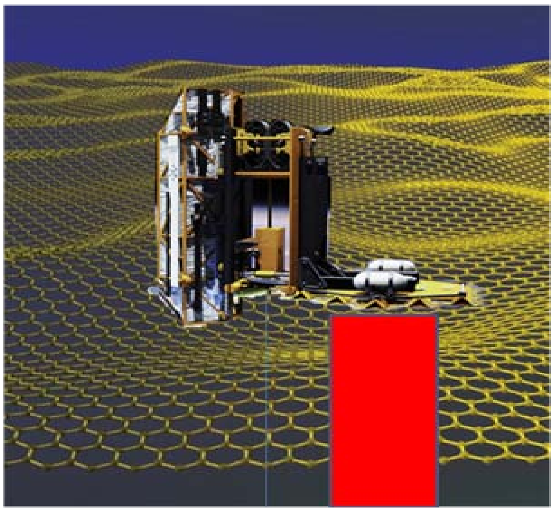
Longest carbon nanotube (CNT) arrays reported, however growth self-termination of CNTs still puzzling! Project CLAVIS could shed light on it! Welding and self-healing of CNTs may accelerate development of CNT mega cable. Elevator cars could use photovoltaic energy produced by the space elevator cable itself! Official kick-off of EuSEC Europe's first space elevator climber competition – Summary of essential results from the 4th International Conference on Carbon Nanotechnology and Space Elevator Systems in Luxembourg.



Luxembourg, Dec 10, 2010. In cooperation with the National Research Fund of Luxembourg the European Spaceward Association (short: EuroSpaceward) has just held its 4th International Conference on Carbon Nanotechnology and Space Elevator Systems on Dec 4-5, 2010. For two days experts from the USA, Japan and Europe presented and discussed the latest scientific-technical findings on carbon nanotechnology, especially on the research and development of super strong CNT fibres as well as recent advancements concerning space elevator systems.

In his introductory address Markus Klettner, Executive Director of EuroSpaceward, pointed out the strategic focus of the year 2010 conference on carbon nanotechnology in order to boost an envisaged research project between Luxembourg laboratories and international partners on the growth of ultra-long CNT fibers that possess at the same time ultrahigh tensile strength. He emphasized the need to further advance the development of high strength macroscopic CNT fibers by focussing on the vital aspects: growing long CNTs as well as aligning and fostering international research work on mechanical properties of CNT fibers.

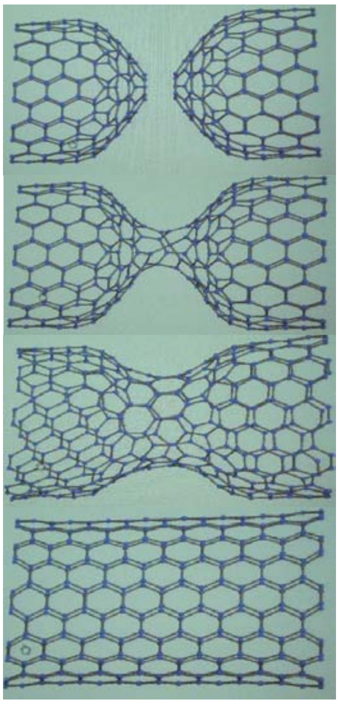
Longest CNT arrays reported by UC – however self-termination of growth of CNTs still puzzling

Prof. Vesselin Shanov from the University of Cincinnati (UC) presented in his keynote lecture on *Advances in synthesis and application of CNT materials* the latest achievements in growing long CNT arrays at UC's Nanoworld research laboratory. With a grown length of CNT arrays of 2.2 cm in 2010 (see image) UC researchers have beaten their own world record of year 2007 when they accomplished a length of 1.4 cm. According to Prof. Shanov CNT array with cm length are easy to process, cast in polymers and spin in threads. Thermal annealing processes developed at Nanoworld increases strength and lowers electrical resistivity of CNT yarn. Potential applications range from CNT wires in aerospace vehicles, carbon electric motors to biomedicine, i.e. powering-up the human body by CNT nano wires. An interesting spin-off of EuroSpaceward's series of conferences is the planned research collaboration on CNT array super-capacitors between UC's Nanoworld and Luxembourg's research center Gabriel Lippmann.

However, why CNTs do stop growing at a few cm and detach from the substrate remains still a million $ question as Prof. Shanov put it. In order to shed light on the riddle EuroSpaceward has stimulated this year the proposal for an international research project on ultra-long CNT growth, named CLAVIS. Dr. Martin Lades, Technical Director of EuroSpaceward, gave an overview of CLAVIS: In cooperation with the two main public research laboratories in Luxembourg, Henri Tudor and Gabriel Lippmann, as well as international partners the research goal has been formulated to find sufficient explanation for the halt of CNT growth in order to overcome the self-termination effect. The aim of the project beyond: growing CNTs to the meter range, considered to be a giant leap towards the construction of CNT mega cables as needed for the space elevator.

Welding and self-healing of CNTs may accelerate development of CNT mega cable

Other intriguing phenomena of CNT behavior depicted Prof. Boris Yakobson, Karl F. Hasselmann chair at Rice University's Smalley Institute. By using computational modeling and simulations he showed the possibilities of welding and fusion of individual CNTs as possible growth mechanism (see figure). According



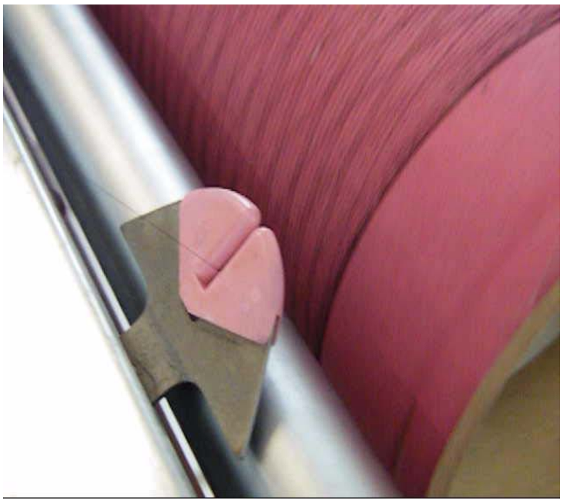
to Prof. Yakobson the control of chirality, i.e. the spiral angle, is essential in growing CNTs. It seems that individual carbon atoms prefer to attach to the step-terrace like kinks offered at the open end of spiral CNT fibers. The overall CNT mass produced by a growth mechanism can be optimized by the right combination of CNT nucleation, CNT chirality and termination control.

In addition Prof. Yakobson described the self-healing capabilities of damaged or defective CNTs. Similar to biological processes CNTs tend to heal their 'skin' themselves. Self-healing of CNTs has also been quantified by the research team of Prof. Nicola Pugno from the Laboratory of Bio-inspired Nanomechanics at the Politecnico di Torino, Italy. In his keynote presentation Prof. Pugno analyzed the role of self-healing and hierarchy on the design of super-strong CNT space elevator cables: A fiber bundle model approach is adopted with a hierarchical multi-scale self-similar procedure which enables to span various orders of magnitudes in size. The approach explicitly takes into account the hierarchical topology and self-healing of natural materials. Prof. Pugno draws the following conclusion from his preliminary research results: bio-inspired optimal strategies could be the key for designing super strong nanotube cables as needed for the space elevator.

Dr. Michaël de Volder, from KU Leuven's IMEC completed the view on CNT microstructures by presenting his findings that condensation of liquid onto vertically aligned CNT microstructures, followed by evaporation, causes a transformation of individual microstructures to intricate 3D shapes. By tailoring this self-assembly process, delicate and heterogeneous geometries can be fabricated in close proximity and over large areas. Due to their anisotropic electrical conductivity these CNT structures can be applied for electrically integrated sensors and actuators.

High strength macroscopic CNT fibers are on the brink of commercialization

How to optimize the wet spinning of macroscopic CNT composite fibers was demonstrated by Dr. Philippe Poulin of Centre de Recherche Paul Pascal (CRPP) in Bordeaux. According to Dr. Poulin wet spinning is particularly suitable to spin continuous yarns of CNT composites since it allows the processing of materials which cannot be melted easily as well as its blending. The team at CRPP has developed impressive laboratory spinning and spooling facilities for CNT composite fibers and is prepared to cooperate with the Luxembourg research centers on project CLAVIS for the processing of ultra-long CNT fibers.



Latest results on high performing CNT fibers were presented by Matthew James, member of the team of Prof. Windle at the Department of Materials Science at the University of Cambridge, which is among the leading laboratories in the global quest for super strong CNT fibers. Up-scaling of the laboratory production of fibers with strengths above 5 N/tex is in process. Q-Flo Ltd., the company that was founded to commercialize the high performance CNT fibres has recently announced a joint venture with Plasan, a global leader in armor solutions: TorTech Nano Fibres Ltd. will produce CNT fiber for the enhancement of body armor and composite armor systems for vehicles.

Elevator cars could use photovoltaic energy produced by the space elevator cable itself!

Referring to his PhD research on the photovoltaic effects of the Cambridge fibers Matthew James proposed to use the space elevator mega cable itself to produce the energy needed for the elevator cars. Though still low in photosensitive efficiency compared to solar cells made of silicon or even GaAs a cable made of Cambridge fibers stretching out over 100.000 km could produce already photovoltaic energy up to 100 GJ per day, provided the sun is illuminating the cable at a certain angle. Hence without the need of using lasers to beam power to the cars the whole system would more resemble the concept of the Japanese space train.

Official kick-off of EuSEC Europe's first space elevator climber competition

After various climber competitions held in the USA and Japan it has been high time to see Europe to follow: In an appreciated speech Franciska Voelgyi, head of the organizing team, announced the first European Space Elevator Challenge (EuSEC) conducted by the Space Elevator Division of the Scientific Workgroup for Rocketry and Spaceflight (WARR) at the Institute of Astronautics of the Technical University Munich (TUM). Cooperating partners are Klaus-Hoechstaetter-Foundation and EuroSpaceward. The event is scheduled to take place at the Campus Munich-Garching of TUM on June 10-12, 2011. The vertical length of the competition track will be 25 m. Contest entries will be evaluated according to the efficiency of the climber, the payload system, the technical realization and the level of innovation. Follow-up events with higher level requirements are already foreseen for 2012 and 2013.

Ted Semon, President of the International Space Elevator Consortium ISEC, closed the conference with an outlook on the strategic activities planned for year 2011: The focus on CNT will be second to none!