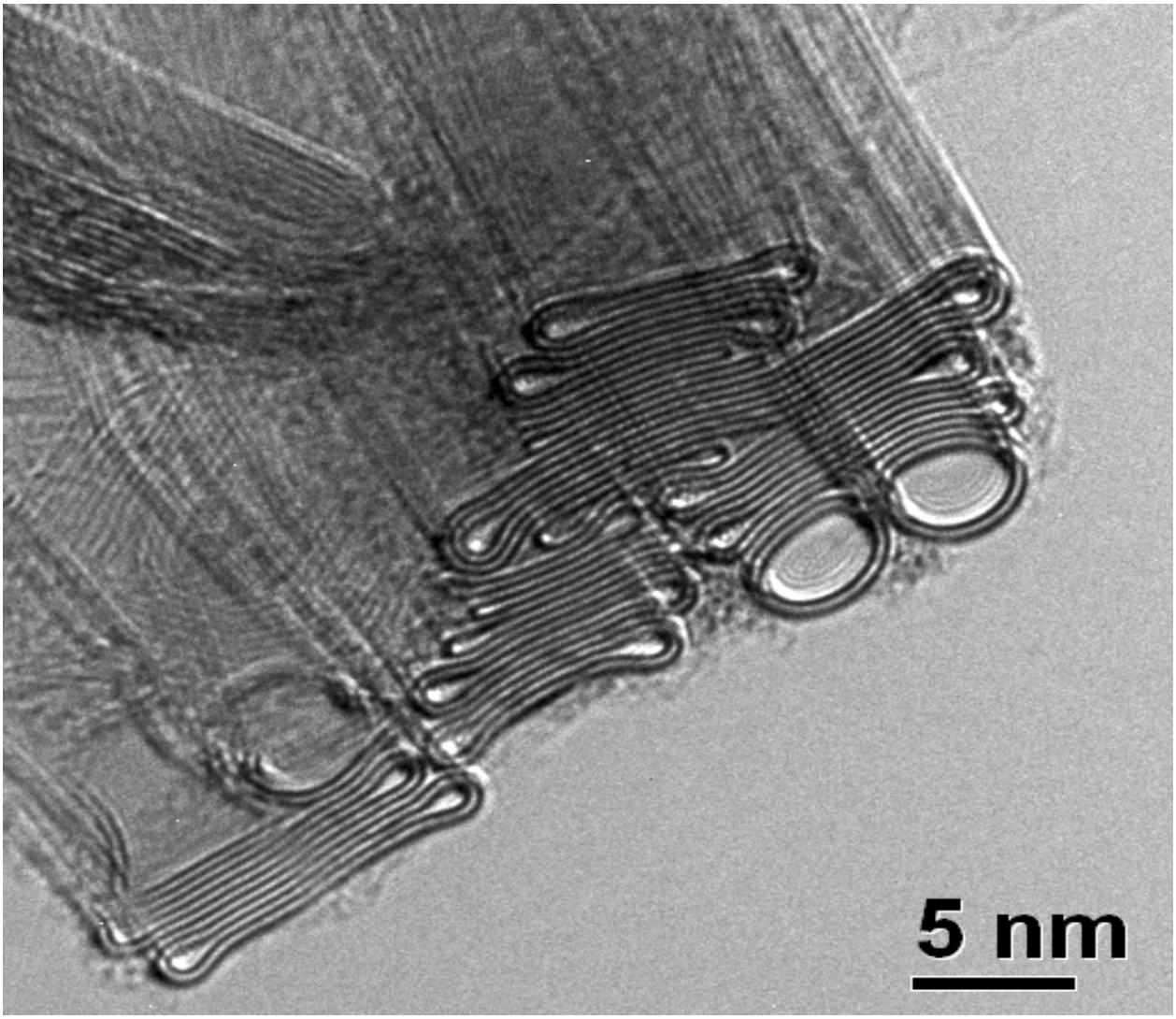
BOOK OF ABSTRACTS – PART II

Morning Session Dec 6, 2009

CNT Fibers and Tether Design



Collapsed carbon nanotubes; image taken by Dr. Marcelo Motta, Cambridge University

In cooperation with: Fonds National de la Recherche Luxembourg

Day 2: December 6, 2009

Morning session: Status of research on super strong CNT tethers

Time	Topic	Speaker
09:15	The Space Elevator feasibility condition – Tether-derived versus power-derived constraints	**Ben Shelef**, Spaceward Foundation, USA
09:45	Advancements on CNT fiber strength	**Dr. Juan Vilatela**, University of Cambridge, UK
10:30	Coffee break	
11:00	**Keynote:** Analytical modeling of the self-collapse and sliding failure of nanotubes in a bundle: implications for a flaw tolerant design of the space elevator cable	**Prof. Dr. Nicola Pugno**, Polytechnic Institute Turin, Italy
12:00	Latest results on plasma functionalization of CNT	**Dr. Jerôme Guillot,** Public Research Center Gabriel Lippmann, Luxembourg
12:30	The Age of Carbon Nanotubes & the Inevitability of the Space Elevator	**Dr. Bryan Laubscher**, Odysseus Technologies, USA
13:00	Lunch	

9.15 – 9.45, Mr. Ben Shelef (The Spaceward Foundation): ***The Space Elevator feasibility condition – Tether-derived versus power-derived constraints***

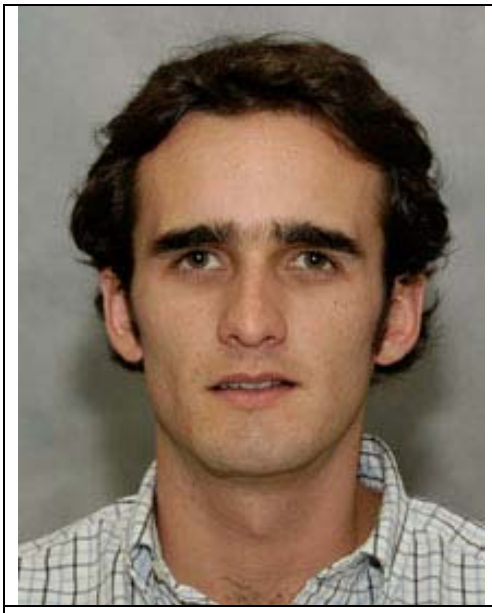
Ben Shelef is founder of the Spaceward Foundation that manages the NASA sponsored Space Elevator games. An aerospace engineer by day, Ben dons the mask and cape of a space crusader by night, and engages in daring escapades such as Space Elevator games and robotic challenges. Ben holds a B.Sc. in electrical and computer engineering from the Technion university in Haifa, Israel. He previously worked on ground and space based astronomical instrument design.

Abstract: This paper ties together parameters pertaining to tether specific strength and to power system mass density to arrive at an inequality that determines whether a Space Elevator system is viable.

The principle for the feasibility condition (FC) is that a Space Elevator must be able to lift its own weight fast enough to grow by bootstrapping, fast enough to replace aging material, and fast enough to have a significant margin for commercial cargo beyond these housekeeping tasks. The FC therefore sets a 3 dimensional design space comprised of specific strength, power density and characteristic time span. After developing the condition, real life limitations on power density and specific strength are plugged in, and the resultant viable design subspace is examined. Finally, a design architecture that satisfies the Feasibility Condition is briefly introduced.

Notes / questions:

9.45 – 10.30, Dr. Juan Vilatela (Cambridge University): ***Advancements on CNT fibre strength***



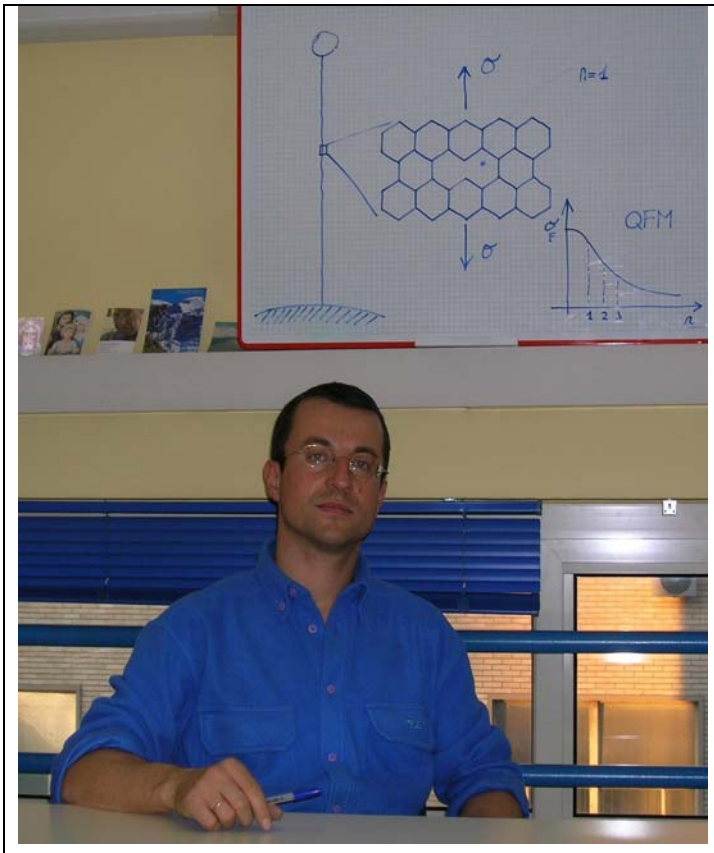
Dr. Juan Vilatela, Cambridge University, UK, is a research leader working in the team of Prof. Windle at the Department of Materials Science of Cambridge University. His initial research focused on nanotechnology and inorganic composites, including a research internship at Rensselaer Polytechnic Institute, in New York to study synthesis and applications of nanomaterials.
For the last few years he has worked on the production of high-performance carbon nanotube fibres and composites, studying their mechanical, electrical and thermal properties.

Abstract: Strength measurements on graphene films and carbon nanotubes show that the theoretical strength predictions for graphene sheet can be matched, although issues with respect to cross sectional area in the case of nanotubes means that the comparison needs to be in terms of GPa/SG (N/tex). In order to realise the excellent in-plane mechanical properties of graphene in a useful material it is necessary to orient as many of the carbon-carbon bonds parallel to the direction in which the strength is desired and in the case of a fibre this means the fibre axis [1]. Graphene layers in the form of nanotubes provide a route to orientation in the case of fibres. However, as the nanotubes are of finite length and they are very slippery, the major issue is to transfer stress into them via shear so that they all carry stress as evenly as possible. The paper will discuss the various parameters which need to be optimised to achieve this stress transfer and also the role of defects, both in terms of nanotube organisation and extraneous material, in limiting properties. Finally strategies for the achievement of optimal fibre structure in the case of material directly spun from the CVD reactor will be discussed.

[1] K.K.K. Koziol, J. Vilatela, A. Moisala, M. Motta, P. Cunniff, M. Sennett, A.H. Windle, High performance carbon nanotube fiber, Science, 318 (2007), 1892-1895

Notes / questions:

11.00 – 12.00, Prof. Dr. Nicola Pugno (Polytechnic Institute Turin): ***Analytical modeling of the self-collapse and sliding failure of nanotubes in a bundle: implications for a flaw tolerant design of the space elevator cable***



Prof. Dr. Nicola Pugno is Associate Professor of Structural Mechanics at the Department of Structural Engineering of the Politecnico di Torino, Italy. He is recognised internationally as a leading expert in the important field of Structural Mechanics and Strength of Materials. In addition Prof. Pugno is "Leading Scientists of the World" laureate and has been collaborator of Nobel Laureate Prof. Kroto. Prof. Pugno has already lectured about the role of defects in the design of a space elevator cable at EuroSpaceward's conference in 2008.

Abstract: We have discovered that the influence of the surrounding nanotubes in a bundle is nearly identical to that of a liquid having surface tension equal to the surface energy of the nanotubes. This surprising behaviour is confirmed by the calculation of the polygonization and especially of the self-collapse diameters (and dog-bone configurations) of nanotubes in a bundle. Accordingly, we have evaluated the strength and toughness of the nanotube bundle, with or without collapsed nanotubes, assuming a sliding failure. Implications on the design of the space-elevator cable will be discussed.

Notes /questions:

12.00 – 12.30, Dr. Jerôme Guillot (CRP Gabriel Lippmann): ***Latest results on plasma functionalization of CNT***

Dr. Jerôme Guillot is a Researcher on CNT functionalisation at the Department for Science and Material Analysis (SAM) at the Public Research Centre Gabriel Lippmann in Belvaux, Luxembourg. His research activity mainly focuses on the characterisation of materials, nano-materials and carbon nanotubes. He is also involved in research projects dealing with the functionalization of surfaces and particles with atmospheric pressure plasma treatments.

Abstract:

Functionalization of carbon nanotubes by atmospheric pressure dielectric barrier discharge

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Department Science and Analysis of Materials, Centre de Recherche Public – Gabriel Lippmann, Belvaux, Luxembourg

Functionalization of Carbon Nanotubes (CNTs) by inorganic particles or by chemical groups is intensively studied because of numerous possible applications in the fields of catalysis,

nanoelectronic, sensor, energy harvesting, … Atmospheric pressure plasma is a powerful technique for surface treatment at low temperature. At SAM, CNTs have been randomly decorated with metallic and metal-oxide nanoclusters using atmospheric pressure plasma and organometallic precursors. The characterization of these nanohybrid materials has been performed by HR-TEM and XPS. It has been evidenced that it is not only possible to control the size and the distribution of the clusters along the CNTs but also, for several metals, to tune their chemical composition from metal to oxide. The decoration process has been then successfully extended to other nanopowders.

A new on-line process to treat wires and yarns by plasma at atmospheric pressure was recently developed at SAM. The functionalization of metallic and polymer wires by different chemical groups was carried out by using a dielectric barrier discharge process either in a discharge or a post-discharge mode. Even with the 3D structure of the braided fibers, the thin film was seen to be uniform along the fibers. Such a process being very versatile, it would be possible to obtain the desired functionalization on CNT yarns by choosing the right gas mixture and plasma parameters.

This work is partly funded by the EU Commission (Nano2hybrids, EC-STREP-033311).

Notes /questions:

12.30 - 13.00, Dr. Bryan Laubscher (Odysseus Industries): ***The Age of Carbon Nanotubes & the Inevitability of the Space Elevator***

Dr. Bryan Laubscher is Astrophysicist. He was a project leader at Los Alamos National Laboratory until 2008. Over the last 20 years he has carried out research and development in astrophysics, electromagnetic detection physics, space instrumentation, spacecraft, non-linear optics, laser technology, lidar and spectrometer development. He is now with Odysseus Technologies focussing on the development of strong CNT threads.

Abstract: The Space Elevator is inevitable. Before the first Space Elevator is deployed, a carbon nanotube-based revolution will have occurred on Earth. This revolution will be two-pronged, one enabled by the remarkable electrical properties of carbon nanotubes (CNTs) and the other enabled by the high strength properties of CNTs. CNT electrical properties will revolutionize energy storage and electronics of all kinds, including computer technology. The high strength materials revolution will transform the way we design, manufacture and use homes and buildings, transportation systems of all kinds and commodities.

This paper will predict these two-pronged revolutions and speculate on their impact for our future. Finally the author will show how the Space Elevator is a natural outcome of these revolutions.

Notes / questions: