electroindustry

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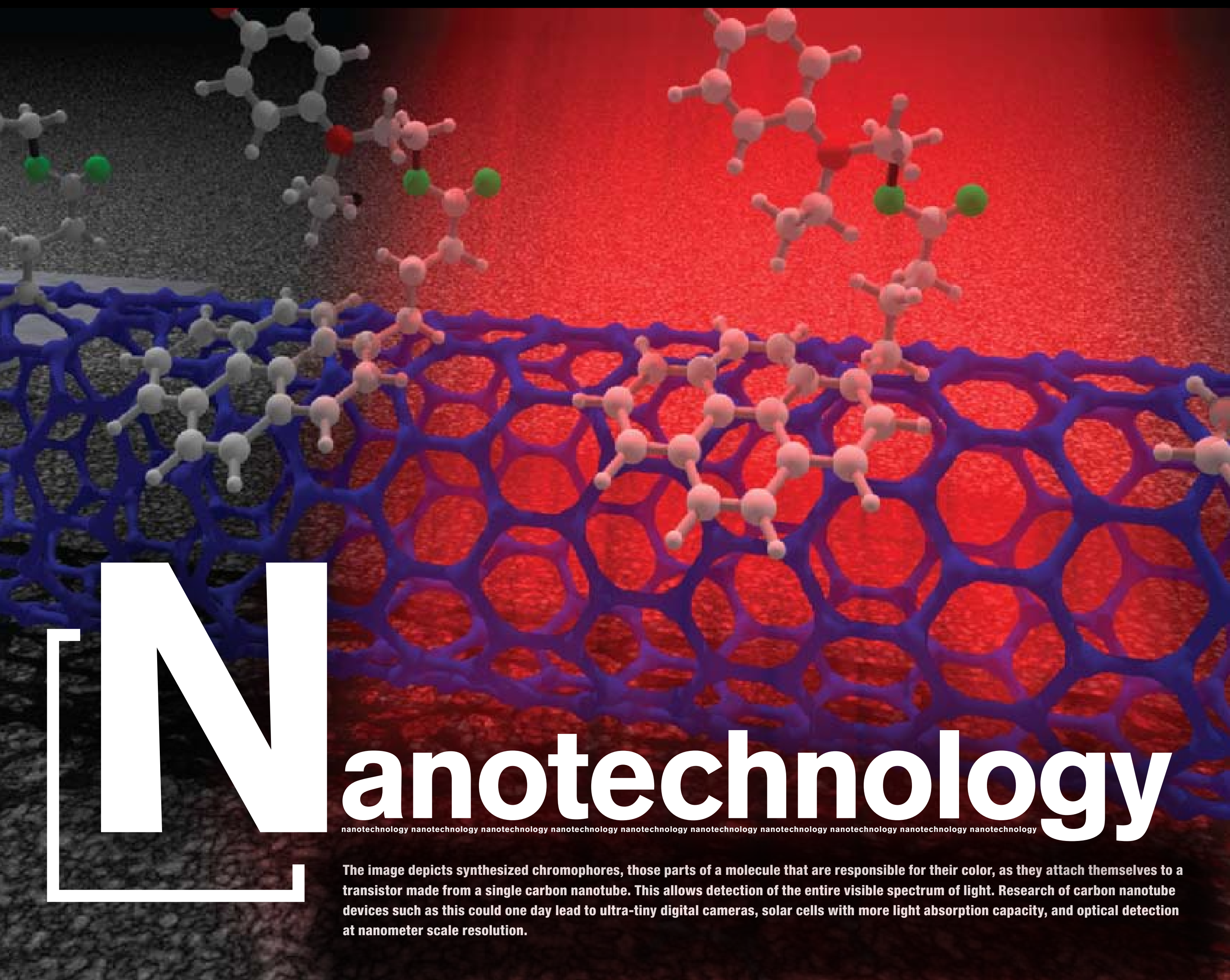

Nanotechnology

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The image depicts synthesized chromophores, those parts of a molecule that are responsible for their color, as they attach themselves to a transistor made from a single carbon nanotube. This allows detection of the entire visible spectrum of light. Research of carbon nanotube devices such as this could one day lead to ultra-tiny digital cameras, solar cells with more light absorption capacity, and optical detection at nanometer scale resolution.

Inside

Hirose, Developing an aberration-corrected Schottky emission SEM and method for measuring aberration, Pages 1017-1020, MNE '08 - 34th International Conference on Micro- and Nano-Engineering (MNE), Copyright 2009. Reprinted with permission from Elsevier.

EXAMPLE 3: SINGLE MOLECULE JUNCTIONS

The Need

The basic idea in molecular electronics is using specially designed single molecules or larger molecular building blocks like carbon nanotubes to provide electronic functions in nano-electronic devices. In contrast to integrated nanoscale contacts fabricated by top-down wafer-based processes, contacts to molecules are manufactured by bottom-up growing and assembling processes based on individual contacts.

The development of products based on molecular electronics devices requires precise control of growing and self-assembling mechanisms as well as a deep understanding of the charge transfer from bulk electrodes to the molecule or molecular building block and the charge transport through the molecule or molecular building block itself.

The Challenge

Worldwide effort is ongoing to understand on a theoretical and experimental basis, the charge transport in molecules and molecular building blocks as well as the charge transfer to metallic electrodes. Nevertheless, today the methods to derive basic properties from experimental measurements, theoretical models, and computer simulations are not standardized so that the comparisons of results are difficult. These difficulties occur in part from the design and controlled fabrication of the molecules, the molecular building blocks themselves, and the contacts to the outer circuit.

The challenge is the development of a standard systematic approach to classify contacts and related characterization methods. Figure 3 illustrates a single-molecule junction formed by binding benzene directly to platinum metal electrodes. [8]

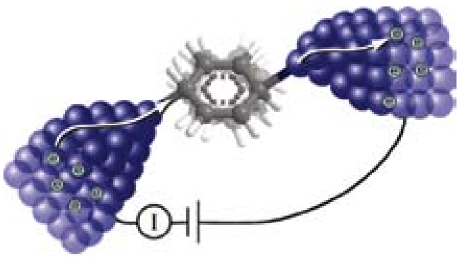

Figure 3: A benzene molecule junction spans platinum atomic point contacts. *Figure from L. Venkataraman, Viewpoint – Benzene provides the missing link in molecular junctions, Physics **1, 5** (2008) at http://physics.aps.org/articles/v1/5 http://dx.doi.org/10.1103/Physics.1.5 Reprinted with American Physical Society permission from Physics, 1, 5 (2008); illustration by Alan Stonebraker.*

Conclusion

An optimum way to address the many challenges and questions summarized here is to tap the collective wisdom of participating IEC national committees and other invited international technical experts to develop a consensus on how best to begin. In 2008, IEC TC 113 started a series of workshops regarding nanoscale contacts to begin building an international agreement on action plans. The results of the workshops will be published in an IEC Technical Report. In light of limited available resources, the task group responsible for the report can be the forum for determining which among the many instrumentation and theoretical approaches for eventual high-volume manufacturing of nanoscale contacts are of highest priority.

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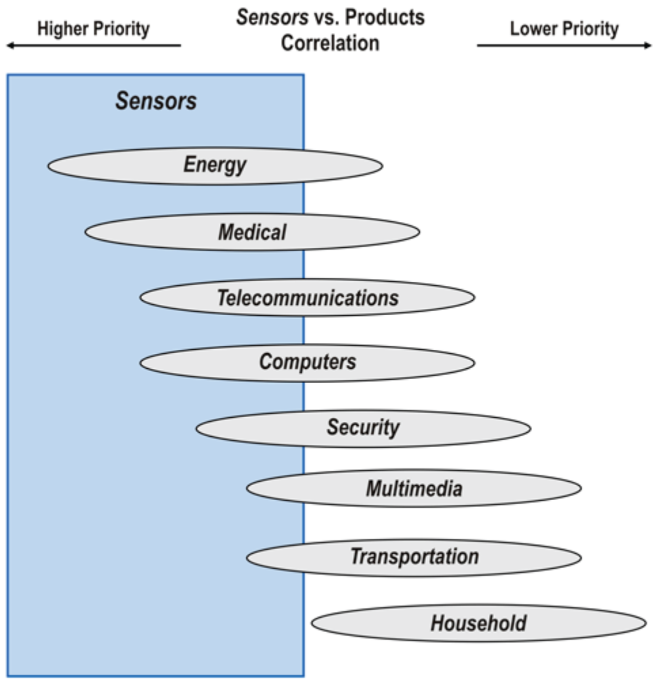
Survey Results Help Set International Nano-Electrotechnical Standardization Priorities

The National Institute of Standards and Technology (NIST) and Energetics Inc. collaborated with IEC Technical Committee 113 to survey members of the international nanotechnology community about priorities for standards and measurements in this field. The survey elicited more than 450 completed responses from 45 countries. Energetics and NIST conducted a joint statistical analysis of the survey results and recently wrote a paper that contains details of the analysis. The paper, *Priorities for Standards and Measurements to Accelerate Innovations in Nano-Electrotechnologies: Analysis of the NIST-Energetics-IEC TC 113 Survey* is available at *http://www.nist.gov/eeel/semiconductor/upload/NIST_Energetics_Survey.pdf*.

Nano-electrotechnologies are expected to be one of the key technologies of the twenty-first century. They have enormous potential for the development of new products with exceptional performance. Recent reports indicate that the materials and equipment market for nanoelectronics is expected to grow to over $4 billion in 2010, up from $1.8 billion in 2005. The continued rapid growth of nano-electrotechnology-based industries has required increased international standardization activities to support equitable and efficient business models. Effective international standards will permit the use of nano-enabled products in any nation.

Analyzing the survey results by two different statistical methods gave consistent priorities for items ranked in each of five nano-electrotechnology categories: properties, products, cross-cutting technologies, general discipline areas, and stages of the linear economic model. The global consensus prioritizations suggest that IEC TC 113 should focus initially on standards and measurements for electronic and electrical properties of sensors and fabrication tools that support performance assessments of nanotechnology enabled sub-assemblies used in energy, medical, and computer products (see figure).

The NIST-Energetics-IEC TC 113 Survey was the first step in developing the IEC TC 113 Nanoelectronics Standards Roadmap (INSR). Members of TC 113 will use these results as one of the inputs to the INSR that will establish a vision of market needs in terms of products and cross-cutting technologies for nano-electrotechnologies and standards and associated measurements to accelerate innovation, fabrication, commercialization, and use of products over their entire life cycle from research to end-of-useful-life/re-cycling/disposal.



Schematic of the correlation of the highest priority Cross-Cutting Technology item *Sensors* with the ranked items in the Products Category

Herbert Bennett, Semiconductor Electronics Division NIST

So What is Nanotechnology?

The U.S. National Nanotechnology Initiative (NNI) defines nanotechnology as

> *"…the understanding and control of matter at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale. ….Dimensions between approximately 1 and 100 nanometers are known as the nanoscale."*

NNI goes on to say, "Unusual physical, chemical, and biological properties can emerge in materials at the nanoscale. These properties may differ in important ways from the properties of bulk materials and single atoms or molecules."

According to the IEC TC 113 Strategic Policy Statement, document SMB/3973/R nano-electrotechnology standards cover the following areas at the nanoscale:

> *sensors; electronics, materials, devices; optoelectronics; optical materials and devices; organic (opto)-electronics; magnetic materials and devices; radio frequency devices, components, and systems; electrodes with nano-structured surfaces; electrotechnical properties of nanotubes/nanowires; analytical equipment and techniques for measurement of electrotechnical properties; patterning equipment and techniques; masks and lithography; performance, durability, and reliability assessment for nanoelectronics; fuel cells; and bio-electronic applications.*

For more information, see *http://www.nano.gov and http://www.iec.ch/online_news/etech/arch_2009/etech_0609/tc_1.htm*