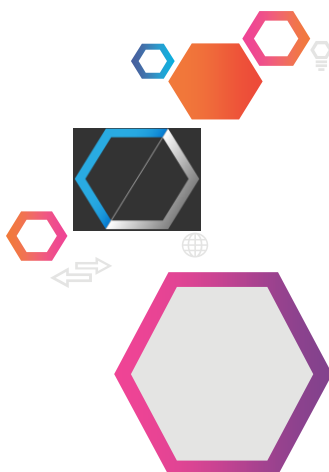




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MODCOMP

*“MODIFIED COST EFFECTIVE FIBRE BASED
STRUCTURES WITH IMPROVED MULTI-
FUNCTIONALITY AND PERFORMANCE”*



NEXT GENERATION OF CARBON FIBRE BASED MATERIALS



This project has received funding from the European Union's Horizon 2020 research and innovation programme, European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme, Industrial Technologies, Advanced Materials and Nanotechnologies, H2020-NMP-2014-2015/H2020-NMP-2015, under grant agreement No. 685844.



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MODCOMP project meeting

The month 30 project meeting took place on 6th and 7th of September 2018 in Brussels, Belgium. The main focus was on the tasks and deliverables accomplished during the last six months of the project.

The following topics were presented:

Functionalization and surface modification of fibres, Production of high performance fibre-based structures, Characterisation and testing of

performance, Modelling, Life Cycle Analysis, Nanosafety and Risk analysis, Scale up / Demonstration, Characterisation of demonstrators, Exploitation and Dissemination activities, management of the projects and all the obligations towards the European Commission.

After the formal part of the meetings, there were also group meetings on a certain topics within the project.



MODCOMP project partners at the 30 Month Project Meeting in Brussels, Belgium





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Participation in Conferences and Events

Carbon Fibre & Advanced High Performance Composites (CFPC) Cluster

The last 6 months lot of activities of the CFPC cluster took place, in which MODCOMP participated. In May 2018, the “CFPC Roadmap exercise” was organised in the European Commission, in Brussels, where core partners from the cluster met to set the main structure of the Composites Roadmap. The same month, experts on CFs and composites hold a meeting in Dresden, which resulted in the establishment of the **Global Scientific Association of Carbon Fibres (GSAC)**.



GSAC, Dresden 2018

The 40 scientists from Europe, Asia and USA that participated are confident that GSAC will give impetus to research and industry.



Roadmap Exercise, Brussels 2018

In June 2018, the **7th CFPC Cluster Workshop** took place in **Chios, Greece**. During the meeting, an overview of what has been achieved till now was presented by NTUA. Dr. Elias Koumoulos presented the Roadmap Status and Perspectives.

Four invited speakers attended the Workshop: Dr. Paolo Bondavalli, who presented THALES achievements in MODCOMP, Sylvia Rueda, who presented ACCIONA's achievements and MAS-TRO Project and Dr. Fabio Pegorin, who presented the recent advancements of Ghent University in composites. Finally, the EuMAT platform and its possible linkage with CFPC was presented by Amaya Igartua.



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The invited speakers of the Workshop



Dr. Elias Koumoulos presenting the main pillars of the CFPC Roadmap

Finally, in October 2018, two events in collaboration with EuMaT were held. Prof. Costas Charitidis attended the **Steering Committee meeting of EuMaT**,

which was held in Brussels, in the beginning of October, while at the end of October, the **Industrial Technologies** took place in Vienna, Austria.

Athens Science Festival 2018

The Athens Science Festival, the festival devoted to Science and Innovation since 2014, is an established cultural landmark in the field of Science, Technology, Innovation and Art in Greece!

For over 5 days every year, residents and schools in and around Attica have the opportunity to explore scientific and technological advancements in an entertaining, innovative and interactive manner. At the same time, researchers, distinguished scientists, educators and artists give their best to communicate science and indulge the visitors to participate in their experience with it. Since its introduction to the people of Athens in 2014, Athens Science Festival has collaborated with more than 3,600 scientific associates, 470 speakers, 240 artists

and 1,100 volunteers. The Festival is repeatedly justifying its social impact having exceeded initial expectations and having reached out to more than 90,000 visitors over the past 4 years. As such, the Athens Science



Festival is righteously considered as one of the largest science and technology festivals in Greece. In this framework, NTUA attended presenting MODCOMP achievements and demonstrating samples of CFs and composites. Kate Trompeta, M.Sc. and Dr. George Konstantopoulos were representing NTUA in the Athens Science Festival 2018.



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Researcher's Night 2018

NTUA opened its gates on Friday, September 28th 2018 for the 5th year, to hold the Researchers' Night at the emblematic Averof building at the Patision historic complex. The aim of the event was to re-invent the connection between Academia and Society, by inviting the public of Athens, to meet hundreds of researchers and understand that research is "serious" but can also be fun. MODCOMP project was on the core side and its main achievements so far were presented during the event. Carbon fibres, composite panels, carbon nanotubes and dispersions were demonstrated to the public.

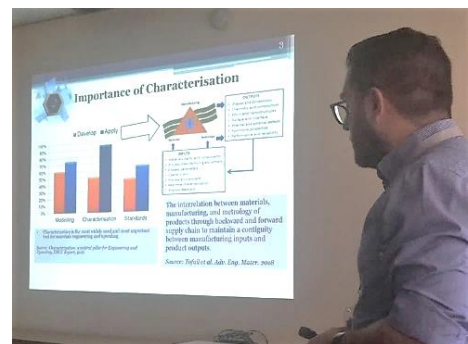


Demonstration of a composite panel, the specimens of which were used for mechanical testing

ICEAF V, Chios 2018

The series of the **International Conference of Engineering Against Failure (ICEAF)** aims to provide on a bi-annual basis a Forum to present relevant scientific and technological achievements and discuss with an audience of international experts. The scope of the Conference was to attract interdisciplinary work dedicated to prevent and design against the engineering failure. In ICEAF V, two MODCOMP studies were orally presented, namely:

- Elias P. Koumoulos, Panagiotis Kainourios, Costas A. Charitidis: **Assessing the integrity of CFRPs through nanomechanical mapping: the effect of CF surface modification.**



Dr. Elias Koumoulos presenting at ICEAF V

- D. Semitekolos, P. Goulis, D. Batsouli, E. Koumoulos, L. Zoumpoulakis, C.A. Charitidis: **Enhancement of mechanical integrity of advanced composites using PMAA-electropolymerised CF fabrics.**



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Diploma Thesis Presentations in NTUA

In July and October 2018 diploma thesis presentation sessions were held in NTUA. The thesis entitled: **“Manufacturing of epoxy matrix composite materials, reinforced with CNTs and CFs via vacuum infusion technique and the evaluation of their mechanical properties”**, was presented by O. Tarnaris, under the supervision of C.A. Charitidis. The thesis was performed under MODCOMP’s framework and dealt with the manufacturing of composites via vacuum infusion, as well as their mechanical assessment. Also, in the same concept, the master thesis

entitled: **“Composite manufacturing with functionalised carbon fibres”**, was presented by D. Semitekolos, in the framework of the Materials Science and Technology Master Program.



Dionysios Semitekolos presented the work with the title: **“Manufacturing of polymer composite materials with modified carbon fibres”**.

Green Chemistry and Technology, Edinburgh, Scotland, November 12-13, 2018

Alberto Tagliaferro presented a joint work between POLITO and NTUA with the title: **“Investigation of Carbon Nanotubes Surface Functionalisation through RAMAN and XPS Analysis”**, authors: M. Giorcelli, K. Trompeta, A. Tagliaferro, C.A. Charitidis.



Alberto Tagliaferro, Ph.D. during the presentation



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Material Science Conference and Times of Polymers (TOP) & Composites Conference

Mauro Giorcelli (POLITO) participated at two conferences where he presented MODCOMP project.

In particular, he discussed about the carbon fibre functionalization by plasma treatments made in collaboration with University of Birmingham (UoB).



M. Giorcelli, Ph.D. at TOP Conference (Ischia, Italy) during poster session

At the **TOP Conference** (June 22-24, Ischia Italy), where industrial audience meets academics, he

had the opportunity to share main MODCOMP results, in particular on carbon fibres functionalisation, that can be used for composites preparation.

Few days later (June 25-27, Rome Italy) he participated at **Material Science Conference 2018** where he presented to the audience MODCOMP project in oral and poster sessions.



M. Giorcelli, Ph.D. (right) at Material Science Conference 2018 (Rome) during poster session

The ICCE-26 conference

Alberto Tagliaferro participated to the ICCE-26 conference, July 15-21, Paris, France, one of the most relevant conference on composites worldwide, and presented in an oral communication with the title: **Epoxy resin with MWCNT filler for**

experimental validation of an electrical conductivity model, Authors: Mauro Giorcelli, Massimo Rovere, Matteo Fasano, Rajat Srivastava, Shahin Mohammadnejad, Eliodoro Chiavazzo, Pietro Asinari and Alberto Tagliaferro.



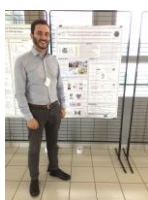
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36th UIT – Heat transfer conference

Pietro Asinari presented the MODCOMP results of POLITO (WP4) at the conference “36th UIT – Heat transfer conference”, Catania (Italy), June 25-27, 2018.

Presentation title was: “*Multiscale simulation of the thermal properties of polymeric composite materials reinforced with carbon nanofillers*”, <http://www.uitconference.com/>

CECAM Workshop: Hot colloids



Matteo Fasano presented the MODCOMP results of POLITO (WP4) at the workshop “[CECAM Workshop: Hot colloids](#)”, Lyon (France), June 11-13, 2018.

Mr. Fasano presented also the Poster with the title: “Multi-scale thermal transport through dispersions of carbon nanoparticles in polymeric matrices”.

The 14th International Conference on Flow Processes in Composite Materials, 30th May – 1st June, 2018, Luleå, Sweden,

Extended abstract and oral presentation: ‘Scaling-up production of CNT-coated fibre reinforcement using EPD for high-performance and multifunctional composites’ Authors: Guan Gong, Birgitha Nyström, Erik Sandlund, Daniel Eklund, Maxime Noël, Robert Westerlund, Roberts Joffe, Liva Pupure, Andrejs Pupurs.

The 29th Annual International SICOMP Conference, 28th -29th May, 2018, Luleå, Sweden,



Oral presentation with the title: ‘Potential, status, challenge and inspiration of nano-modified polymer composites – A specific case study when up scaling the production of CNT-coated fibre using continuous EPD for advanced composites’ was presented by Ms. Guan Gong, Ph.D. (picture on the left) at the 29th Annual International SICOMP Conference.

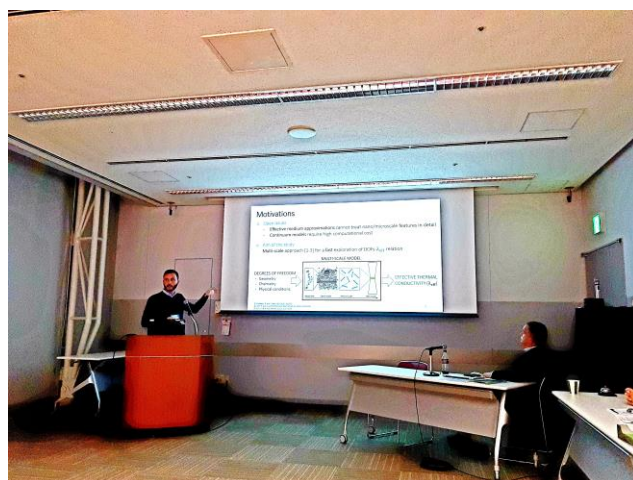


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Multiscale Materials Modeling 2018 conference

Mr. Matteo Fasano attended the “Multiscale Materials Modeling 2018” conference (<http://mmm2018.jp/>), where he presented the MODCOMP project. The presentation with the title **“Thermal transport in polymer-based nano-composite materials across multiple scales”**, authors: Rajat Srivastava, Matteo Fasano, Shahin Mohammadnejad, Hernan Chavez Thielemann, Eliodoro Chiavazzo, Pietro Asinari, took place on November 1 2018, in Osaka (Japan).

The book of abstracts is available [here](#).



Matteo Fasano, Ph.D. at the CECAM Workshop

Renewable Energy meets High Performance Computing: Final Conference of the Energy-Oriented Centre of Excellence

Pietro Asinari presented MODCOMP results at the conference **“Renewable Energy meets High Performance Computing: Final Conference of the Energy-Oriented Centre of Excellence”** organised by [EoCoE](#).

The presentation took place on September 17 2018, in Nicosia (Cyprus). Title: **“Multiscale simulation of the thermal properties of materials for energy applications”**.

Authors: Annalisa Cardellini, Matteo Fasano, Rajat Srivastava, Matteo Alberghini, Hernan Chavez Thielemann, Shahin Mohammadnejad, Eliodoro Chiavazzo, Pietro Asinari.



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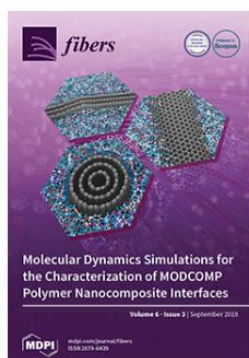
Publications in Journals and Conference proceedings/Workshops:

- Koumoulos, E.P.; Charitidis, C.A.: ["Integrity of Carbon-Fibre Epoxy Composites through a Nanomechanical Mapping Protocol towards Quality Assurance"](#), *Fibers* 2018, 6, 78.
- D. Semitekolos, P. Kainourgios, C. Jones, A. Rana, E. Koumoulos, C.A. Charitidis: ["Advanced CF composites via PMAA surface treatment; surface analysis and mechanical properties investigation"](#), *Composites Part B*, 2018.
- E.P. Koumoulos, Y. Liang, X. Li, H. Dong, C. Charitidis: ["Assessing the integrity of CFRPs through nanomechanical mapping and push-out tests: the effect of CF surface modification"](#), *FEMS* 2018.
- G. Stamatopoulos, D. Modi, C. Lira, N. Pantelidis, M. Stojkovic: ["Development of a procedure for accurate simulation of the resin transfer moulding process"](#), ECCM18 - 18th European Conference on Composite Materials at Athens, Greece, 24-28th June 2018.
- Carlos Sáenz Ezquerro, Manuel Laspalas, Agustín Chiminelli, Francisco Serrano and Clara Valero: ["Interface Characterization of Epoxy Resin Nanocomposites: A Molecular Dynamics Approach"](#), ECCM18, Fibers Editorial Office, MDPI, Base, Switzerland, 2018.
- Dionysios A. Semitekolos, Panagiotis Goulis, Despoina Batsouli, Elias P. Koumoulos, Loukas Zoumpoulakis and Costas Charitidis: ["Enhancement of Mechanical Integrity of Advanced Composites using PMAA-Electro-polymerised CF Fabrics"](#).
- Elias P. Koumoulos, Panagiotis Kainourios, Costas A. Charitidis: ["Assessing the integrity of CFRPs through nanomechanical mapping: the effect of CF surface modification"](#).
- Alessandro Crisafulli, Ali Khodayari, Shahin Mohammadnejad and Matteo Fasano: ["Sliding Dynamics of Parallel Graphene Sheets: Effect of Geometry and Van Der Waals Interactions on Nano-Spring Behavior"](#).
- Manuel Laspalas, Agustín Chiminelli, Carlos Saenz, Francisco Serrano and Clara Valero: ["Analysis of the elastic properties of CNTs and their effect in polymer nanocomposites"](#), International Conference of Engineering Against Failure, ICEAF V, Chios, 2018.
- Dionysios Semitekolos: ["Manufacturing of polymer composite materials with modified carbon fibres."](#), Thesis/Dissertation.
- Paolo Bondavalli, Gregory Pognon, Elias Koumoulos and Costas Charitidis: ["Dynamic Air-Brush Deposition Method for the New Generation of Graphene Based Supercapacitors"](#).



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- M. Giorcelli, P. Mandracci, A. Tagliaferro: ["Fibre functionalization by plasma treatment"](#), Journal Nanomaterials & Molecular Nanotechnology, June 2018 Volume 7, page 40, published by: International Conference on Material Science and Engineering, Rome, Italy, 2018.
- Santiago Corujeira Gallo, Xiaoying Li, Zhenxue Zhang, Constantinos Charitidis,, Hanshan Dong: ["Viscoelastic response of carbon fibre reinforced polymer during push-out tests"](#), Journal: Composites Part A: Applied Science and Manufacturing, ELSEVIER, Neetherlands, June 2018.



Molecular Dynamics Simulations for The Characterization of MODCOMP Polymer Nanocomposite Interfaces

Fibers, Volume 6, Issue 3 (September 2018)

Special Issue devoted to MODCOMP in Fibers Journal

Lectures for the Students

Matteo Fasano presented some MODCOMP results of POLITO (WP4) during a lecture for the students of the course **"Advanced topics of Engineering Thermodynamics"** of the MSc degree in Mechanical Engineering at Politecnico di Torino, Torino (Italy), May 15, 2018. Presentation title: **"An introduction to classical molecular dynamics modelling"**.

Mr. Fasano also presented the MODCOMP results of POLITO (WP4) during a lecture for the students of the course **"Materials for energy applications"** of the MSc degree in Energy Engineering at Politecnico di Torino, Torino (Italy), April 20, 2018. Presentation title: **"MODCOMP Presentation to AEM course"**.

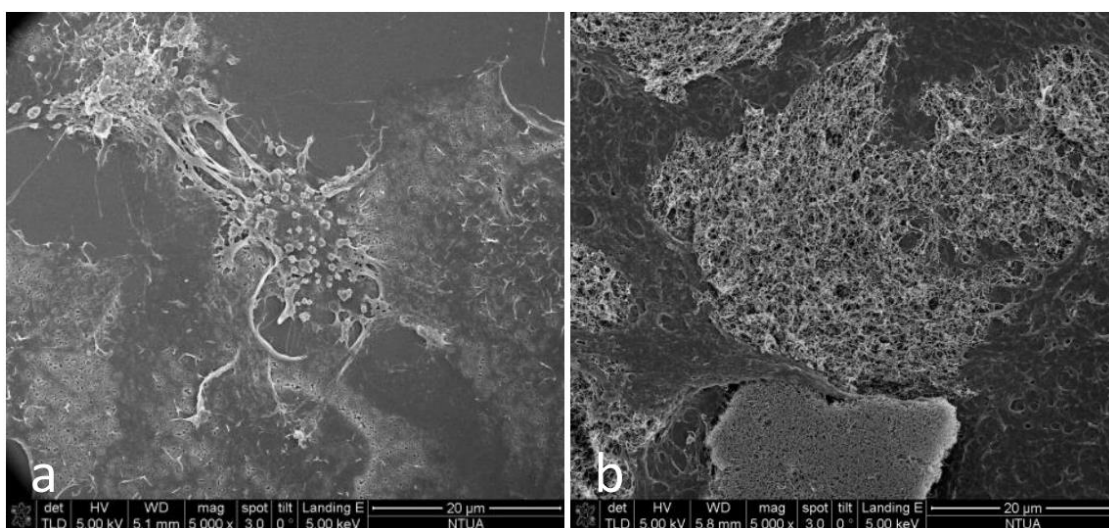


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Recent Research Achievements

Cytotoxicity assessment of carbon nanotubes

NTUA in collaboration with IRES successfully accomplished D5.1: Release and Exposure Assessment, in September 2018. One of the goals of this study was the evaluation of the potential cytotoxic effect of multiwalled carbon nanotubes (MWCNTs) either in their pristine form (not functionalized) or after their functionalisation with oxygen containing groups, by applying the instructions and protocols reported in the ISO 10993-5. Cell attachment and cell morphology was assessed through SEM. SEM micrographs revealed a firm interaction between the cultured cells' surface and the MWCNTs. Both in the case of not functionalized and functionalized MWCNTs the cells' morphology appeared altered and distorted compared to the morphology of the cells in the control sample, thus indicating that the presence of MWCNTs negatively affect cells viability. It is evident that MWCNTs established unyielding contacts with the cellular membrane and as the time that cells remained in contact with MWCNTs increased, the cellular membrane started to break down, suggesting that cells will initiate their apoptotic process. In the case of not functionalized MWCNTs this effect was milder, which can be attributed to the absence of the carboxylic groups (present in functionalized MWCNTs).

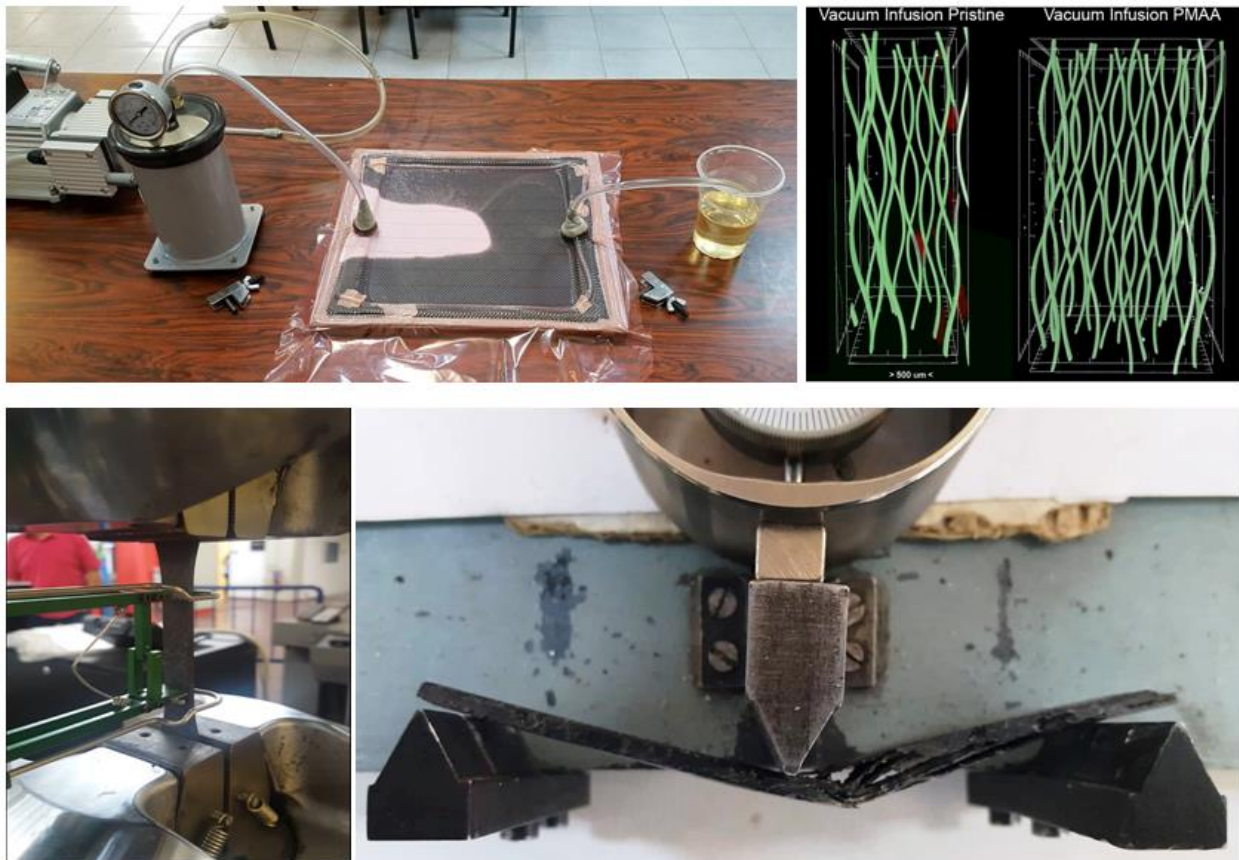


SEM micrographs showing cells morphology in contact for 3 hours with a suspension of 50 µg/ml of (a) not functionalized MWCNTs and (b) functionalized MWCNTs

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Manufacturing, Structural Characterisation and Mechanical Testing of Composites

NTUA for the last six months worked in WP3: Characterisation and Testing of Performance, on the manufacturing of composites with carbon fibre fabrics that have undergone different surface treatments (e.g. plasma from POLITO, electropolymerisation with PMAA from NTUA, etc), through the vacuum infusion technique. After the manufacturing of the composites, NTUA evaluated the structural characteristics with micro computed tomography analysis. Then, mechanical testing in macro-scale took place; tensile testing, as well as bend and shear testing. The results revealed that Atmospheric Plasma treatment (APP) by POLITO, offered increased tensile properties, while PMAA on the CFs led to increased interlaminar shear strength.



Manufacturing of composites through vacuum infusion, μ -CT analysis and mechanical testing (tensile & bend testing).



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Simulation of lightning strikes effects

Last months, AED have been struggling with the so complicated issue of modeling the Lightning Strike (LS) effects on composite structures. Several software packages were used: ANSYS (HFSS and MECHANICAL) and ABAQUS (Electro-thermal tool).

The first software is implemented to carry out a qualitative comparison between several lightning strike protections: Expanded Copper Mesh (ECM), doped CNT resin, etc.

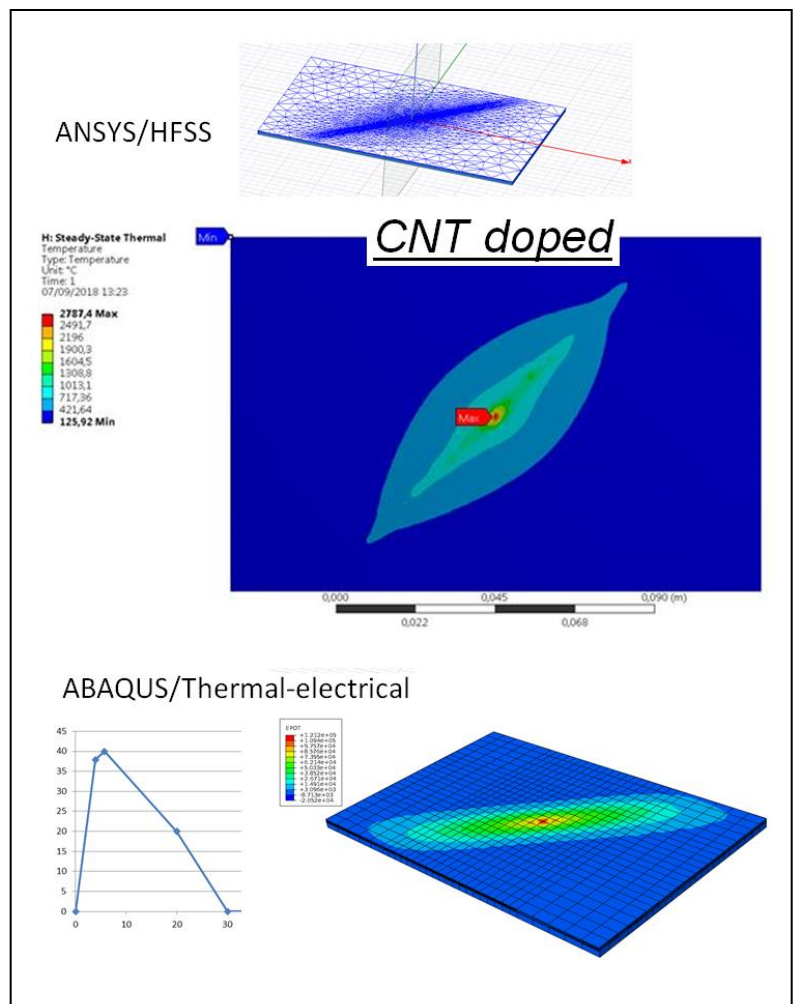
The second one has been used to obtain a reliable way to predict the lightning strike affected zone. This task is in progress with promising results.

It will be used to numerically reproduce the damage areas on the aeronautical demonstrators that are scheduled to be tested. This will provide a numerical feasibility approach to design new structures against LS.

This study will be a new contribution in the emerging field of the numerical analysis of the lightning strike phenomena effects.

The study has been carried out from May until now.

As it has been pointed out above, this tool will be helpful for the technology down selection process, in order to decide which composite modifications give the best combination of properties to deal with lightning strike composites.



Contact person: Yasser Essa, yasser.essa@aernnova.com; Ignacio Briones Clar, ignacio.briones@aernnova.com.

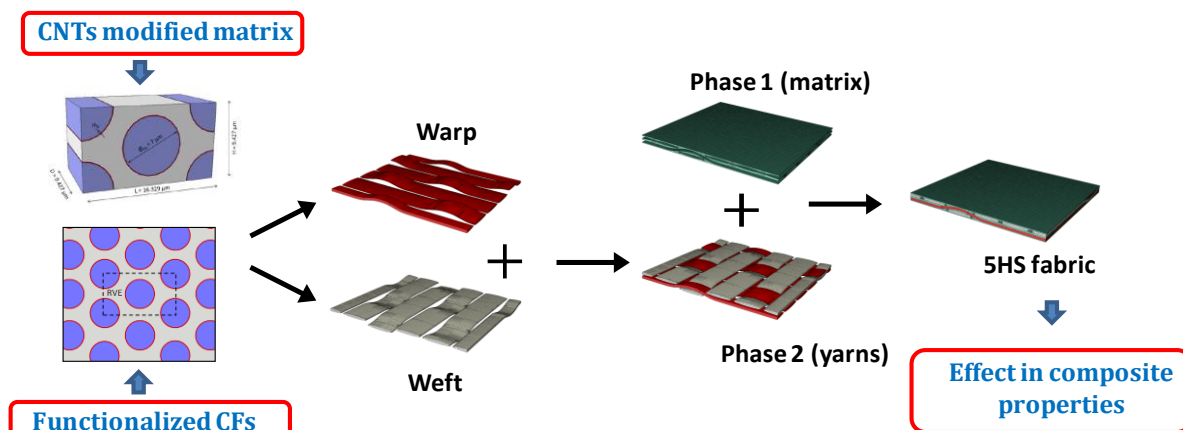
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Numerical analysis of structure-processes-property relationships

During period M24-M30, accordingly with the multi-scale approach proposed in the project, the effect of the CNTs resins modifications and the CFs functionalizations proposed have been studied through micro/mili scale FE continuum models.

These models are feed with the information obtained at lower scales (nano/micro models).

The analyses done allow to evaluate the improvements that could be obtained through the specific techniques being studied in MODCOMP in terms of mechanical, thermal and electrical properties.



Part of the results obtained from these simulations will be used for the demonstrators design in the next periods.

For further details, you can contact to achiminelli@itainnova.es

Studies of mechanical properties of carbon plastic made of initial and modified filler (HTA 40 CF) and resin improved with nano-particles

Yuzhnoye SDO is a scientific and design company. Yuzhnoye's main activity is the development of rocket and space technology. Existing manufacturing needs show growing requirements for innovative materials with new properties, to extend the applications in rougher and extreme conditions along with cost effective operation of products manufacturing.

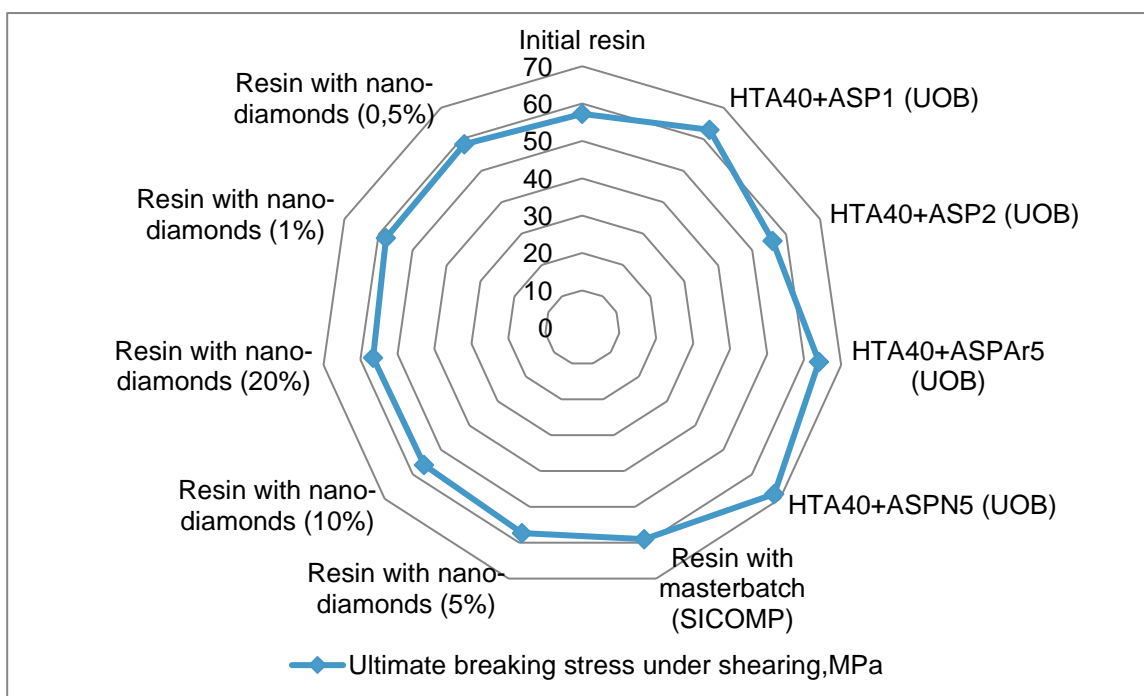


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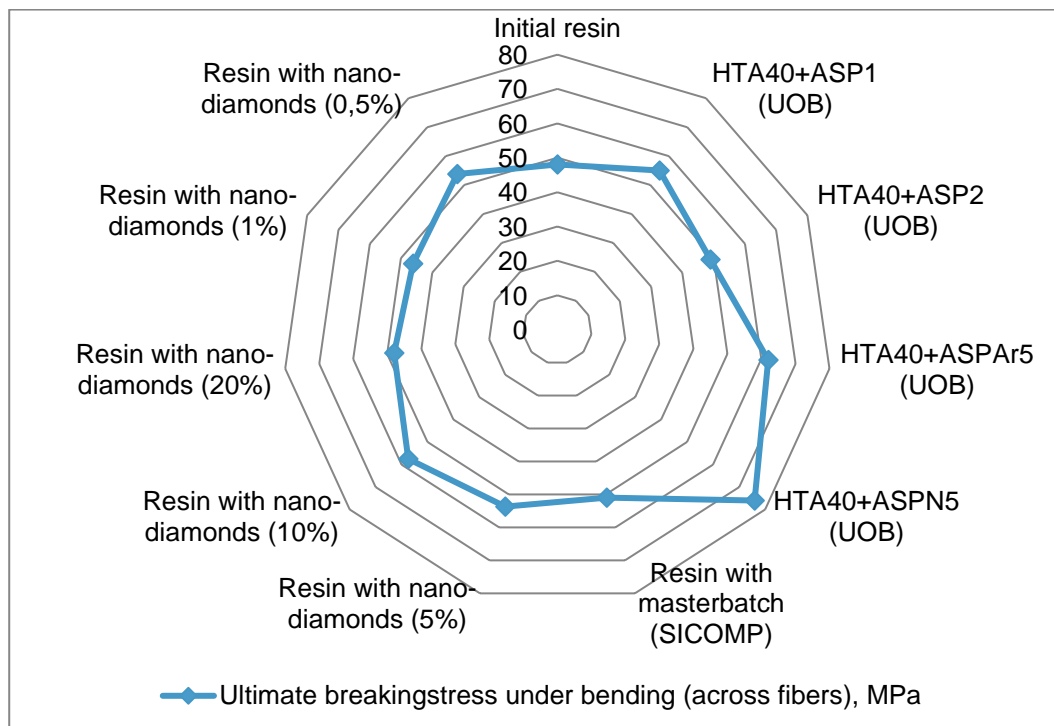
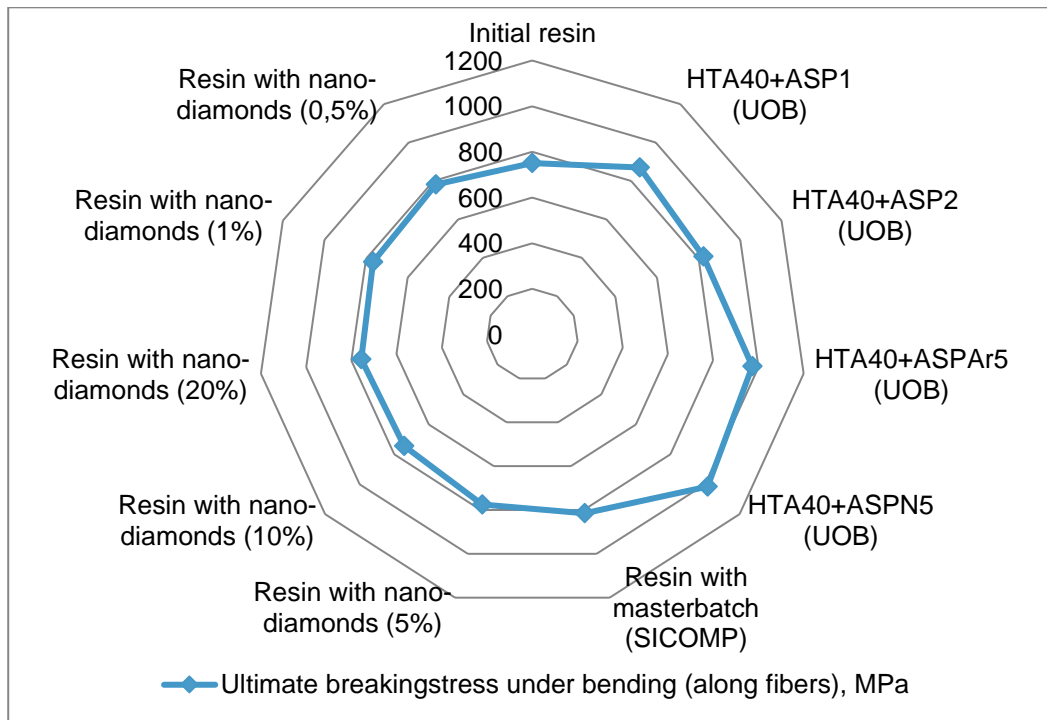
Currently, Yuzhnoye uses carbon-plastic as a material for manufacturing of our products, which is based on carbon fiber and epoxy resin. It is known that properties of carbon-plastic are depended to a great extent on adhesion strength of the “filler-resin” phase interface.

MODCOMP project is intended to develop different methods of improving and modifying both filler and resin. One of the filler modifying methods is active screen plasma treatment of different modes (ASP1, ASP2, ASPAr5, ASPN5), which were developed in University of Birmingham. Resin modifying methods is injection of nano-particles (masterbatch and nano-diamonds).

Yuzhnoye performed studies of treated filler (carbon-fiber HTA-40) mechanical properties characterization and resin (Araldite LY556/Aradur 917/ Accelerator DY070) with nano-particles (figure 1).



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Tests results of carbon-plastic, based on modified initial materials

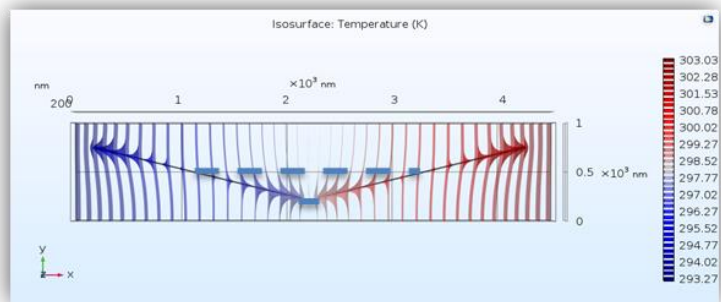
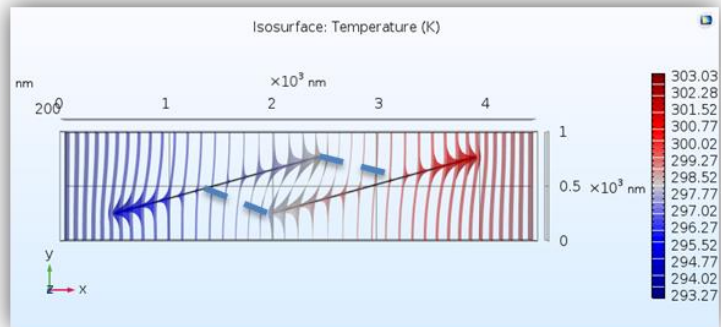
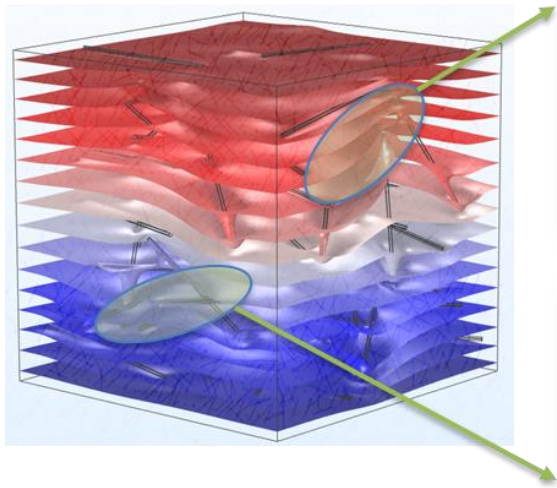
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The results from the shearing and bending tests showed an improvement for the carbon-plastic based on HTA-40 carbon fiber, treated by active screen plasma on ASPN5 mode. Therefore, Yuzhnoye SDO for manufacturing its demonstrator (small-scale mock-up) under the project will use that particular fiber.

Dataset for 3D shape factor between two cylinders

Shape factors (S) are a simple means of accounting for the geometric factors affecting conduction in 1D, 2D and 3D systems.

$$Q = -\lambda \frac{A}{\Delta x} \Delta T = -\lambda \textcolor{red}{S} \Delta T$$



We have considered two cylinders CYL1 and CYL2 with diameter D, and lengths L1 and L2, respectively. The coordinates of one end of the cylinders are denoted by CYL1_(x,y,z) and CYL2_(x,y,z). The other end can be calculated using following formulas:

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$$CYL1_X^e = CYL1_X + L_1 \sin(\theta_1) \cos(\phi_1)$$

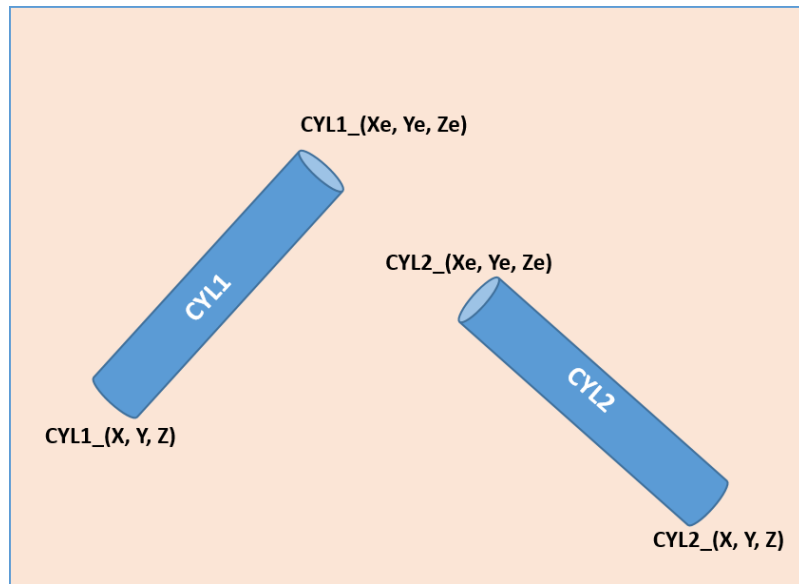
$$CYL1_Y^e = CYL1_Y + L_1 \sin(\theta_1) \sin(\phi_1)$$

$$CYL1_Z^e = CYL1_Z + L_1 \cos(\theta_1)$$

$$CYL2_X^e = CYL2_X + L_2 \sin(\theta_2) \cos(\phi_2)$$

$$CYL2_Y^e = CYL2_Y + L_2 \sin(\theta_2) \sin(\phi_2)$$

$$CYL2_Z^e = CYL2_Z + L_2 \cos(\theta_2)$$



The heat conduction shape factor (S) is computed for several configurations ($< 20,000$) of two randomly oriented cylinders in 3D space using finite element modelling (COMSOL). The results are stored in the dataset along with the geometrical configurations of the cylinders and uploaded on Zenodo.

The details of the dataset are as follows:

DOI : 10.5281/zenodo.1636187

Publication date: 28/11/2018

URL: <https://doi.org/10.5281/zenodo.1636187>

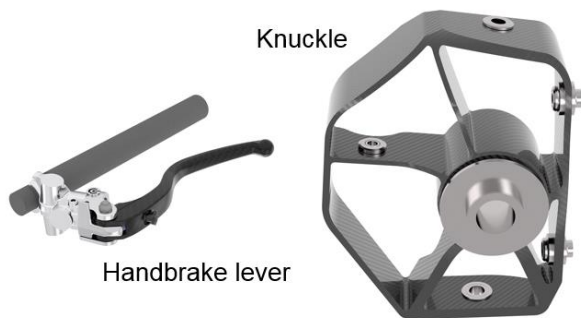
Title: Dataset for 3D shape factor between two cylinders

Authors: Rajat Srivastava, Matteo Fasano, Eliodoro Chiavazzo, and Pietro Asinari

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Handbrake lever and a knuckle

Within MODCOMP project Brembo is developing together with Sicomp and Yuzhnoye two demonstrators: a handbrake lever and a knuckle.



Both the demonstrators aim to reduce the weight of the components that are currently made by aluminum. The final target is to decrease the fuel consumption and consequently also the pollution.



Mold of the handbrake lever (ext. side)

The concepts of the components have been already defined and the preliminary simulations (FEA) were done. The mold of the handbrake

lever has been built and the initial prototypes will be available in the beginning of the next year (2019).



Simplified segment of the steering knuckle

A simplified segment of the steering knuckle has been manufactured and tested to check the stiffness and defined the final geometry of the prototype. The knuckle will be delivered in the middle of next year (2019).

Both the components will be tested by benches and apparatus available in Brembo S.p.A. in 2019, in order to verify their resistance to specific loads.

Contact person: Giorgio Valota (mail: giorgio_valota@brembo.it, phone: +39 035 605 2328).



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	<p><i><u>http://modcomp-project.eu/</u></i></p>
	<p><i>CONTACT US:</i> Prof. Dr. Costas A. Charitidis: <u>charitidis@chemeng.ntua.gr</u> Kate A. Trompeta: <u>ktrompeta@chemeng.ntua.gr</u></p>
<p><i>QR CODE</i></p>	
<p><i>SOCIAL MEDIA</i></p>	<p> <u>https://www.facebook.com/MODCOMPproject</u>  <u>https://www.linkedin.com/company/modcompproject/</u>  <u>https://twitter.com/comp_mod</u></p> <p>You can also use #modcomp on Social Media and get the newest information about the project progress from all partners.</p>