Integrated Materials Systems (IMS)

Hamburg University of Technology (TUHH)

in cooperation with

the Helmholtz Research Centres GKSS and DESY

and

the University of Hamburg (UHH)

TUHH
Technische Universität Hamburg-Harburg

GKSS
FORSCHUNGSZENTRUM
in der HELMHOLTZ-GEMEINSCHAFT

DESY

UHH

Structure of the “Landesexzellenzcluster”

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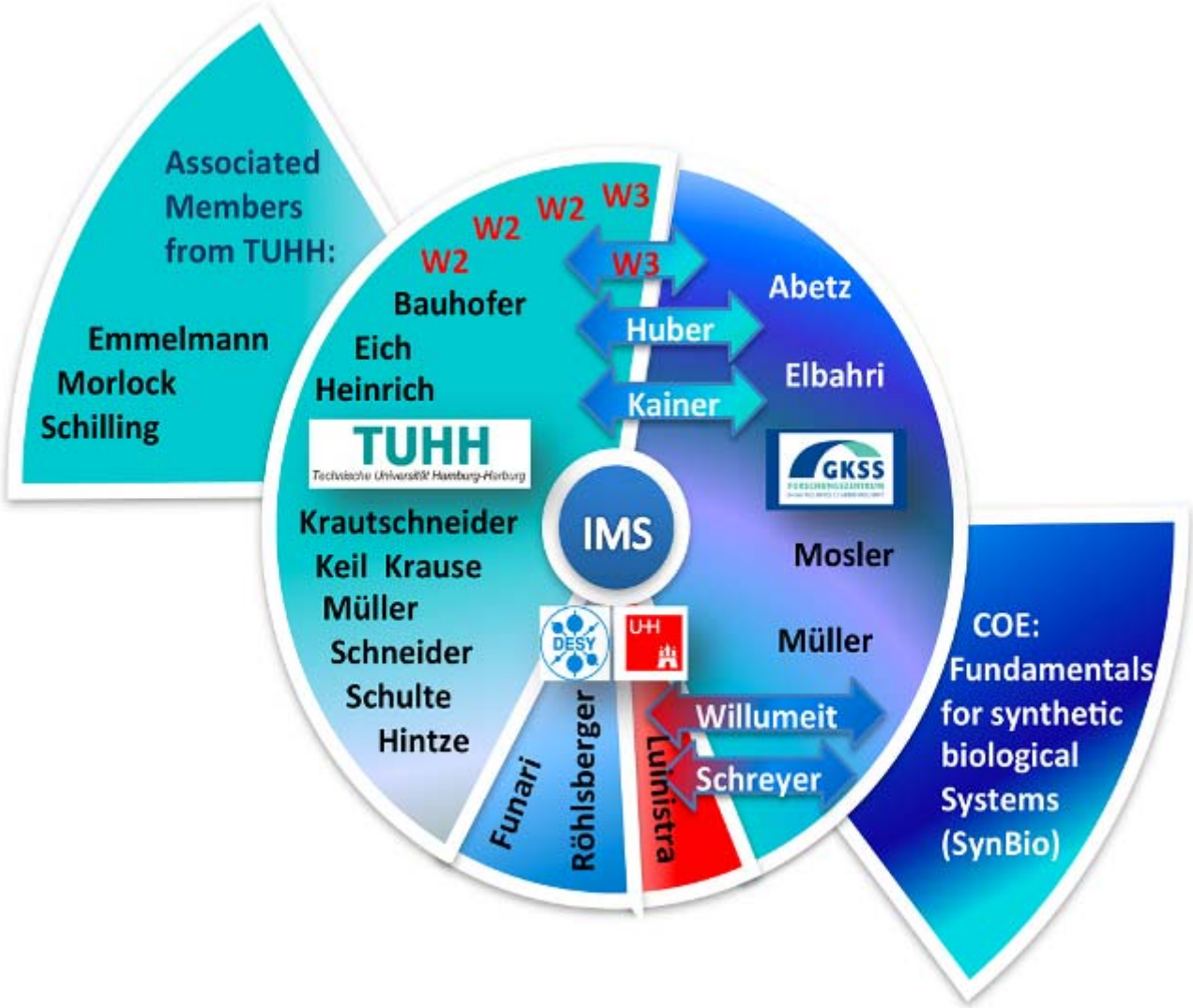


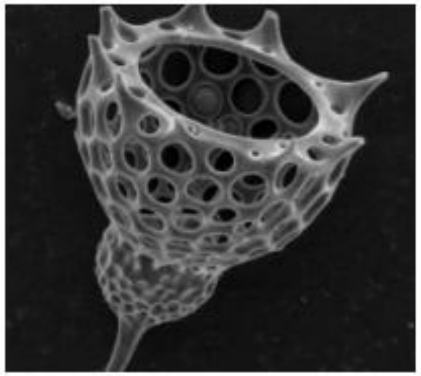
Applications – Fibre reinforced polymers

- Very high specific strength and stiffness
- Excellent fatigue properties
- High corrosion / chemical restistance
- High importance in lightweight construction applications

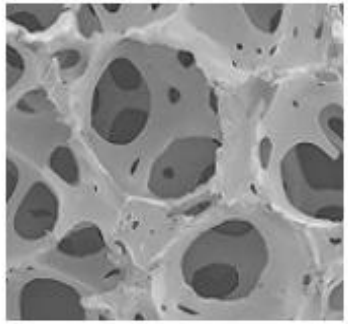
- Need for effective health monitoring

„Bioceramics“

Biominerals



Artificial medical ceramics



CeramTec

GKSS NanoLab
Nano-/Micromechanical Characterisation

Technische Universität Hamburg-Harburg

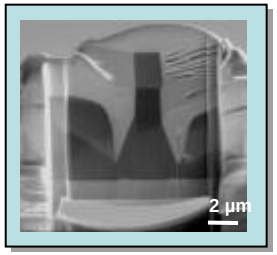
Instrumentation

- Dual Beam FIB

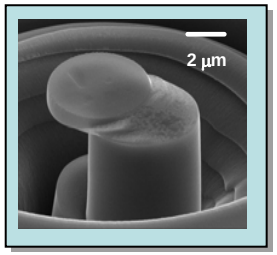
- Nanoindentation

- In-situ Testing
  - FIB
  - PNI beamline
  - Environmental

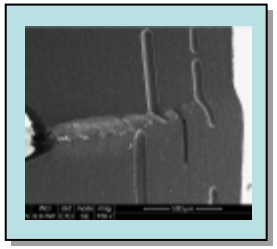
Methods



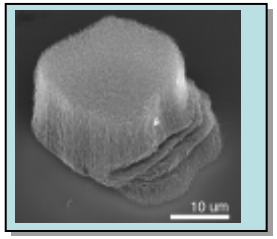
FIB-Preparation TEM lamellas



Mg Micro-compression

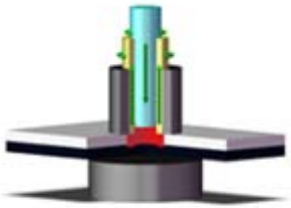


CFK in-situ Damage testing

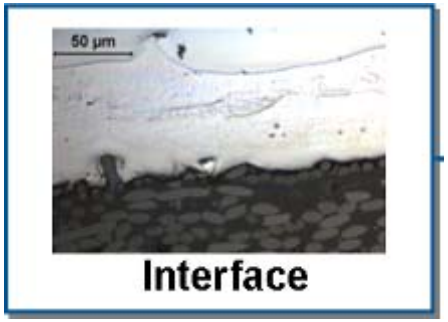


Props. CNT Haystacks

Properties on microstructural level



Friction Spot Welding



Interface

Example: Properties of polymer/metal interfaces

Application fields

- Materials development
- Mechanism identification
- Interface properties
- Properties of soft materials
- Input to micromechanical modelling

Novel hierarchical ceramic/metal-polymer composites with extremely small amounts of polymers (Research Area A)

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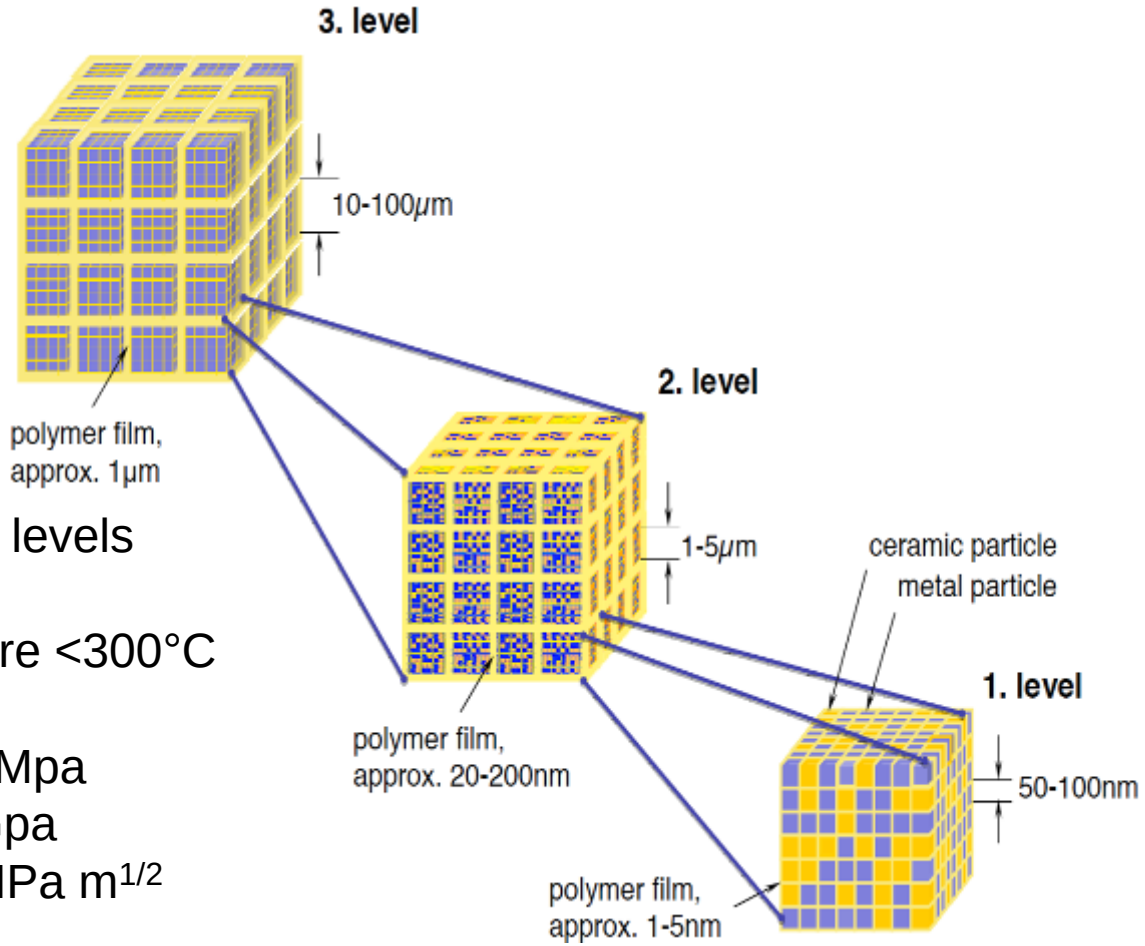


Objective:

Hierarchical material: at least 2 levels

Less than 15 Vol% polymer

Consolidation at low temperature <300°C

Mechanical properties

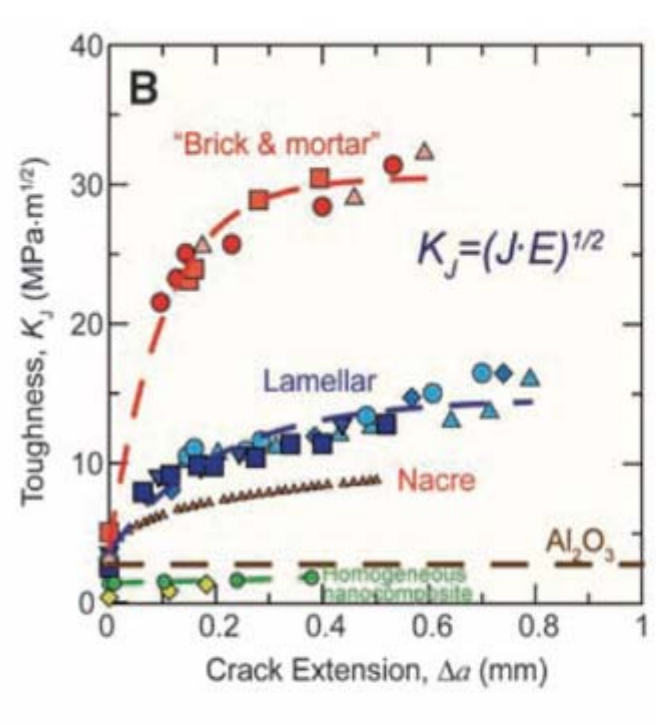
Strength	> 50 Mpa
Hardness	> 4 Gpa
Toughness	> 5 MPa $m^{1/2}$

Options:

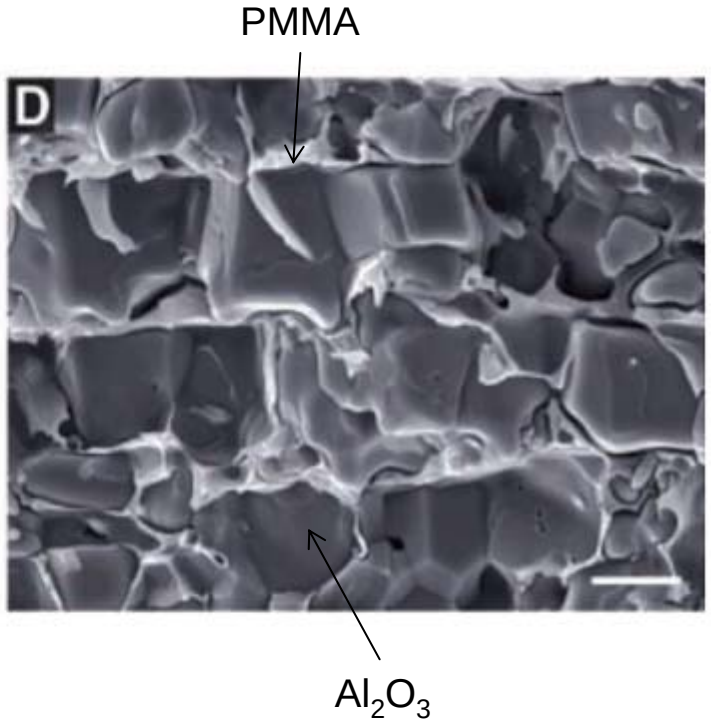
Multifunctional: ferroelectric/ferromagnetic

Biocompatible

Hierarchical Al_2O_3 / PMMA composite with exceptionally high toughness



a)



b)

Fracture toughness (a) and microstructure (b) of synthetic Al_2O_3/PMMA hybrid composite

E. Munch, M. E. Launey, D. H. Alsem, E. Saiz, A.P. Tomsia, R.O. Ritchie, Tough, Bio-Inspired Hybrid Materials, Science 2008, **322**, 1516

Novel hierarchical ceramic/metal-polymer composites with extremely small amounts of polymers (Research Area A)

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Activities:

Processing:

- Exchange of water with polymers in clay minerals: first level
- Spray drying of polymer/metal/ceramic mixtures: second and third level

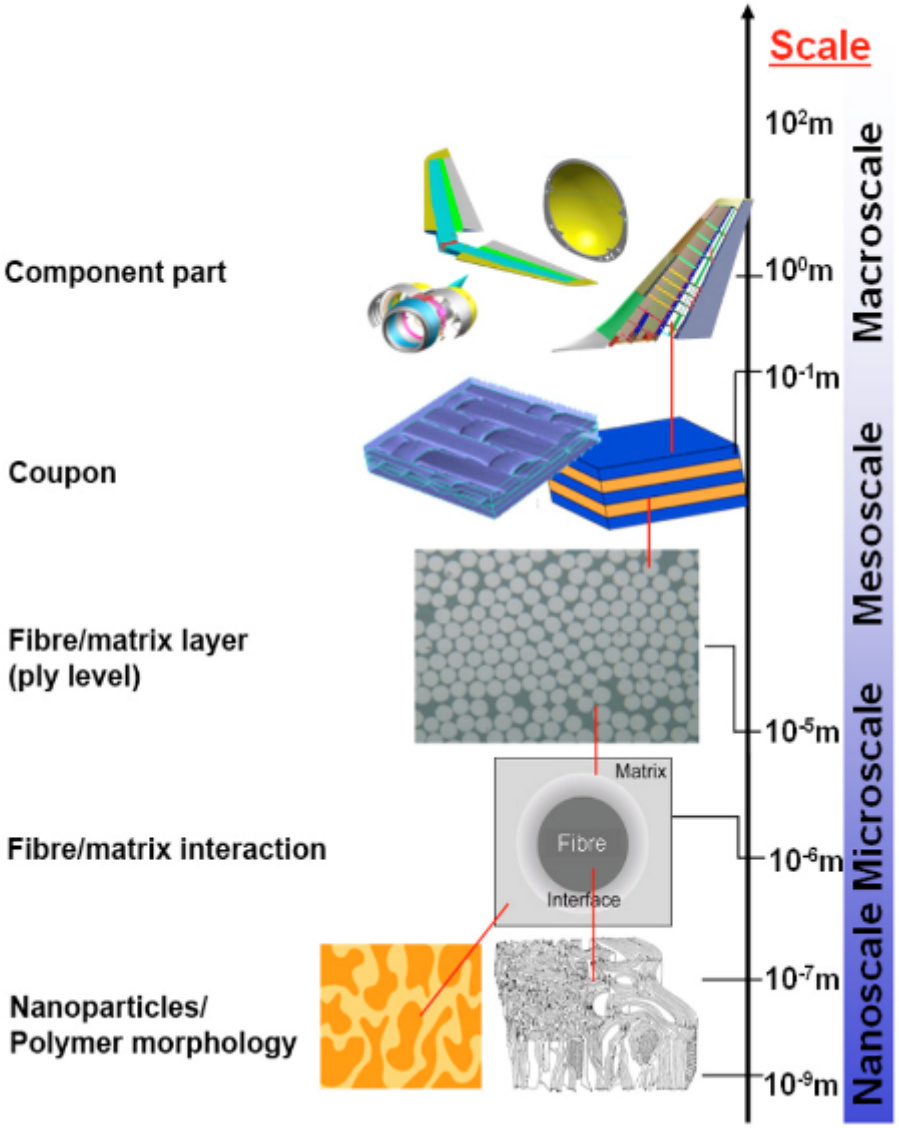
Synchrotron radiation:

- Tomography to image the hierachical structure
- In operando X-ray diffraction and small angle scattering of frictional contacts: strain, structural properties

Modelling:

- ab initio : ceramic/polymer interface
- Particle models: powder drying and mechanical strength
- Homogenization methods in order to model the mechanical behaviour of the multiscale structure

Hierarchically structured polymers and polymer composite materials (Reasearch Area B)



Multiscale Approach

Hierarchically structured polymers and polymer composite materials (Research Area B)

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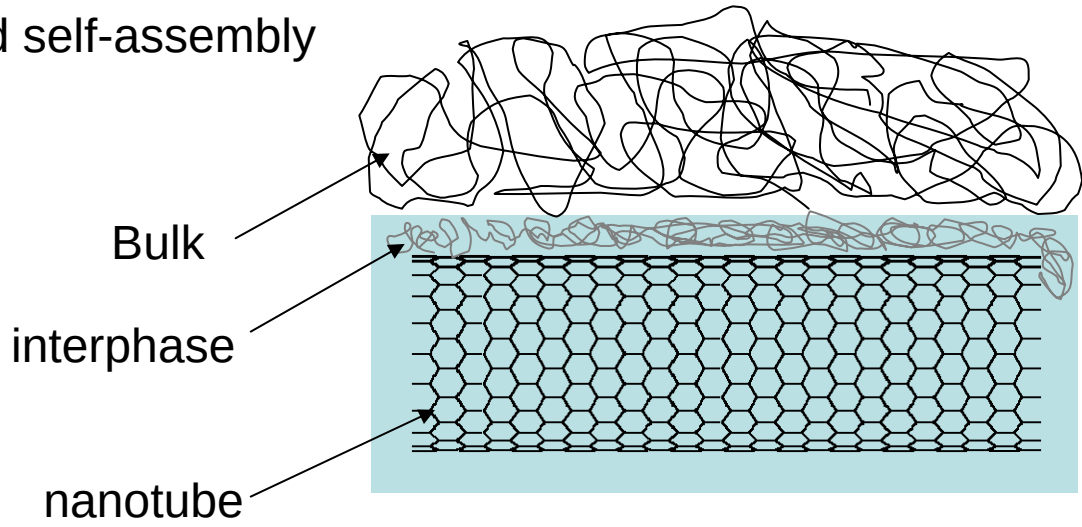
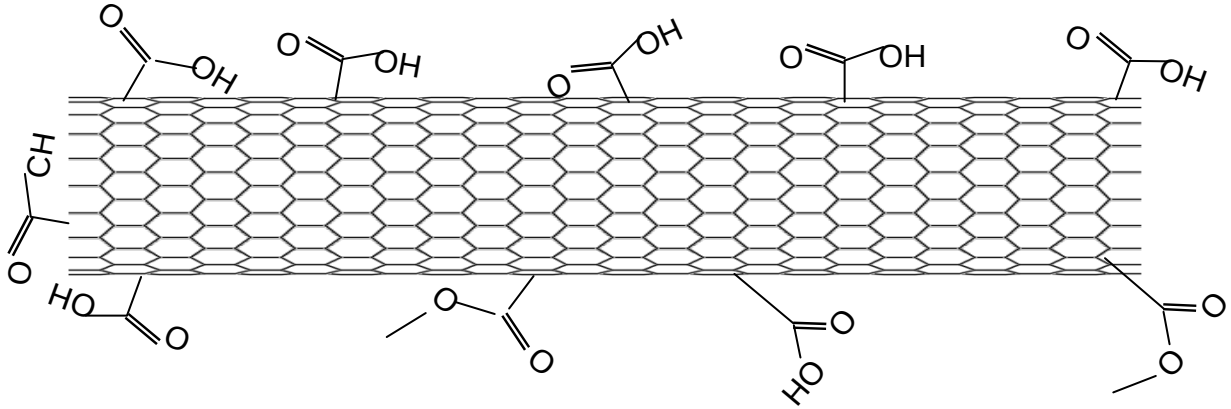
Polymer Composites

Understanding their properties and self-assembly
DFT, ab initio
Dissipative Particle Mechanics
Brownian Dynamics
Coarse Graining Methods
Kinetic MC

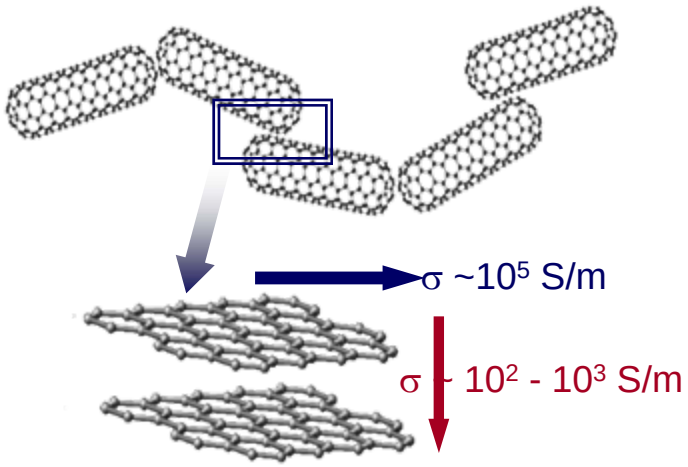


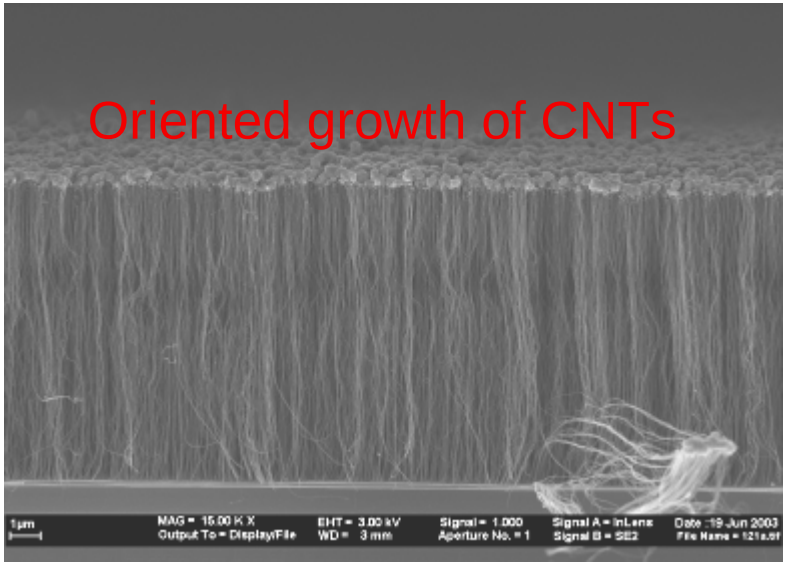
Functionalized CNTs

Adsorption, Separation properties
Grand Canonical MC



Electrical conductivity of nano-composites





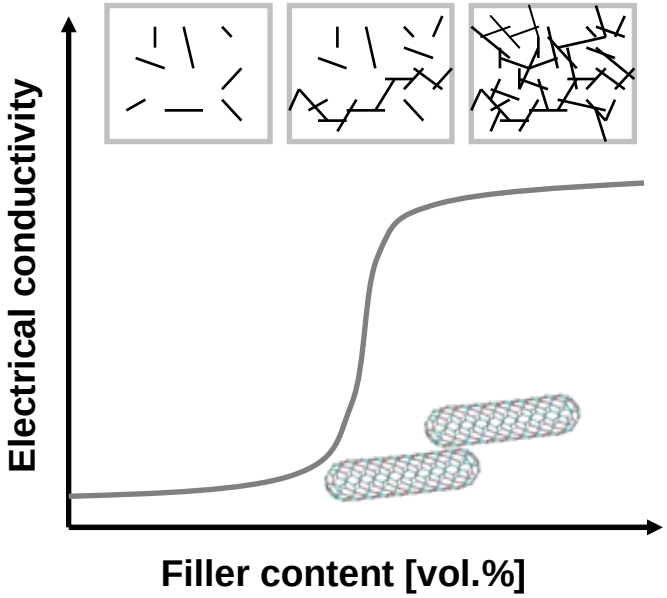
Percolated networks of CNTs induce electrical conductivity

⇒ Controlled self assembly required

Limitation

⇒ Resistance between graphite layers

⇒ functionalisation



Actuating CNT-fibres as replacement for Bucky paper in Actuators

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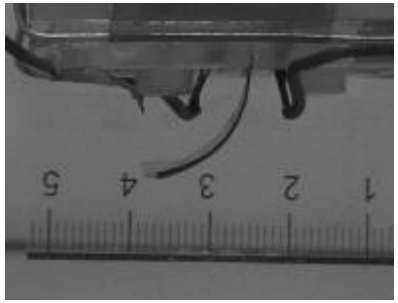
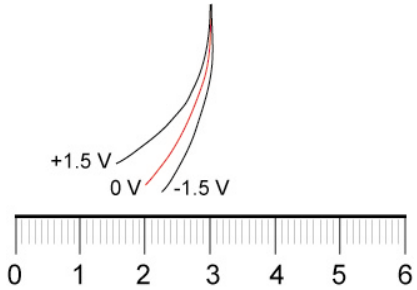
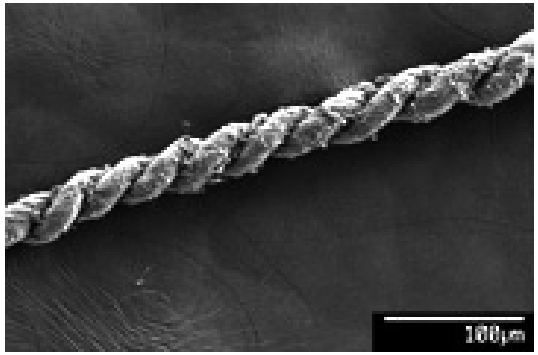




CNT actuator based on a solid electrolyte (left) and twisted stripes of bucky paper and bending lines of the actuators (right)

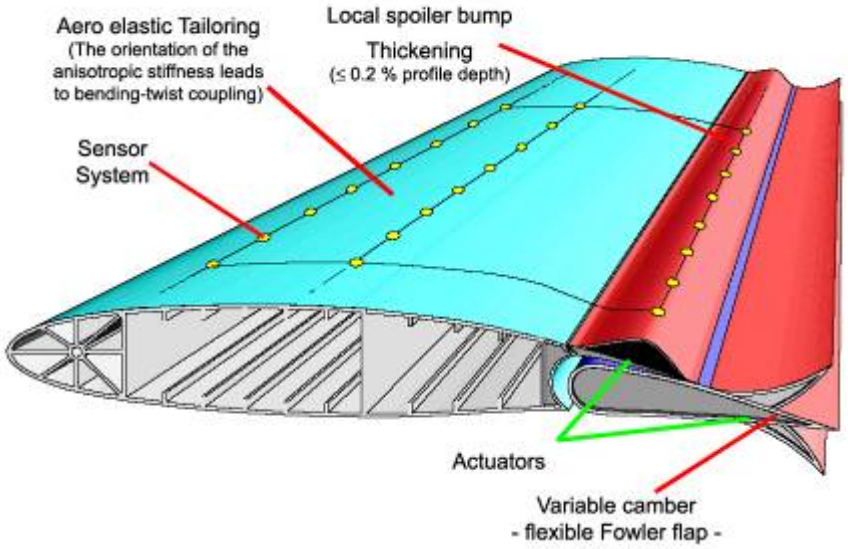
Suppiger, Ermanni, ETH Zürich

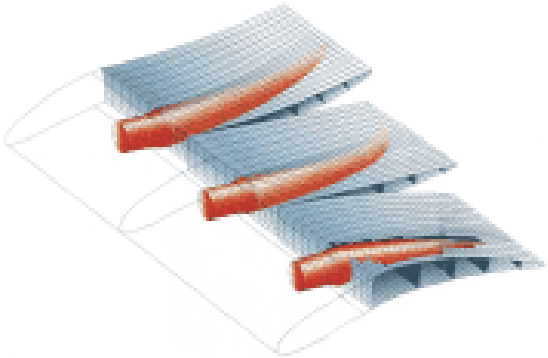


Twisted CNT fibre

Cambridge, UK

Adaptive wings





Self assembled ceramic photonic crystals for high temperature control (Research Area C)

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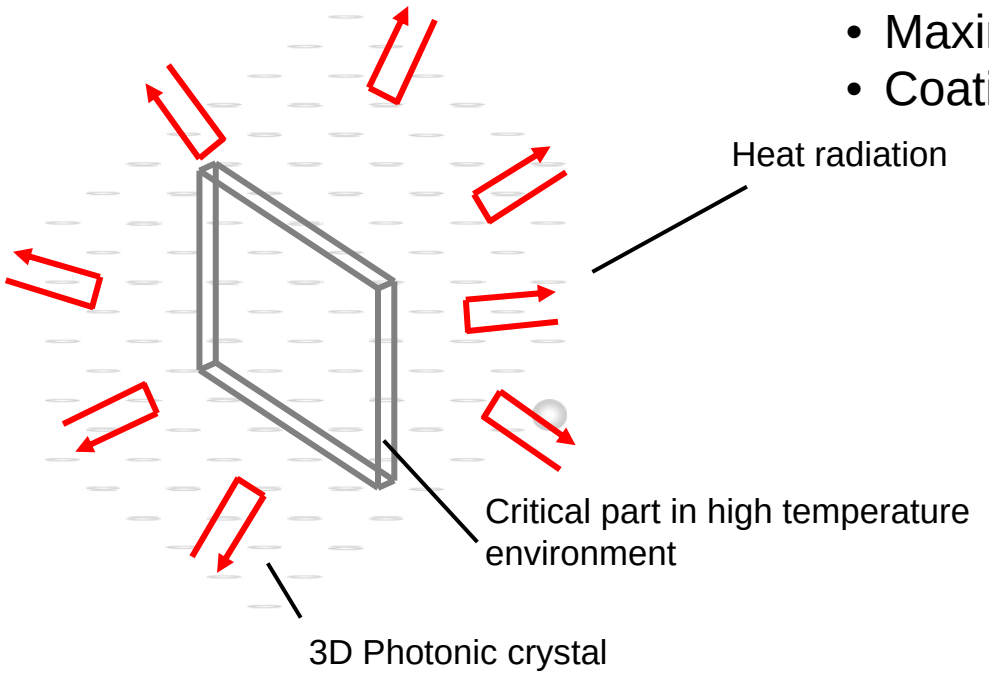
Objective:

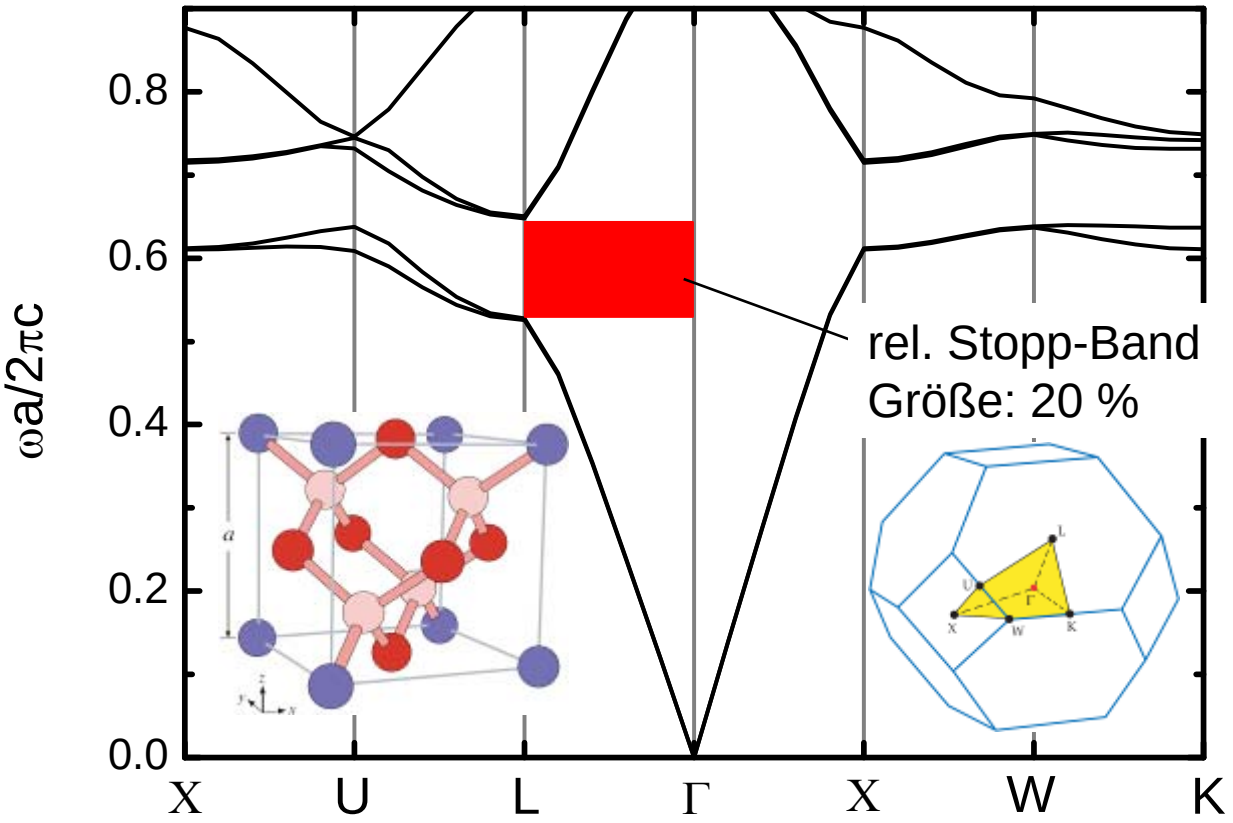
Increase lifetime of critical high temperature components (>1200°C) by protecting them from heat radiation

Methods:

- Self assembled ceramic material systems for
  -mechanical stability
  -photonic band gapücke
- Maximisation of reflectivity
- Coating process



Band structure of 3D photonic crystal
Band gap of forbidden optical frequencies



$n = 2.12$

$r / a = 0.235$

$\lambda_{center} = 2\,\mu m$

$\Rightarrow a = 1.29 \mu m$

$\Rightarrow r = 303 nm$

$\Delta\lambda_{Stopp-Band} = 400\,nm$

Already produced 3D photonic crystals

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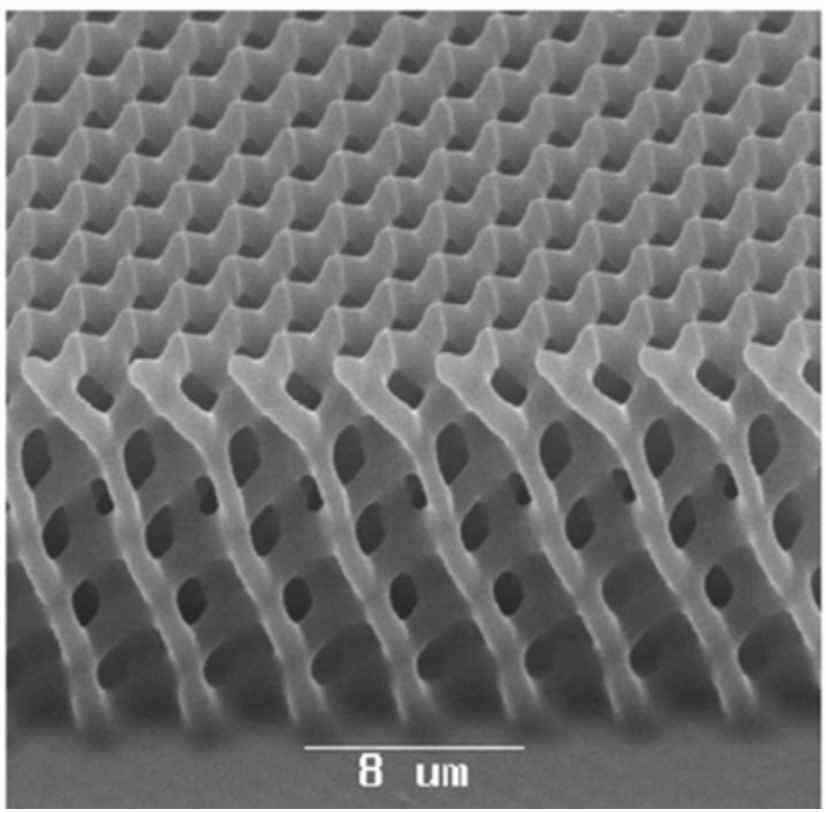
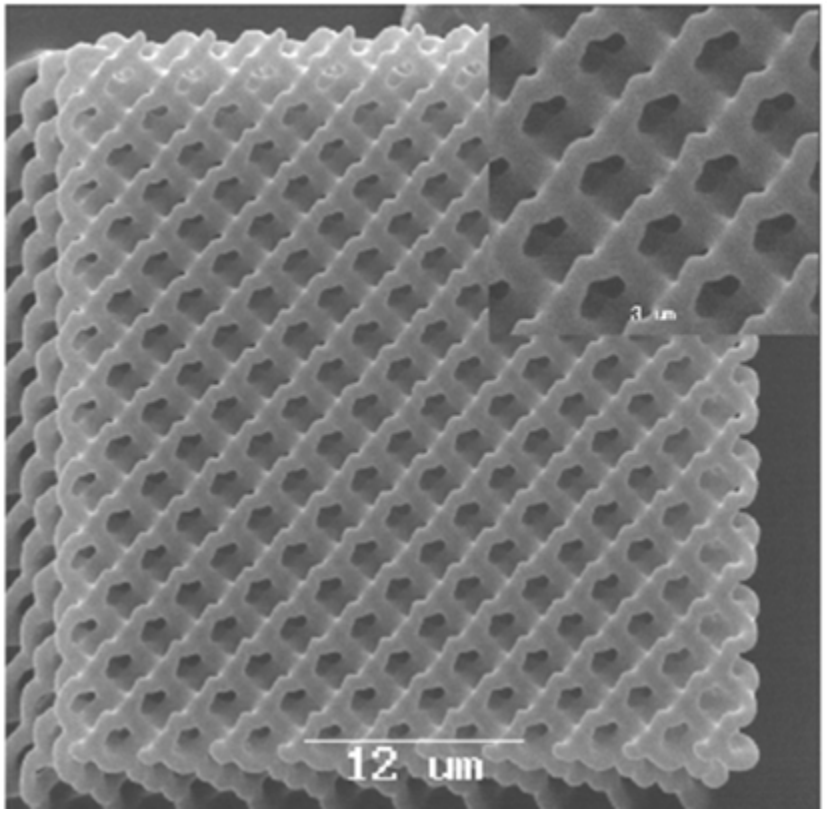
3D-PHOTONIC CRYSTAL





N. Grossman, M.Eich et al., *Optics Express 2007*, **15**, Issue 20, 13236 (2007)