Tomographic reconstruction of the demonstrator bone model



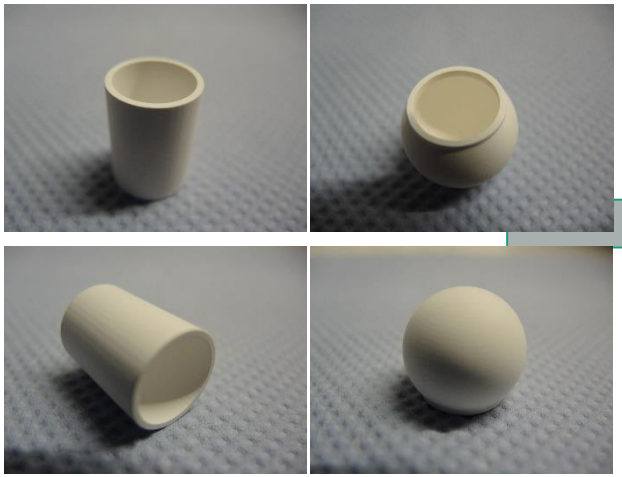
- Mainly partial or complete form fit between freeze foam and dense LCM shell → connected cortical and cancellous features

3. Next-generation Bio Scaffolds

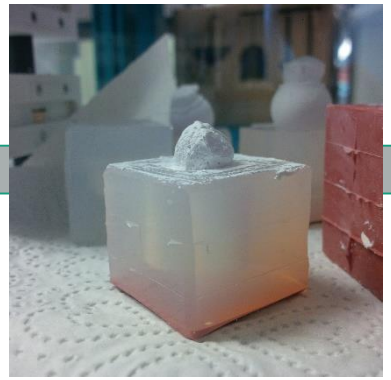
LCM + Freeze Foaming

- **towards biodegradable** material
  - ZrO_2/Hydroxyapatite (50:50 Vol.-%) composite by LCM and Freeze Foaming

1. LCM parts



2. In-situ Freeze Foaming

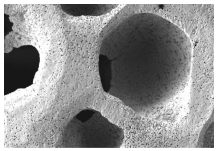


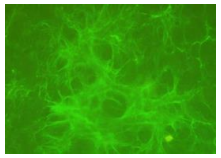
3. Co-manufacturing to LCM/Freeze Foam composites

  - Green state → sintering and interface characterization
  - Aim: enhanced compressive strength (due to zirconia) whilst retained bioactivity (due to hydroxyapatite) → long term implant
  - Next: fully resorbable complex structures

Status, Prospects & new Partners

- *Phase of development*:
  - Proof-of-concept (biocompatibility & osteogenic activity, in-vitro)
  - Recently adressing issues for better reproducibility and in-depth understanding of the process
- *Prospects*:
  - Bone replacement materials: biocompatible, bioresorbable, osteoconductive, osteoinductive, **structurally similar to bone** → demand
  - Interbody fusion cages etc. and combine different materials and geometries etc.
- *New projects, R&D and partners*:
  - Biomedical and pharmaceutical expertise for product specification and surface treatment
  - End-user for clinical and mechanical testing (especially in-vivo testings)
    - Surgeons, Orthopaedics, Physicians
  - **Partners for common projects in the field of novel porous structures**



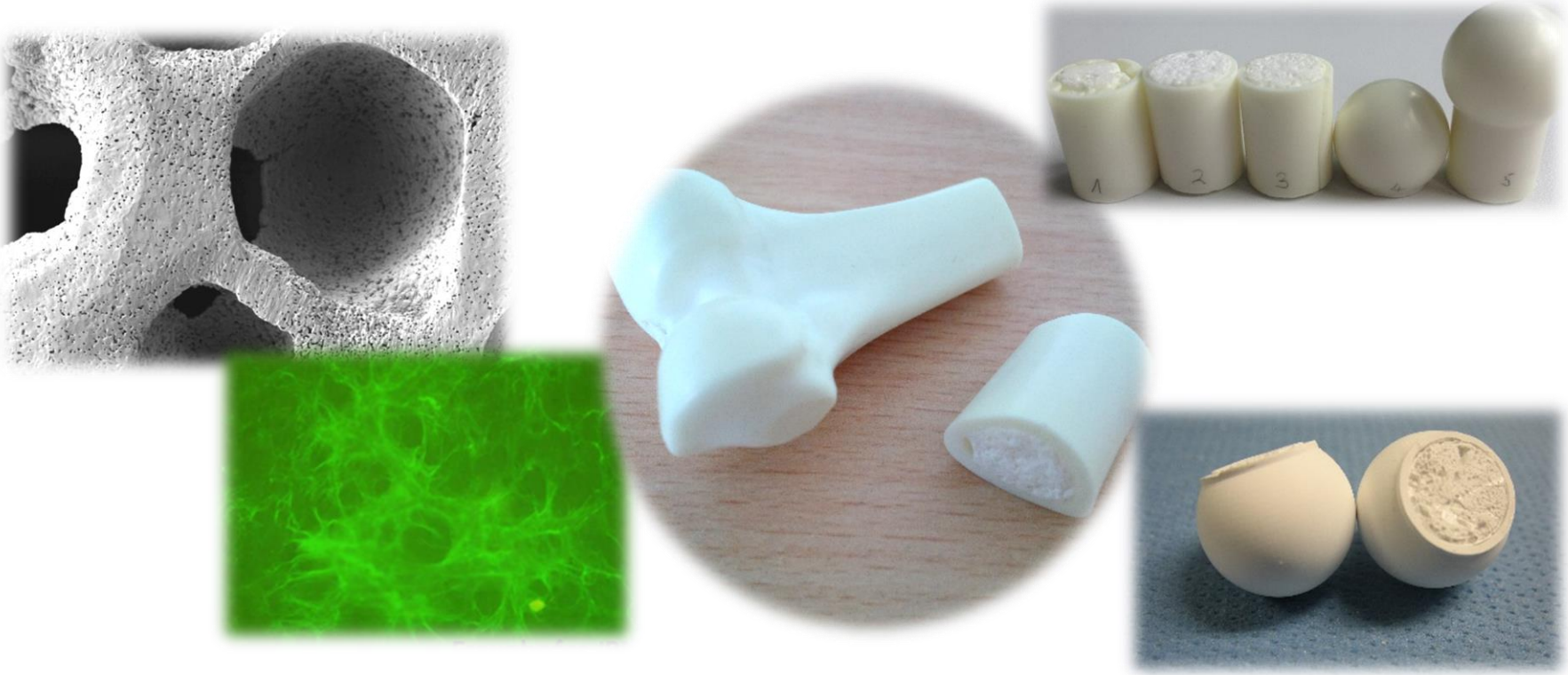


Source: TitanSpine Interbbody

Source: PEEK-OSTEON™

Thank you very much! Visit Poster V18!

Joining the network, generating new ideas and executing new bilateral and EU-projects is very much appreciated.



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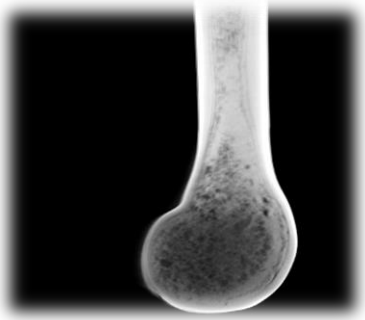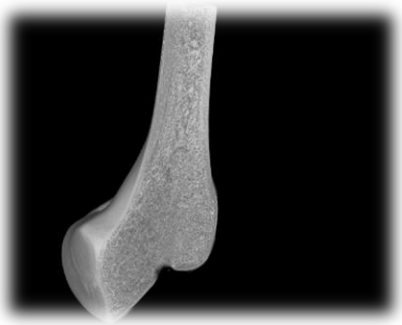
Many thanks for your attention!