Organic/Inorganic Materials and CFRP Structures Reinforced with Carbon Nanotubes for Space Applications

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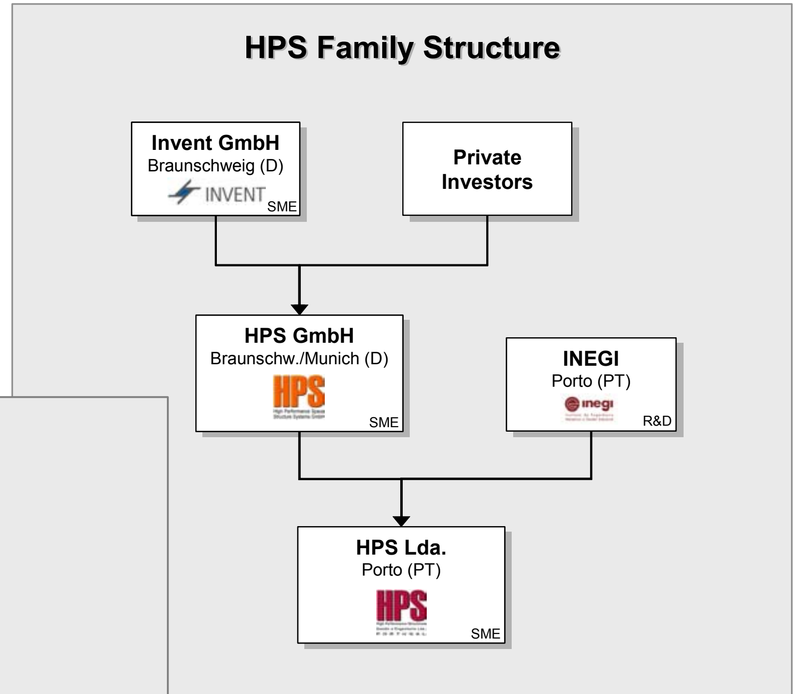
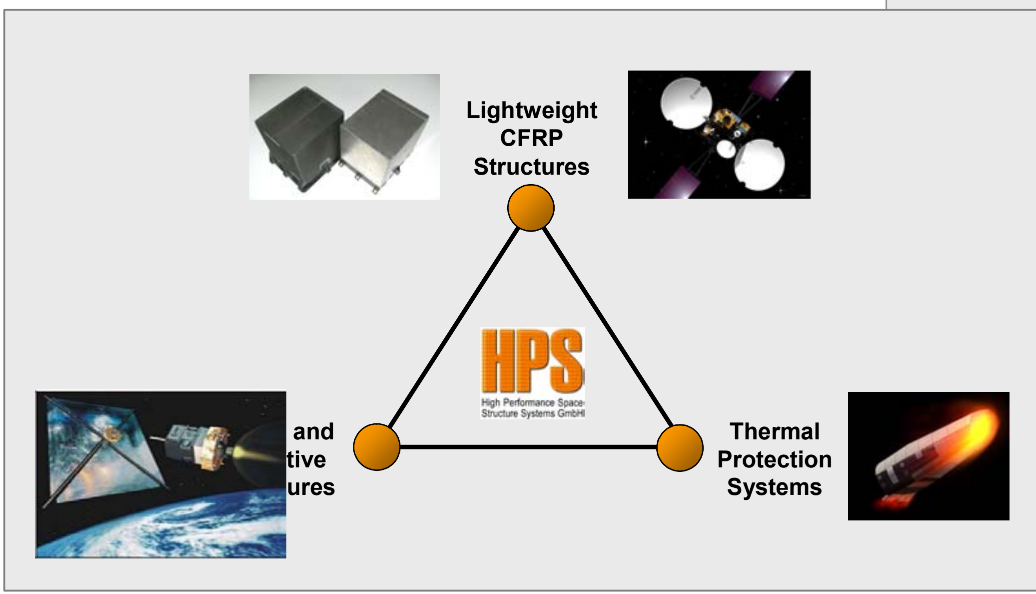
High Performance Space
Structure Systems GmbH

HPS GmbH & HPS Lda

- Braunschweig
- Munich
- Porto





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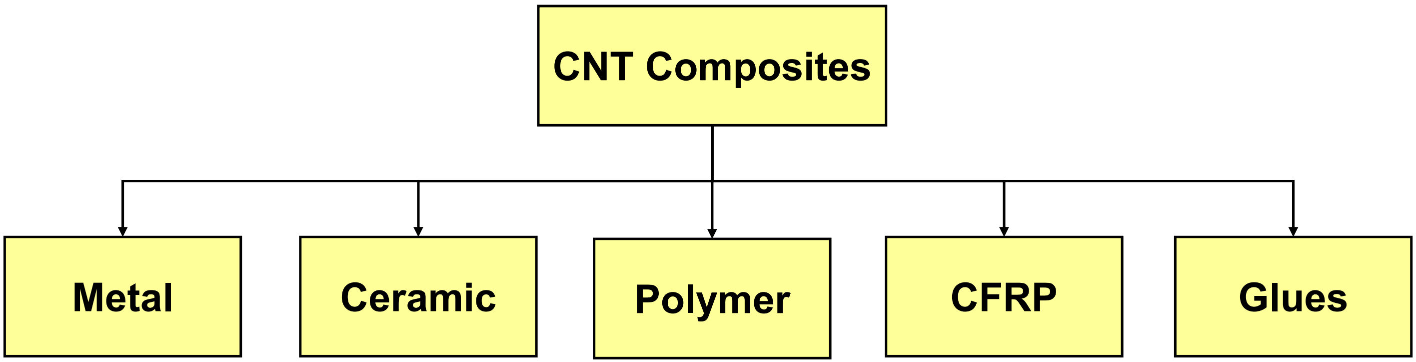
Different Materials for Different Applications:



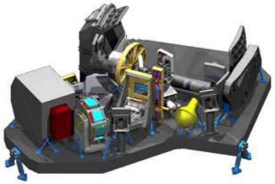
Different Classes and Production Principles:

- High Amount
- Low Amount
- CNT mixed in Matrix
- Matrix infiltrated in CNT Skeletton

Ceramic / Metal Applications

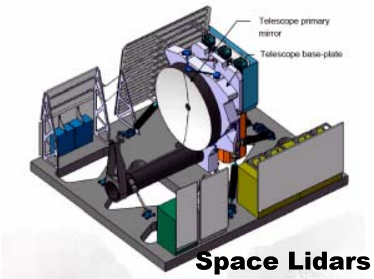
Improvement of:

- Electrical Conductance
- Thermal Conductance
- Surface Conductance
- Low CTE
- Brittleness (Ceramics)
- Damping of Structures



Optical Instruments

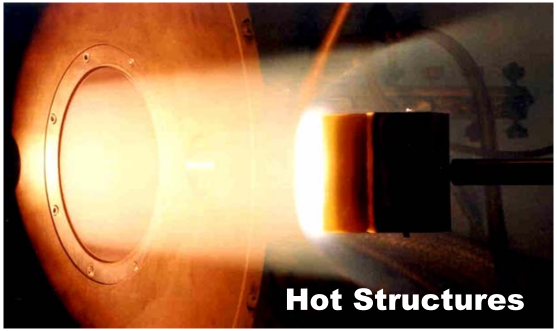
Optical Benches



Space Lidars

Electronic Packages

Optical Mirrors

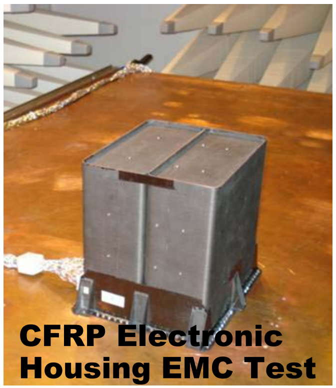


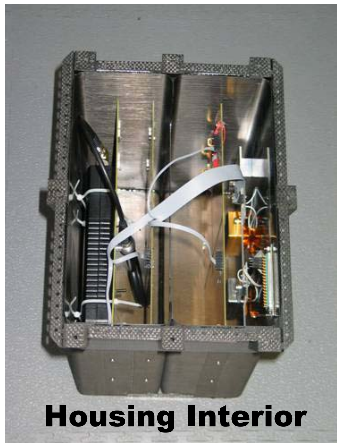
Hot Structures

All Pictures by EADS-Friedrichshafen

CNT Applications in CFRP Products of HPS

- **Already Realized / Under Realization:**


CFRP Electronic Housing EMC Test


Housing Interior


Reflector Grid

Improvement of:

Primary:

- Electrical Conductivity (inside and on surface)
- Thermal Conductivity

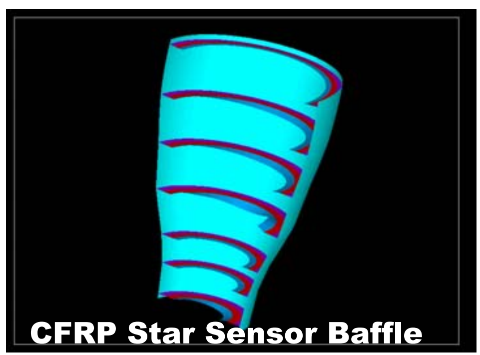
Secondary:

- Tensile Strength
- Damping of Structures


Q/V-Band Reflector

- **Envisaged:**


CFRP Baffle Aperture


CFRP Star Sensor Baffle

Overview on

3 Studies on CNT-based Materials under contract to ESTEC

and 1 Study where CNT composites have been used.

„NANOTUBE BASED COMPOSITE MATERIALS“

Customer: ESA/ESTEC, (2005 – 2007)

Selecting two model nano-composite systems :

Determining potential space applications SiC matrix

Collecting concepts by CNT composite producers

► **Low volume fraction of CNT** as reinforcement (1 - 5 %) :

- **SiC matrix** , (2 production routes)
- Potential Applications: Mirrors, optical benches, „conductive“ cermic structures

► **High volume fraction of CNT**, (17 – 20 %)

- **Cu matrix** (1 – 2 vol% Ni)
- Potential Applications: Heat sinks

Enhancement of properties brought by presence of CNT with respect to bulk matrix presently evaluated.

Main subcontractors to HPS :
ASTRIUM (D), BOOSTEC (F), CIRIMAT (F), FHN (D), FutureCarbon (D), NMW (D), SUPSI (CH), TUW (A).

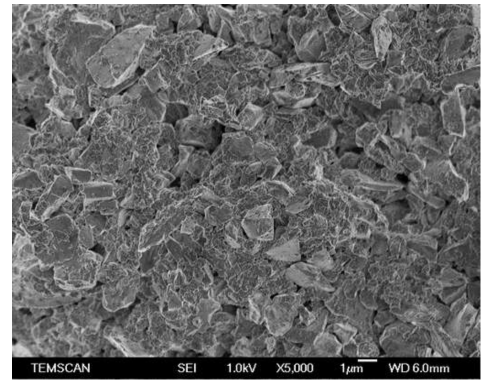


Fig.1: FEG-SEM-image (**5000 X**)
of 0.86 vol.% **CNT-SiC**
Green body composite before pressureless sintering
(Production process by BOOSTEC, Analysis by CIRIMAT)

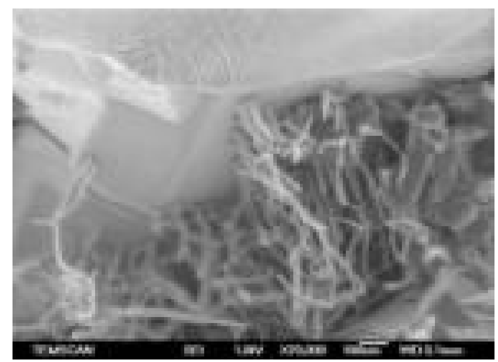
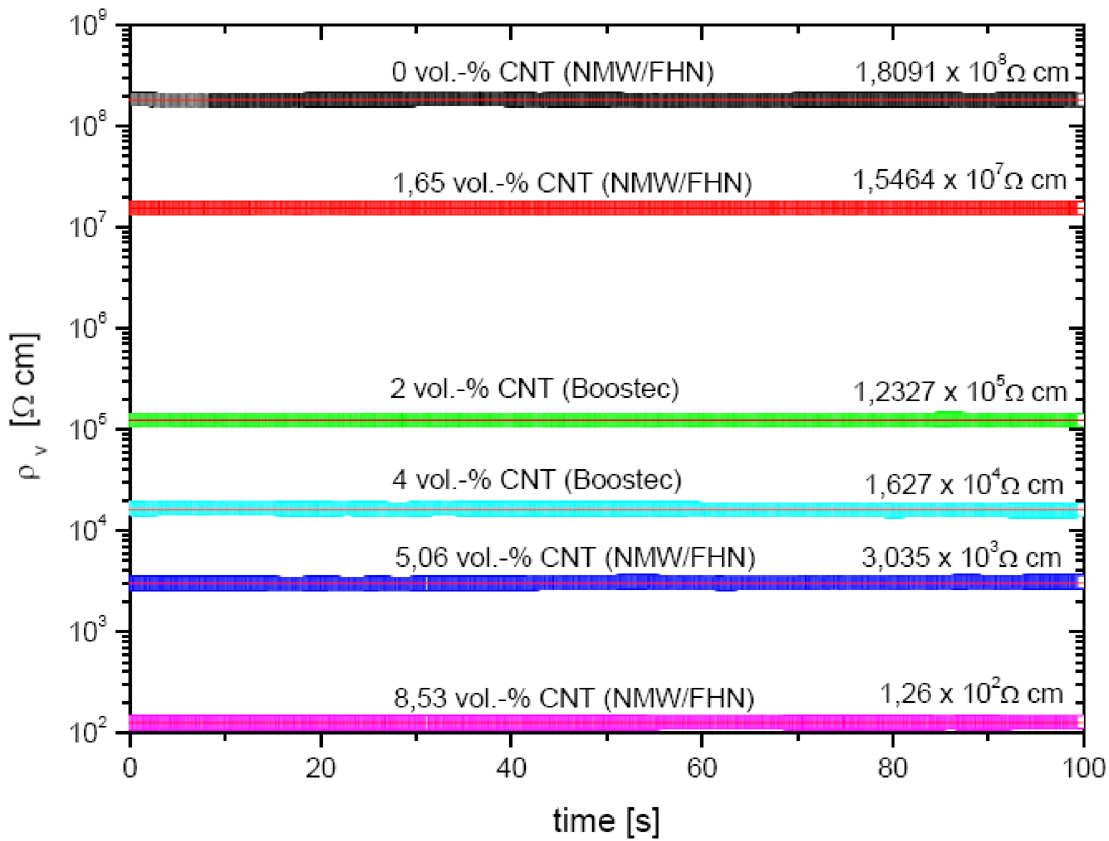


Fig. 2: FEG-SEM-image (**70.000 X**),
Fracture surface of 0.86 vol.% **CNT-SiC**
composite after **pressureless sintering**
(Production process by BOOSTEC, Analysis by CIRIMAT)

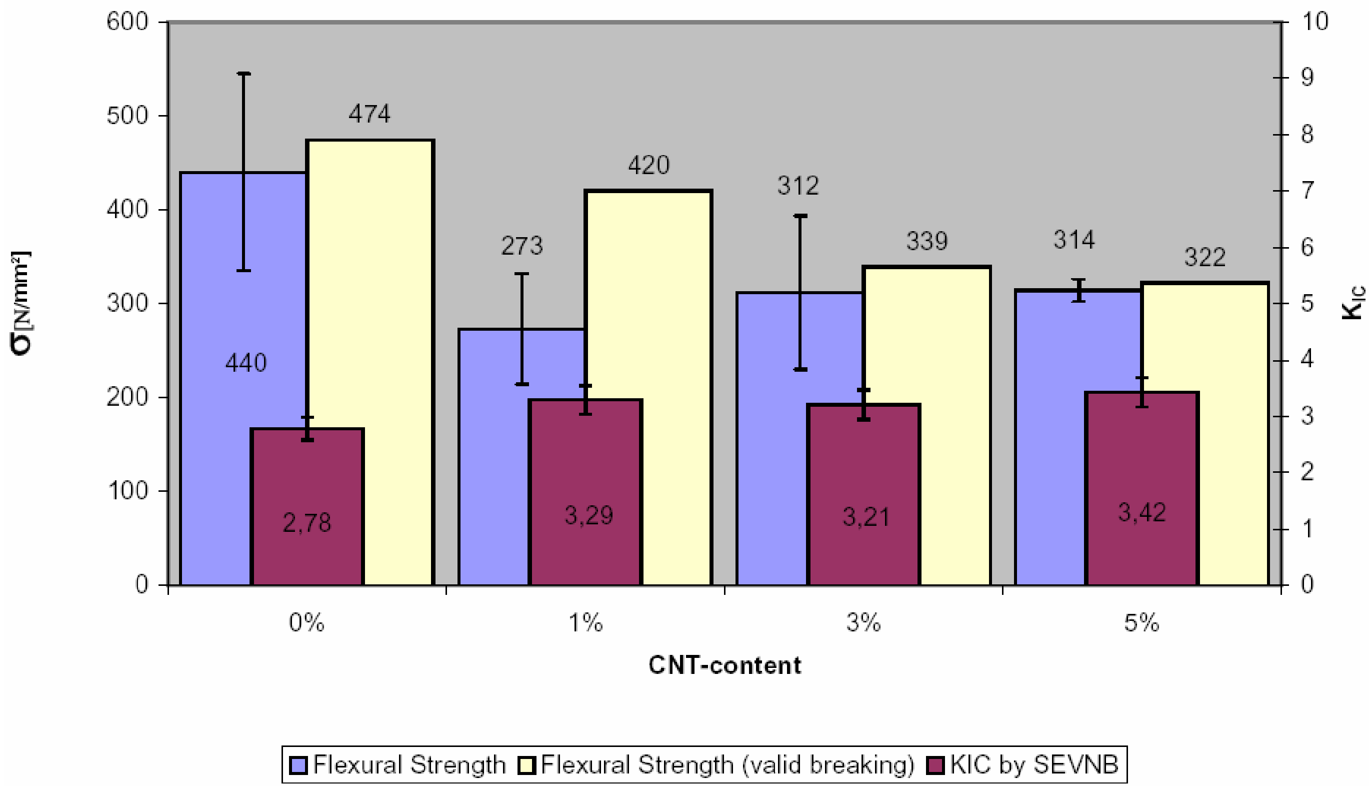
CNTM: Examples of First Test Results I (Tests performed by NMW, FHN)

CNT SiC Composite (BOOSTEC, NMW, FHN): Electrical conductivity



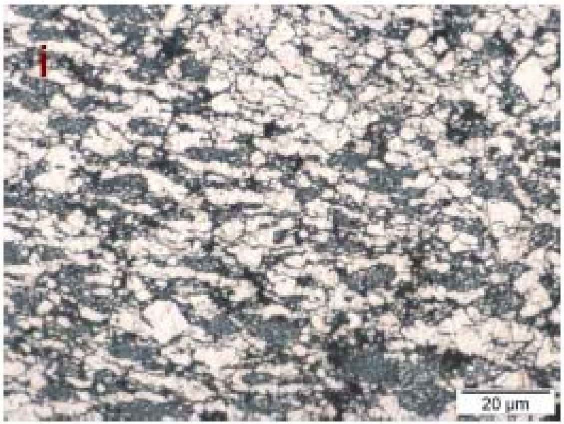
CNTM: Examples of First Test Results II (Tests performed by NMW, FHN)

CNT SiC Composite: Fracture toughness and flexural strength



CNTM: Examples of First Test Results III (Tests performed by TUW, TUM)

CNT Cu Composite (TUW): LOM Images (TUW), Thermal Expansion (CTE) Measurements (TUM)



LOM image of hot pressed sample, central area : CNTs visible as agglomerates,

: α (physical) -150/+150°C of CNT2-REF, CNT2-B and CNT2-C

samples	α (physical) -150/+150°C [1/K *10^{-6}]	
	measurement 1	*measurement 2*
Reference sample	15,95	15,97
	16,10	16,17
Pieces cut from hot pressed samples	15,65	15,68
	15,65	15,67
	15,46	15,48
	15,22	15,21

CTE measurements of hot pressed samples

„NON CONVENTIONAL MATRIX CARBON NANOTUBES REINFORCED COMPOSITE FOR APPLICATIONS IN SPACE“

Customer: ESA/ESTEC (2007 – 2009)

„Skeleton" or "CNT Network" out of carbon nanotubes (paper, felt)

infiltrated with

- **polymer matrix (Cyanate Ester, Epoxy)**
- **metal matrix (Cu, Al, and Alloys thereof)**
- **ceramic matrix (SiC).**

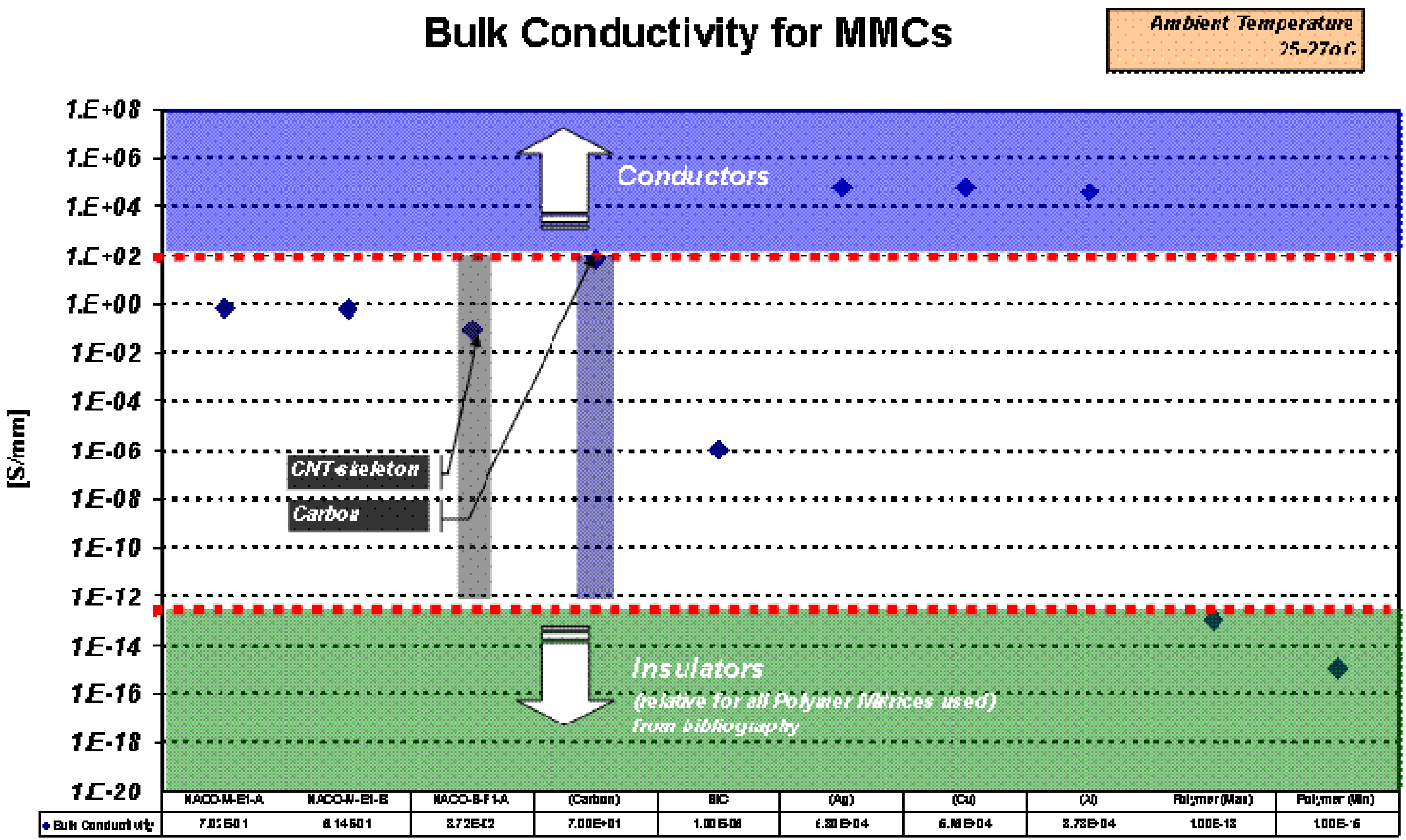
Determining most interesting material / application couples.
Developing a sound route for **manufacturing CNT network** as composite preform,
Measuring features of developed CNT network (physical and mechanical properties),
Developing technologies for CNT network infiltration

Characterising CNT reinforced composite materials according to targeted applications.

Last Step: Production of demonstrators

Main subcontractors to HPS :
ARC Seibersdorf (A), ASTRIUM (D), DLR (D),
Electrovac (A), FutureCarbon (D), INEGI (P), PIEP (P), U of Patras (Gr)

Example of First Test Result



IMPROVEMENT OF THERMAL DISSIPATION BY NANO-MATERIAL

Customer: ESA/ESTEC (2007 – 2008)

Epoxy matrices + CNT + other nano-particles: Improving thermal conductivity between electronic chip and substrate.

1st task: Identifying possible nano-materials for improving thermal dissipative properties of epoxies: 2 routes

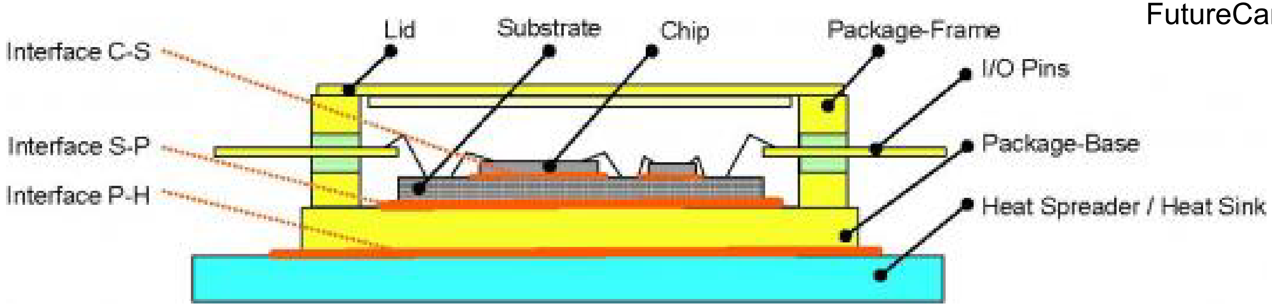
- ► Standard space qualified epoxy (semiconductor industry) filled with Ag-microparticles) + CNT
- ► Standard epoxy material + nano-particles (BN, Ag-nanoparticles, carbon black)+ CNT

2nd task: Breadboarding and testing for thermal/mechanical properties

Most performant modified die attach material

- ► Validation
- ► Measurement/characterisation of hybrid circuit demonstrator

Main subcontractors to HPS :
FutureCarbon (D), KT (D), RHE (D),



Development of a CFRP Electronic Housing
Customer: ESA/ESTEC (2005-2007)

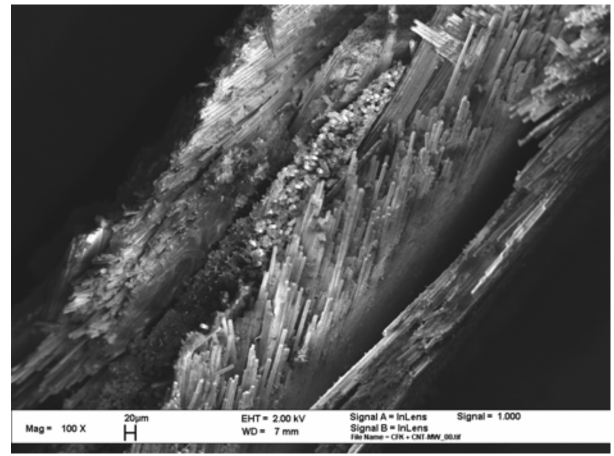
CFRP structures + CNT:

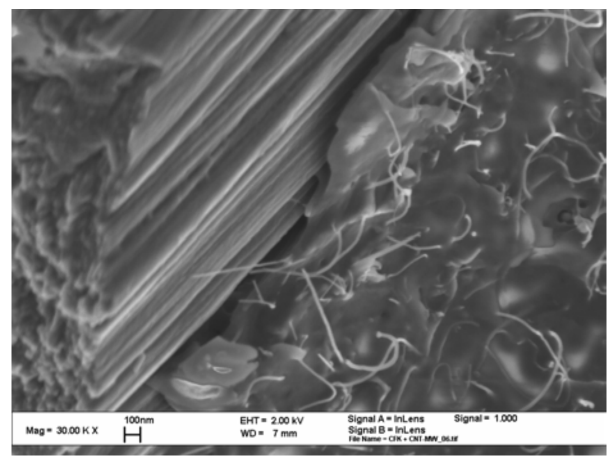
Mechanical strength is only slightly increasing, electrical conductivity ⊥ to the fibre orientation: increases by 1-2 orders of magnitude.

→ potential for excellent electromagnetic shielding performance

→ better thermal conductivity (good thermal control of hot electronic boards)

→ good electrical conductivity between the plates (grounding).





Thank you for your attention!

Questions?

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