

Aerospace Nanotube Hybrid Composite Structures with Sensing and Actuating Capabilities – the **NOESIS** project

*by Dr. George Maistros
INASCO Hellas & NOESIS Consortium*

the path of an EC funded research project
Framework 6 – Aeronautics & Space area



EuroNanoForum 2009
3 June 2009 - Prague



The NOESIS project

Project partners

1.  INASCO Hellas (co-ordinator)
2.  ATECA
3.  BRIMALM Engineering
4.  Swerea SICOMP
5.  IVW
6.  CNRS-CRPP
7.  INASMET Fundacion
8.  Centro Ricerche FIAT
9.  Weizmann Institute of Science
10.  Technische Universitaet Hamburg-Harburg
11.  University of Patras
12.  SENER Ingenieria y Sistemas
13.  Israel Aircraft Industries Ltd. - IAI
14.  ARKEMA
15.  Hellenic Aerospace Industry

Facts and figures

Start date: 1/4/2005

Finish date: 30/6/2009

Total effort: 538 man-months

Total cost: €4.97 Million

Workplan: 6 technical WPs
1 exploitation WP
1 management WP

- 7 nations
- 3 large companies
- 3 SMEs
- 1 engineering firm
- 4 research institutes
- 4 universities



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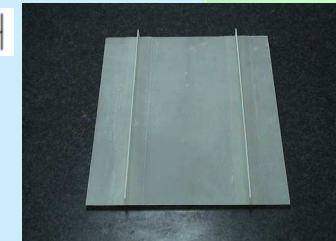
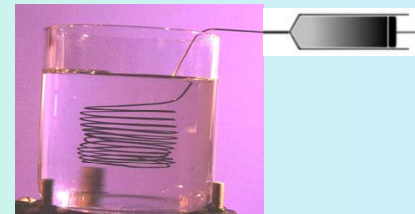
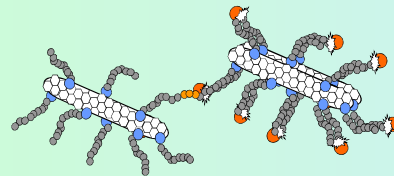
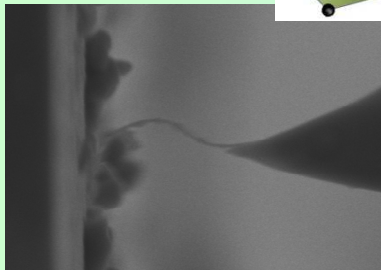
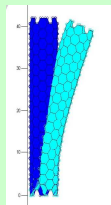
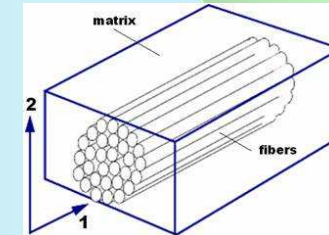
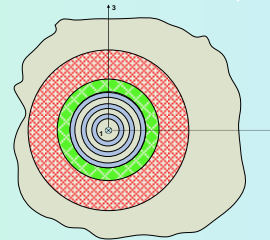
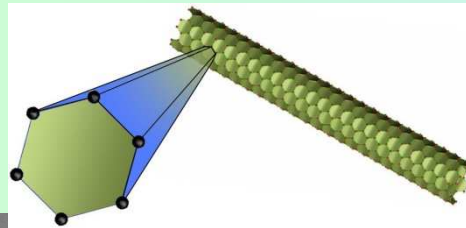
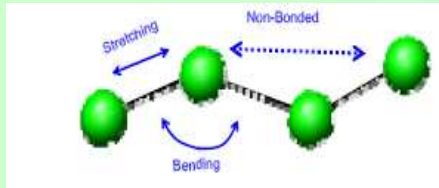
NOESIS field of activities

- Forming of CNT structured assemblies embedded into resin systems while retaining sensing / actuating properties and providing the desired mechanical performance
- Enhancement of the electrospinning process as a means to realize alignment and carriage of CNTs in the form of nano-fibres
- Devising/implementing multi-scale approach in designing nanocomposites
- Design of a coupled platform for mechanical / sensing-actuating behaviour predictions
- Development of stimuli-response nanocomposites as actuators

nano-scale



macro-scale



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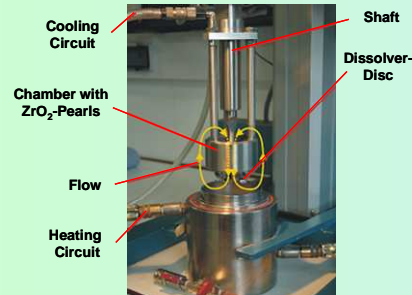
NOESIS technology description [1]

Description: CNT inclusions in thermoset matrices (Level 1) and CNT/CFRP composite manufacturing processes (Level 2)

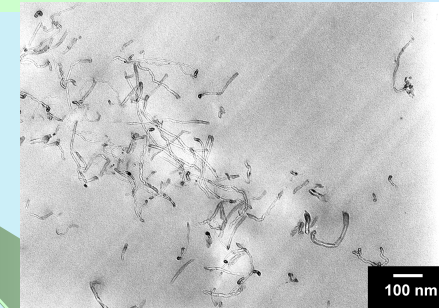
Dissolver



Torus Mill



Sonication

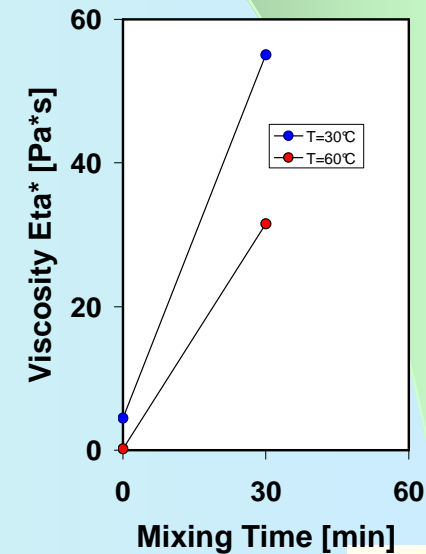


Good dispersion of CNTs in resin matrix has been achieved

Readiness: TRL 5 (Fidelity of breadboard technology increases significantly)

Industrial need: Demand of new additives or reinforcements (such as CNTs, CNT fibres or CNT mats) in advanced composites offering multi—functionality, while reducing weight and improving maintenance potential (repairability)

Quality index of dispersion is the resin viscosity

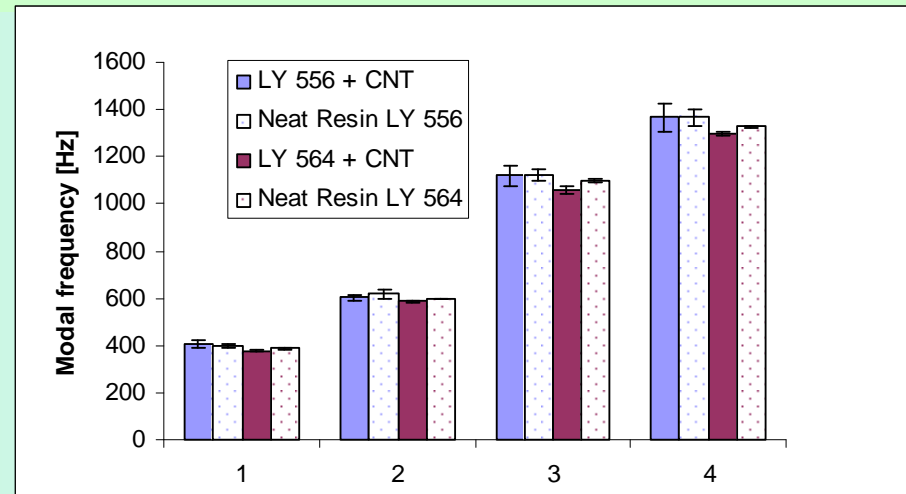
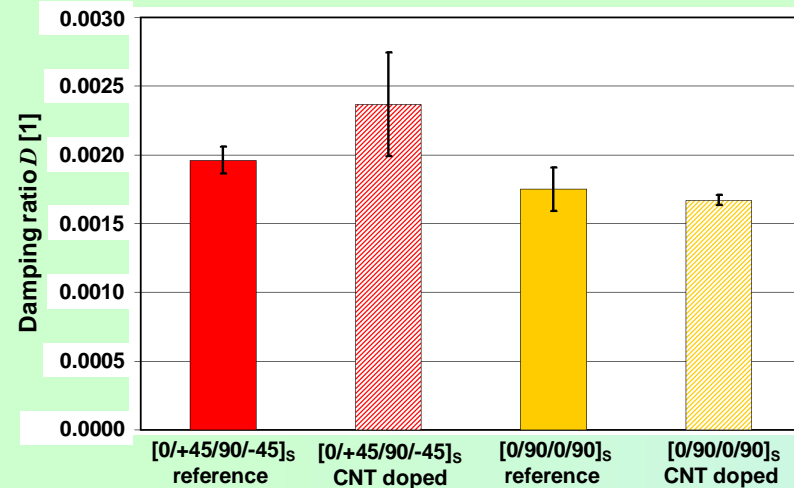


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NOESIS technology description [2]

Description: improving mechanical performance of aeronautical composites through the addition of CNTs



Results show little impact of CNT content on mechanical performance of resins & composites (improvement in fatigue and tensile modulus, dependence on mixing quality)

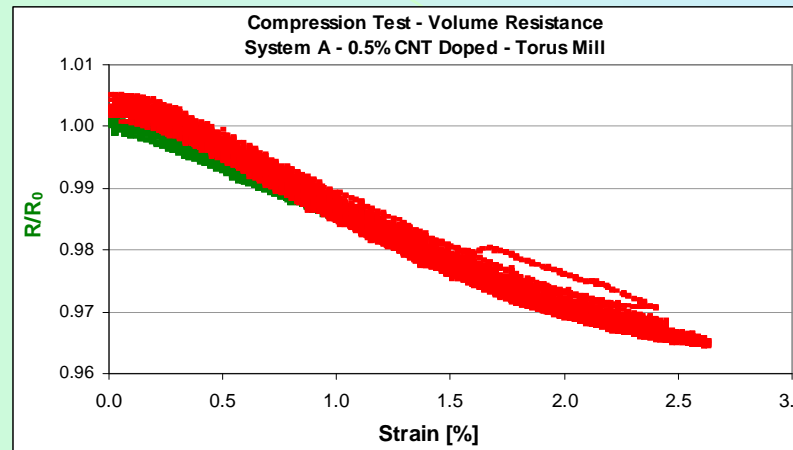
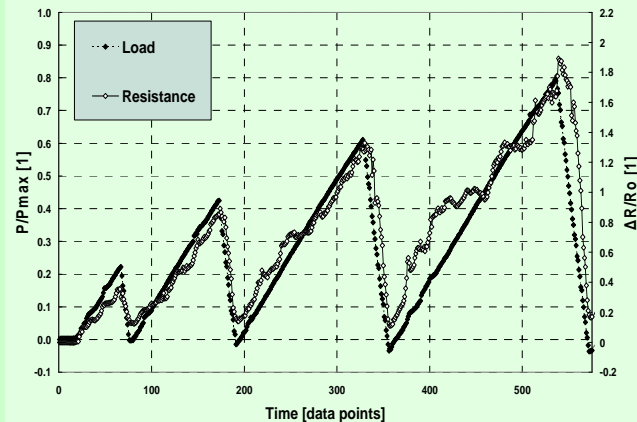
Readiness: TRL 4 (Basic technological components are integrated to establish that they will work together – currently ‘low fidelity’)

Industrial need: Demanding increased conductivity (lightning strike protection) and mechanical performance improvement (energy absorbance, fatigue improvement) of aeronautical composite materials through addition of CNTs in thermoset matrices



NOESIS technology description [3]

Description: sensing in composites loaded with CNTs and CNT fibres
(specifications, modelling, design and implementation)



*Good correlation
of conductivity
and strain for
CNT doped
systems and CNT
fibres in
composites*

Readiness: TRL 6 (Representative model or prototype system is tested in a relevant environment)

Industrial need: Establishing simple, reliable and accurate method of measuring strain in structural composites for in-service monitoring and fault detection through the use of CNT network or CNT structured arrays as embedded sensors



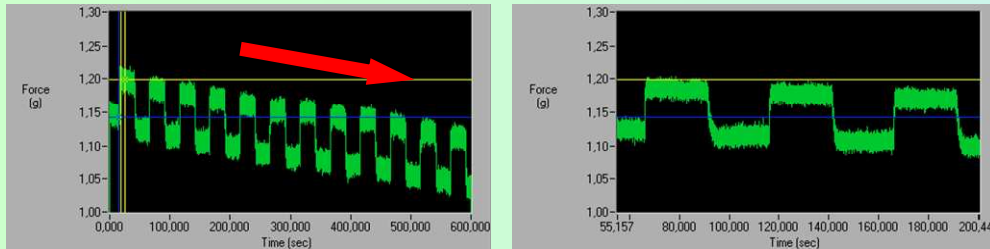
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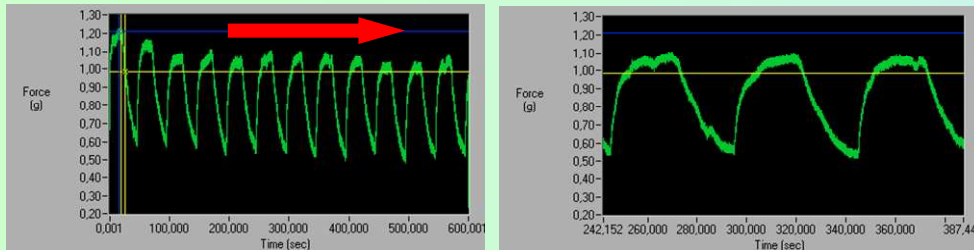
NOESIS technology description [4]

Description: actuation in composites loaded with CNTs and their arrays (specifications, modelling, design and implementation)

Annealed SWNT fiber



Annealed SWNT/resin P6 fiber

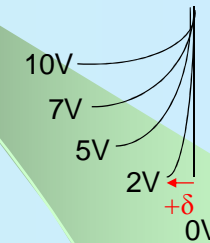


CNT-COOH/PVA paper

Deposit of Au
Deposit of PVA



Test at constant frequency (0,05Hz) and variable voltage (0, 2, 5,7,10V)



Actuation potential has been developed via charge injection and ionic swelling; however the stress levels are not sufficient for aeronautical applications

Readiness: TRL 3 (Active research and development is initiated)

Industrial need: Proving the potential of active shape change in advanced composite structures through the inclusion of CNT-based architectures with capacity to produce stresses when they are loaded with electrical current

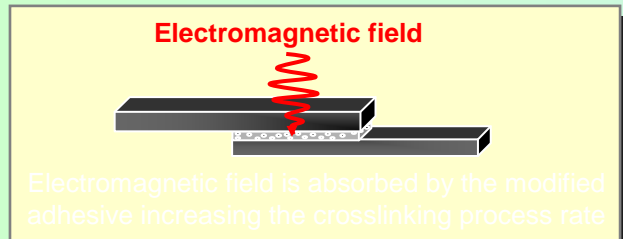


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NOESIS achievements

Demonstrators: several cases of property and processing enhancement were studied: CNT reinforcement of adhesive joints, conductivity enhancement of composites, health monitoring of structure integrity

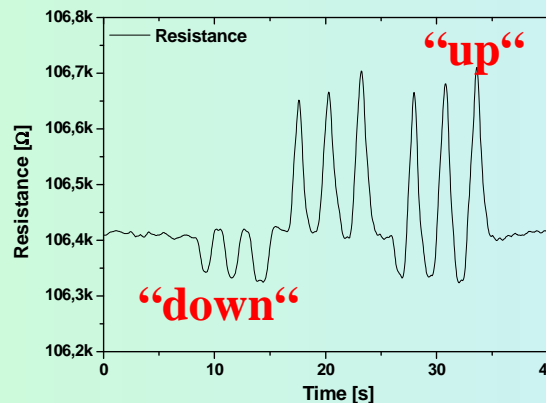
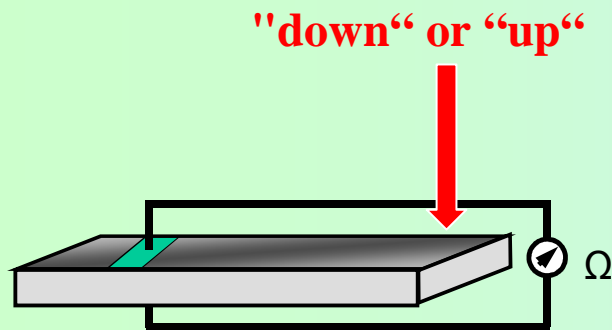


Thermal conductivity effects: CNTs dispersed in resin amplify degree of cure and affect cure rates at microwave curing of resins



Electromechanical test: CNT act as piezoresistive agent at any deformation

Nano-reinforcement: CNT hollow spheres for crash energy absorption



Sensing strain: CNTs dispersed in resin increase conductance of the thermoset and the changes of resistance can be used to estimate strain levels



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NOESIS technology benefits and risks

Benefits: All these can lead to improved and multi-functional composites structures, optimised structural design criteria and fail-safe features, while facilitating processing and reducing component weight.

Impact: The application potential is not only limited to aerospace structures. The experience from this project is of great interest also for other industrial innovations as in fabrication techniques for processing structural composites with sensor and actuator integration or automotive systems, electronic packaging, deployment of compacted structures in space, and self-healing surfaces and coatings.

Risks: There are not clear risk assessment in the application of CNTs in aeronautical applications. The cost of pure CNTs may become an issue (in case of CNT fibre reinforcements) as cost reduction is a strong driver in the transport sector.

Recommendation: Multi-disciplinary research groups offer the potential for targeted technological development and fast knowledge transfer of nanotechnology to several industrial sectors. These activities should be encouraged and actively supported.



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Many thanks
(from the NOESIS Consortium)
to the organisers
for allowing NOESIS output
to be disseminated
to the Euro Nanotechnology forum

Welcome to attend
NOESIS industrial seminar
for more details and follow-up actions
Venue: ARKEMA, Pau, France
Date: 25 June 2009
Contact: g.maistros@inasco.com



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