Newsletter, Volume 1

MODCOMP

"MODIFIED COST EFFECTIVE FIBRE BASED STRUCTURES WITH IMPROVED MULTI-FUNCTIONALITY AND PERFORMANCE"

NEXT GENERATION OF CARBON FIBRE BASED MATERIALS

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MODCOMP at a glance

MODCOMP develops the next generation of CF-based materials. It is a revolutionary and new approach in order to reach the novel engineered fibre-based materials for technical, high value, high performance products for non-clothing applications.

The realistic cost with improved functionality and safety is the necessity.

Demonstrators will be designed to fulfil scalability towards industrial needs.

Application of composites - Composites Leadership Forum, https://compositesuk.co.uk/about/industry/composites-leadership-forum (accessed on 15 June 2016)

End users from a wide range of industrial sectors (transport, construction, leisure and electronics) will adapt the knowledge gained from the project and test the innovative high added value demonstrators.

An in-depth and broad analysis of material development, coupled with dedicated multi-scale modelling, recycling and safety studies are conducted in parallel for two types of materials (concepts):

- **CF-based structures with increased functionality** (enhanced mechanical, electrical and thermal properties).
- **Carbon nanofibre (CNF) - based structures** for new flexible electronics applications.

Meanwhile, standardization, up-scaling, cost-effectiveness and production of reference materials are also considered.

Newsletter, Volume 1

MODCOMP contribution

Current technological demands are increasingly stretching the properties of traditional materials to expand their applications to more severe or extreme conditions, whilst simultaneously seeking cost-effective production processes and final products.

The aim of MODCOMP project is to demonstrate the influence of different surface enhancing and modification techniques on carbon fibre (CF) - based materials for high value and high performance applications.

These materials are a route to further exploiting advanced materials, using enabling technologies for additional functionalities, without compromising structural integrity.

CF based materials have particular advantages due to their lightweight, good mechanical, electrical and thermal properties. Current generation CFs have extensively been used in a multitude of applications, taking advantage of their valuable properties to provide solutions in complex problems of materials science and technology. The limits of the current capability of such materials, however, have now been reached.

MODCOMP provides new approaches to improve functionality in particular electrical and thermal properties as well as structural performance of fibre-based materials, by integrating nanostructures and/or using environmentally-benign surface treatment technologies.

The benefits of fibre-based materials have clearly been shown in aerospace applications, which require **lightweight, high strength, high stiffness and high fatigue-resistant materials.**

Therefore consortium focuses on the desire for fibre-based materials **for high value, high performance products** by demonstrating the successful development of functionalized fibre-based composites for a range of industrial applications.

The reduced cost of CFs are addressed by optimizing the fraction of fibres present in the composite without a detrimental reduction in performance. Small quantities of nano-fillers are introduced, which can significantly improve the overall functionality of the final product with a competitive total price.

Objectives

- **Objective 1:** Development of CF-based composites with multi-functionalities (i.e. a combination of enhanced mechanical properties, electrical conductivity, thermal stability, flexibility) by the incorporation of nanomaterials.
- **Objective 2:** Development of cost-effective manufacturing processes which consider **sustainability** and **recycling/energy** (new (bio) - precursors/ bioresins and life cycle), and **safety** (safe-by-design and toxicology).
- **Objective 3:** Evaluation of new configurations in lighter structural composite taking advantage of nanotechnologies to sustain damage from lightning strike for Zone 2A of the Horizontal Tail Plane.
- **Objective 4:** Looking for the optimum processes and the best multiscale reinforcement combinations using synergistically experimental testing and analytical together with computational modelling techniques.
- **Objective 5:** Use of the CF-based materials developed from MODCOMP to re-design final products with reduced weight (>20%), increased stiffness (>20%) and enhanced performance (faster response to driver actions and improved safety).
- **Objective 6:** Demonstration of innovative secure storage modules, flat pack shelter system and training sailing craft with reduced cost and high performance (corrosion, UV and abrasion resistance, rigidity and increased thermal properties).
- **Objective 7:** Promotion of the exploitation of industrial-preferred composite materials and standardize activities throughout the production chain.
- **Objective 8:** Dissemination of outputs for raising the profile of the new MODCOMP technologies.
- **Objective 9:** Identification of new potential market for the developed fibre-based composite materials in avionics, construction, and electronics industry.
- **Objective 10:** Evaluation of the industrial impact of MODCOMP-concept with respect to economic as well as technical aspects.
- **Objective 11:** Opening a new field of innovation based on materials and technologies development and push for the industrial leadership of Europe in strategic domains (electronics, defence, aerospace).

Coordinator and project partners

The MODCOMP consortium brings together **seventeen partners** from **Ten European States** and includes all the expertise and access to facilities needed to reach the ambitious aim of the project.

As no single organization or country has the capacity to successfully bring about the innovations and validations intended in MODCOMP on its own, a well-balanced consortium has been arranged, with partners that are complementary to each other and are willing to closely cooperate in creating a research environment as envisioned in **MODCOMP's ambitious aim.**

Prof. Dr. Costas A. Charitidis
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Project progress

Kick off meeting, 19 April 2016, Brussels, Belgium

The MODOCMP Kick off meeting took place on 19th of April 2016 in Brussels, Belgium. The project brought together 17 project partners from 10 European countries.

MODCOMP Consortium

The 48 months project will result in 64 deliverables and 11 major milestones, through which the researchers and experts are following 11 major objectives, presented in this Newsletter.

Mr. Achilleas Stalios, EC Project Officer emphasised the importance of this project following the aims and tasks and it is vitally contributing to the market and to the benefits that the project really provides to the industries.

Follow up project meeting, 4/5 October 2016, Zaragoza, Spain

The follow up meeting took place six months after the Kick off meeting and it presented the first project progress and work development. The meeting was held on 4th and 5th of October 2016 at Technological Institute of Aragon in Zaragoza, Spain. The main focus was on the project progress, which is in detailed presented in this Newsletter.
All project partners made a plan for the next activities.

Project meeting in Zaragoza, Spain

Follow up project meeting, 7/8 March 2017, Paris, France

Next project meeting took place from 7th till 8th of March 2017 in Paris, France at Thales Research & Technology (TRT) premises.

Project meeting in Paris, France

The main focus was on the tasks and deliverables done in the period from October 2016 until end of February 2017 and the plans for the next six months.

Review on recent development of surface modification technologies

The purpose of the review on the recent research work in the area of carbon fibre surface modifications and carbon fibre/polymer interfacial adhesion is to give us the good basis and the basic starting point for research on the MODCOPM project. In view of the research approaches proposed and the expertise, this review is in particular focused on recent development of surface modification technologies in the following three major areas: (1) Electrochemical treatment (led by National Technical University of Athens - NTUA); (2) atmospheric plasma & low-pressure plasma treatment (led by Politechnico di Torino - POLITO) and (3) active screen & hybrid plasma treatment (led by University of Birmingham - UOB).

Definition of characterization criteria

An understanding of the influences from specific treatment cycles for reinforcing composites by employing carbon nanofibers (CNFs) and their response to difference performance criteria aims to be developed. As such, it is essential that the characterisation techniques that were employed are described. A list of the characterisation criteria were created and defined for

each application in order to determine the composite's fitness for purpose.

The MODCOMP project has so far identified the key criteria, which are essential for the characterisation of the pre- and post-manufactured materials in programme. Further work will be done to establish a full set of criteria for each application.

Project website with content for public access

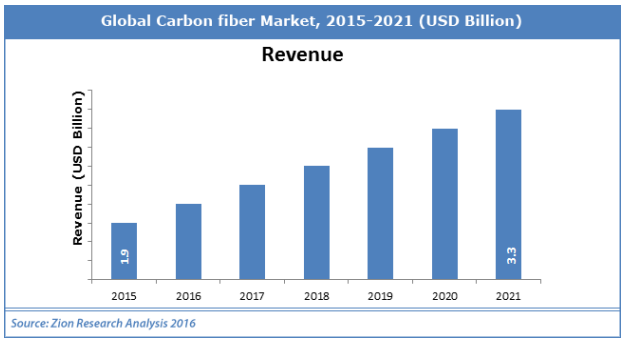
A primary means of keeping stakeholders apprised of the work involved in the MODCOMP project is the project website, which is one of the most important sources of information about the project available to most stakeholders.
The MODCOMP website can be accessed via the Internet at the following address:

http:/modcomp-project.eu/

The MODCOMP project website has been set up at the early beginning of the project (April 2016) and it's constantly updated. It provides general information about project, its main goals, the partners and reporting the various public project dissemination activities.
The website is continually updated throughout the life of the project and thus acts as a dynamic and up-to-date source of information for stakeholders interested in the next generation of CF-based materials for structural and electronics applications. The site is going to be maintained for at least two years after the project comes to a conclusion.

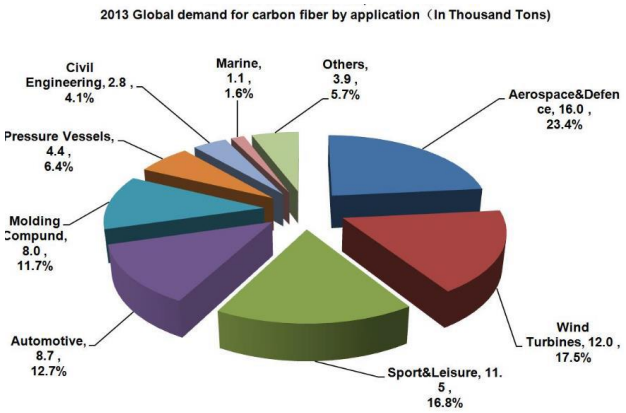
Market analysis

The global carbon fiber market is forecast to grow at a CAGR of 11.0% by value from 2016 to 2021. The major growth drivers of this market are the growing demand of lightweight material in end-use industries.



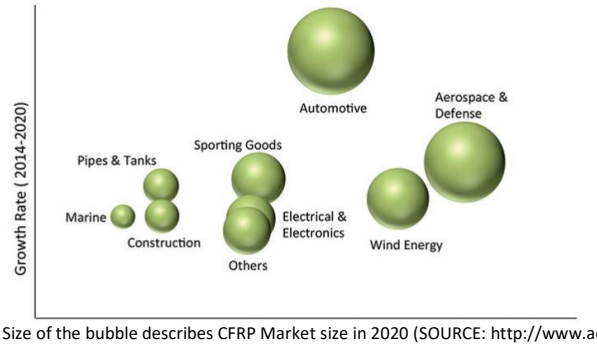
CF Market expected revenue (Source: https://www.zionmarket-research.com/market-analysis/carbon-fiber-market)

The other major drivers are the increasing penetration of carbon fiber in commercial aircraft (B787 and A380), wind turbine blades, automotive applications and various industrial applications. In this market, sporting goods, aerospace, and industrial applications are the end use applications of carbon fiber. The demand for industrial application is expected to experience the highest growth in the forecast period, supported by growing wind energy industry and increase demand for lightweight materials in automotive industry. The future of the global carbon fiber market looks attractive with opportunities in the aerospace, sporting goods, and industrial applications.



2013 Global demand for CF by application (in thousand tons) (Source: http://www.materialstoday.com/carbon-fiber/features/carbon-fibre-reinforced-plastics-market-continues/)

Within global carbon fiber market, industrial applications are expected to remain as the largest market by volume consumption. Growing demand of lightweight materials in the automotive industry and increased wind turbine blade length is expected to spur growth for this segment over the forecast period. Based on precursors type, the carbon fiber market can be segmented into two types, i.e. PAN (polyacrylonitrile)-based and pitch-based. Pan-based carbon fiber usage is higher by value and volume because of its lower cost than pitch-based. North America is expected to remain the largest market due to growth in end-use industries and increasing demand of lightweight materials in the aerospace and automotive industries.



Size of the bubble describes CFRP Market size in 2020 (SOURCE: http://www.adhesivesmag.com/articles/94350-market-trends-lightening-up-with-carbon-fiber-reinforced-plastics)

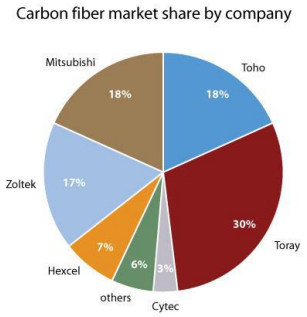
Rest of World, including Asia Pacific is expected to witness the highest growth over the forecast period due to the anticipated growth in the end-use industries and increasing focus on high performance composite materials. Expanding markets will be based on innovation and new product development, where the unique characteristics of carbon fiber can be capitalized. Expected is also the development of partnerships between producers and customers to create win-win situations and development of high performance products for the end-use industries. Toho Tenax, Toray, SGL, Cytec, Hexcel, Mitsubishi Rayon are among the major suppliers of the carbon fiber.

Market overview and IPR status updated at regular intervals, in order to illustrate the EU and worldwide market characteristics and structure

The purpose of market overview is to raise awareness on the project external environment in order to be ready to maximize the commercialisation of results in a post-project phase. That is to define proactive strategies in order to protect, share, manage, and ensure the knowledge and IPR exploitation. This study is based mainly on industrial reports.

The structure of carbon fibres and its dependence on the precursor material gives an under-

standing of the properties of today's commercial fibre types. Economic considerations are presented, comprising a review on present technology, the world demand and the price situation.



Rocky Mountain Institute. (Source: www.RMI.org/ReinventingFire)

The various fields for application of carbon fibres — such as aerospace, transportation, sport, machinery and apparatus, cryogenic technology, as well as medicine are discussed.

The future of Carbon Fiber is bright, with potential in many different industries. Among them are:

- Alternate Energy –– Wind turbines, compressed natural gas storage and transportation, fuel cells.
- Fuel Efficient Automobiles — Currently used in small production, high performance automobiles, but moving toward large production series cars.
- Construction and Infrastructure –– Light weight pre-cast concrete, earth quake protection.
- Oil Exploration –– Deep Sea drilling platforms, buoyancy, umbilical, choke, and kill lines, drill pipes.

In order to fully develop carbon fibers in main industries and others, carbon fiber manufacturers need to continue to increase their capacity and change their mindset so that they are committed to the commercialization concept. The ideal conditions that would allow the carbon fiber industry to reach its vast potential are if carbon manufacturers:

- Target new applications
- Develop new and lower cost technology
- Reinvest profits with long term objectives in mind – no small operators focusing on low volume, high price
- Fully understand supplier's costs and future strategy
- Identify and focus on market driver's
- Work to aggressively reduce costs
- Consolidate so that weaker players help strengthen the stronger ones
- Share incremental improvements to help support market growth
- Understand that the primary competitors to carbon fibers are other materials, not other carbon fiber manufacturers

Initial Risk Management Plan (RMP) and Quality Assurance Plan (QAP)

A review on possible risks associated with the project execution along with the corresponding

mitigation actions and mechanisms has been implemented. On the other hand MODCOMP also presents the provisions taken by the consortium to assure the delivery of quality results in time and in budget.

Uncertainty is one of the major inherent difficulties in developing innovative products, due to their highly dynamic markets and technologies. The presence of a large degree of uncertainty leads to high R&D risks, resulting in many R&D failures. Therefore, it is important to manage R&D risks through all R&D stages to improve R&D project success rates.

The balanced scorecard is used to identify major performance measures of an R&D organization based on the firm vision and strategy. Quality function deployment is adapted to transform organizational performance measures into project performance measures and a systematic procedure is developed for risk identification, assessment, response planning, and control. Risk management framework enables an R&D project to be focused on achieving the corporate goals and provides a more effective way to identify, assess, analyse, and monitor R&D risks along the project cycle.

Quality is clearly one of the key components of the project success. The MODCOMP team aims at acquiring the capability to improve project implementation and assure quality end-products. In order to assure that quality is built into the project, quality management is the answer, which combines four individual steps: quality planning, quality assurance, quality control and quality improvement.

Continuous line for the growth of CNTs on CFs via CVD

National Technical University of Athens – NTUA made the first set up of a continuous line for the growth of CNTs on CFs via CVD.

First set up of a continuous line for the growth of CNTs on CFs via CVD

Production of high performance fibre-based structures will firstly focus on the de-positioning of CNTs/CNFs on carbon fibre-based structures using CVD method. The first set up is established and the results will be presented in the next Newsletter.

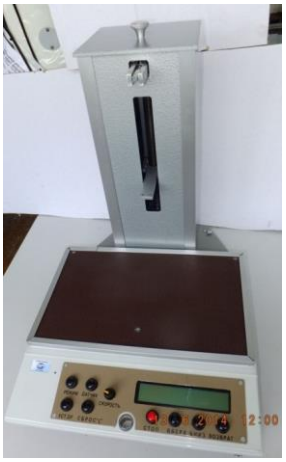
Demonstrators

An important part of the project lays down to the confirmation of the project concept accuracy. The works in this direction will be performed by Yuzhnoye design office - Yuzhnoye,

FRENI BREMBO Spa - BREMBO, Global Safe-Guard Ltd. - GSG and Anthony, Patrick & Murta-Exportacao LDA - APM partners.

The equipment for the strength determination of single fiber: tensile test machine MRM-10M that ensures the loading of the sample with the constant predetermined speed and the measurement of the load has max 1% inaccuracy of the measured value
(a.)

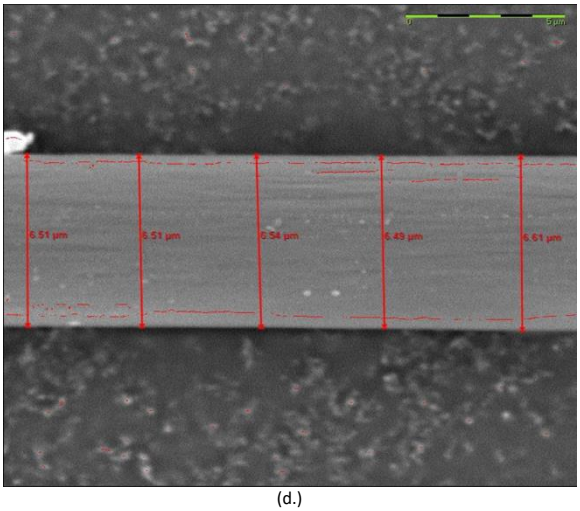
Yuzhnoye will determine physical and mechanical properties of initial and modified fiber (see picture a. and b., c. and d.) and carbon plastic specimens, as well as test of mock-ups of standard structures (demonstrators), produced based on both types of fibers (initial and modified).



(b.)

The microstructure of all materials is studied using Phenom Pro electron microscope.

General view of Phenom Pro scanning electron microscope (a) and an example of diameter measurement of single fiber type T700 (magnification 17000x)
(c.)



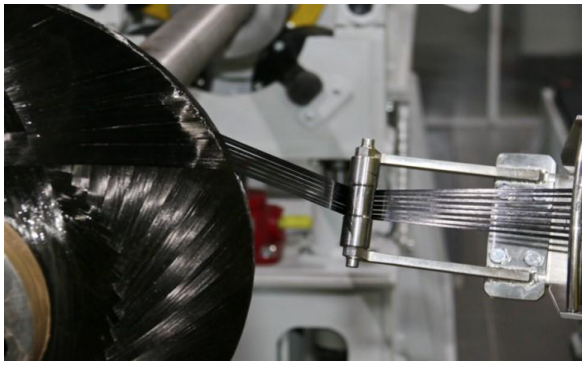
(d.)

In order to produce the samples from carbon plastic (see pic f.) and demonstrators (see pic g.) MAW 20 FB 5/1 filament winding machine (picture e.) is planned to be used.
The microstructure of all materials is studied using Phenom Pro electron microscope.

Technological equipment for demonstrators manufacturing is presented in Picture e., f., and g.

MAW 20 FB 5/1 winding machine
(e.)

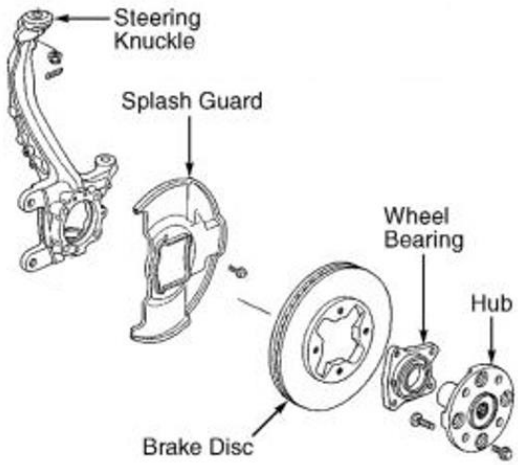
(f.)



(g.)

The demonstrators proposed by BREMBO in MODCOMP project are a steering knuckle and a motorcycle handbrake lever.

The steering knuckle is one of the main and critical components used in suspension system of automobiles subjected to millions of varying stresses cycles during its service. It links suspension, steering system, wheel hub and brake to the chassis. In the automobile industry, the requirement of properties of steering knuckle is that it must be strong, inflexible and light as well as possible to reduce fuel consumption.



Steering knuckle

The motorcycle handbrake lever converts mechanical force into hydraulic pressure acting on a piston that presses the brake fluid.

Motorcycle handbrake lever

The force with which the lever is pulled, the lever's leverage ratio, and the size of the master-cylinder piston determine the amount of pressure imparted in the brake system. The levers must be ergonomic and light as well as possible.

It has been a hectic 12 months for MODCOMP partners Global Safeguard Ltd. (GSG) in the UK and Anthony, Patrick and Murta Exportacao (APM) in Portugal.

Responsible for three of the demonstrators within the project they are on schedule with the tasks detailed below in order for them to deliver on the associated deliverable due in Month 18.

Sailing boat component - "SleekFast" prototyping

In October 2016 a new prototype class of training sailing vessel using hybrid glass and carbon systems was designed. The new lightweight components for project demonstration will be created.

Current progress is focused on the work with the design team. Technical drawings, design specifications, artists´ impressions and research of suitable processes for the demonstrator are established. Initial prototype hull is now undergoing testing.

In the next 6 months the refining and testing initial prototype hull will continue.

Advanced Material Shelter System - "AdShel" Shelter System – is a flat pack shelter unit that can be used across several market sectors including Humanitarian aid, Hospitality, Leisure and Construction.

"AdShel" Shelter System – Prototyping

GSG has taken delivery of the AdShel CAD drawings, artists´ impressions and animated movie and had so far meetings with suppliers and designers to discuss the self-supporting roof system.

They are also working with 'sister company' MetiComp Group to design the metal fixings.

APM and GSG have held meetings regarding the creation of moulds for the AdShel demonstrator. In the next six months they will work on the AdShel Prototype Moulds.

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