80–90% by selected nanowires on average. Theory also suggested filling the inner core of a nanotube with a diamond nanowire, which was successfully demonstrated by Shinohara using a diamondoid precursor. More theory is now needed to account for the detailed results that were actually obtained, such as the formation of two thin Eu nanowires rather than a single large-diameter nanowire, and to explain why these nanowires wrap around each other, rather than forming a straight aligned pair. Theory should also provide an incentive for attempting other new filling configurations with new interesting structures and filling materials. Furthermore, what systematic studies of rare-earth nanowires can be made that would bring new understanding either of electron transport or maybe also spin transport in such nanowires? Maybe temperature dependence or pressure dependence could cause different crystallographic structures, giving rise to new research directions.

Applications of carbon nanotubes to other scientific disciplines played a much greater role at NT13 than before. In biological applications, we heard about the use of nanotubes to penetrate the walls of cells, with biological cargo delivered to the cells through the nanotube channels, a promising growing interdisciplinary research field for biophysics. The study of specific enzymes at the single-enzyme level studied from a nanotube sensor viewpoint was also featured, and suggests development of interdisciplinary group activities between biologists, chemists, physicists, and materials scientists, as promoted by the US National Institutes of Health. The study of biological damage for medical applications is another research direction that is occurring. The injection of single-walled carbon nanotubes into lung and neuron cells has been found to be damaging for SWNT lengths in excess of 200 nm. Innovations like ionic liquids when combined with carbon nanotubes have been shown to provide novel functionality when used with electrolytes, and for increasing the flexibility and stretchability of materials used in supercapacitors. Nanocarbons have for some time been used for battery applications, but at NT13 we saw new uses of nanotubes to increase the performance of battery materials, as well as of carbon fiber yarn materials. Other examples of the use of nanotubes in other fields of science include their use as active probes in plasmonics, in increasing the sensitivity in piezoresistance measurements, in scale-up of piezoresistance technology applications, and to microelectromechanical systems technology at the nanoscale.

These are just a few of the highlights presented at NT13. In addition, satellite workshops were held on more focused topics, such as nanometrology as reported by Ado Jorio in this issue of *MRS Bulletin*. The interaction between theoretical and experimental research to advance research frontiers should be further promoted to accelerate the progress of nanotube research into new directions. Increasing interest in carbon nanotubes globally follows general international growth trends in nanotube research (see Figure). Remarkably, as the graph shows, while graphene came onto the scene with such fervor, advances in nanotube research also continue to flourish. Due to Europe's Graphene Flagship program that started in the Fall of 2013, we may expect in the future to more regularly see novel examples of graphene/nanotube hybrid structures presented at international conferences.

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Nanometrology satellite workshop reveals significant progress

nt13.aalto.fi/satellites/MSIN13

About six years ago, the international ISO Standards Committee began emphasizing carbon nanotubes and related materials as a prototype material for establishing nanometrology standards. These standards are needed in order to transition the achievements in nanoscience to nanotechnology. Due to the different properties exhibited by materials in bulk form as compared to the nanoscale, the research community recognizes the need for establishing metrology on the nanoscale level. In view of this need, the International Conference on Carbon Nanotubes established a satellite series of workshops on this topic. The Sixth International Workshop on Metrology, Standardization and Industrial Quality of Nanotubes (MSIN13) took place in Tallinn, Estonia, on June 29.

For synthesis and processing, the advances on separation of single-walled carbon nanotubes by diameter, metallicity, and chiral angle show that chemistry has a key role in adding value to nanotechnology. It appears that separation is no longer the cost limit of carbon nanotube products. Further reduction in manufacturing costs for bulk production is needed. In this context, exfoliation of graphene from natural graphite may have an advantage.

Separation procedures by diameter and chirality are likely to play an important role in the development of standard reference materials for characterizing nanotubes. Interestingly, the application of carbon-related standards can be used for developing nanometrology in general, with graphene being proposed as a reference material for characterizing the limiting properties of focused ion-beam devices, which were widely used for nanopatterning.

On the issue of quality and evaluation protocols, characterization protocols proposed in early reports of MSIN meetings are already being considered as standard techniques, as they are being broadly used for purity and quality evaluation. Commonly used characterization techniques are electron microscopy, thermo gravimetric analysis, Raman spectroscopy, and optical absorp-

tion spectroscopy. X-ray photoelectron spectroscopy has been used to quantify very low concentrations of dopants (below 1% in weight). The ISO TC229 has made great progress on standardizing these tools.

On the development of new metrology tools, various optical techniques provide fast and noninvasive methods. While optical absorption and Raman spectroscopy can already be considered standard methods, new techniques are pushing the limits, such as tip-enhanced Raman spectroscopy, nonlinear optics, plasmonics, and photocurrent spectroscopy. Graphene, again, was discussed because the use of isotope metrology on this material allowed the identification of the signal from specific layers in a multilayer sample and enhanced the understanding of the structure and properties of graphite intercalation compounds.

Overall, the nanotube field needs further development from a metrology standpoint. Further work is needed to speed the development of metrology, especially with regard to the application of carbon nanotube materials in biology, medicine, and issues related to toxicology.

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Bilateral Energy Conference to be held in France in 2014
www.emrs-strasbourg.com

The Bilateral Energy Conference, held jointly by the Materials Research Society (MRS) and the European Materials Research Society (E-MRS,) will be included as part of the 2014 E-MRS Spring Meeting in Lille, France, on May 26–30. The conference chairs are Hans Richter of Gesellschaft zur Förderung von Wissenschaft und Wirtschaft, Germany, and William Tumas of the National Renewable Energy Laboratory, USA.

The symposia topics are:

- Materials research for group IV semiconductors: growth, characterization and technological developments
- Advanced materials and characterization techniques for solar cells II
- Materials development for solar fuel production and energy conversion
- Organic/polymer and hybrid photovoltaics
- Materials by design for energy applications through theory and experiment
- Materials for electrochemical energy conversion—from modular to large-scale energy generation and storage
- Crystals for energy conversion and storage (jointly organized with the International Organization for Crystal Growth)

The abstract deadline is January 16, 2014.

The E-MRS Spring Meeting also includes topics on materials for energy and environment; nanomaterials; materials and light; hybrid, organic, and biomaterials; and crystal growth in materials science (with symposia jointly organized with the International Organization for Crystal Growth), with the January 16, 2014 deadline for abstracts. This Meeting—chaired by Ian W. Boyd (University of Brunel, UK), Gilles Dennler (IMRA Europe, France), Roberto M. Faria (University of São Paulo, Brazil), Roberto Fornari (University of Parma, Italy), and Elvira Fortunato (FCT-UNL, Portugal)—also features a workshop on grand challenges in materials and a tutorial, on May 25, about analysis of radioactive nuclear materials.

For more information, access the E-MRS website www.emrs-strasbourg.com.

E-MRS call for nominations for 2014 €U-40 Materials Prize
www.emrs-strasbourg.com

The European Materials Research Society (E-MRS) is accepting nominations for the **2014 €U-40 Materials Prize**. This award is given to recognize outstanding contributions to materials research by a scientist under 40. The award is reserved for researchers showing exceptional promise as leaders in materials science, having performed the research for which this prize is awarded while working in Europe.

The award consists of a €5000 cash prize, a certificate, waiver of the meeting registration fee, and a plenary talk at the 2014 Spring Meeting of the European Materials Research Society (May 26–30, Congress Centre, Lille, France) where the award will be presented.

Nominations should include

- Curriculum Vitae including birth date;
- List of key publications (including citations and impact factors);
- Letters of support from two well-established scientists; and
- Any additional supporting information relevant to the award.

The nomination package should not exceed 10 pages (excluding the list of key publications) and should be sent by email to emrs@emrs-strasbourg.com (subject: eu40materials) before the January 31, 2014 deadline. The nominee shall not have reached his/her 40th birthday in the year in which the nomination is submitted. □