Standardization of Carbon Nanomaterials for Industrial Applications
What we want, What should be done.

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Abstract

Recent years, new materials are demanded from broad industry area, electronics, heavy industry, healthcare, etc.. On the ITRS roadmap [1], graphene and carbon nanotubes (CNT) device, interconnect technology and frontier materials are demanded. In addition, electromagnetic application, mobile telecommunication equipment (smart phone), and automotive radar system are become explosively popularized. In the case of mobile telecommunications and automotive industry demand excellent electromagnetic properties, i.e. electromagnetic compatibility, electronics performance, as minimum requirement for commercialization in the products. Mobile telecommunication industry have interest around new materials to realize not only excellent electromagnetic performance but also lightweight and/or thinner.

Researches and developments in the nanotechnology turn out innovative new materials, CNT and graphene, etc., in the scientific sectors. The standardization activity of nanotechnology is giving a boost to commercialization of them in the industries. In this occasions, IEC standards undertake a role to suggest as follows;

- Terms and definition,
- Product and its specification,
- Testing and measurement methods.

Terms and definition give the common knowledge and an effective way to communicate with many kinds of industrial sectors, i.e. telecommunication, automotive, life-science and material providers, etc.. Product (material) specifications proclaim technical superiority in the material science and are compared to initial requirements in the industrial production. In the standards of testing and measurement methods, there are two type of nature. One is for analysis in material science, another is testing for industrial acceptable to production. In the former case, standard measurement method is specific for the nanotechnology society. However, researchers and engineers working in broad industry area have interests under the latter circumstance.

In the IEC TC113, many standards of electromagnetic property measurements are strongly related to other broad industry area. Then, the many industries establish each IEC Technical Committee. If we want to establish successful standardization in nanotechnology area, IEC TC113 needs aggressively to make collaboration with other specific technical committee, TC46, TC47, TC48 and TC86 etc.. They have soma knowledge, industrial needs and trends, business strategy and history on the each business. In Japan, we are communicating to IEC TC46 around electromagnetic measurements standardizations proposed in IEC TC113.

Other consideration in the standards for the testing and measurements, calibration, measurement traceability and uncertainty analysis under the ISO/IEC 17025 are required in the IEC and other standards. This trend are demanded from the quality control and conformance to a requirement in the regulations.

Table INTC10 Advantages and Concerns for Cu Extensions, Replacements and Native Device Interconnects

Application	Option	Potential Advantages	Primary Concerns
Cu Replacements:	Other metals (Ag, silicides, stacks)	Potential lower resistance in fine geometries	Grain boundary scattering, integration issues, reliability
	Nanowires	Ballistic conduction in narrow lines	Quantum contact resistance, controlled placement, low density, substrate interactions
	Carbon Nanotubes	Ballistic conduction in narrow lines, electromigration resistance	Quantum contact resistance, controlled placement, low density, chirality control, substrate interactions, parametric spread
	Graphene Nanoribbons	Ballistic conduction in narrow films, planar growth, electromigration resistance	Quantum contact resistance, control of edges, deposition, etch stopping, and stacking, substrate interactions
	Optical (interchip)	High bandwidth, low power and latency, noise immunity	Connection and alignment between die and package, optical /electrical conversion efficiencies
	Optical (intrachip)	Latency and power reduction for long lines, high bandwidth with WDM	Benefits only for long lines, need compact components, integration issues, need WDM, Energy cost
	Wireless	Available with current technology, parallel transport medium, high fan out capability	Very limited bandwidth, intra-die communication difficult, large area and power overhead
	Superconductors	Zero resistance interconnect, high Q passives	Cryogenic cooling, frequency dependent resistance, defects, low critical current density, inductive noise and crosstalk
Native Device Interconnects:	Nanowires	No contact resistance to device, ballistic transport over microns	Quantum contact resistance to Cu, substrate interactions, fan out/branching and placement control
	Carbon Nanotubes	No contact resistance to device, ballistic transport over microns	Quantum contact resistance to Cu, fan out/branching and placement control
	Graphene Nanoribbons	No contact resistance to device, ballistic transport over microns, support for multi-fanouts	Quantum contact resistance to Cu, deposition and patterning processes.
	Spin Conductors- Si(Mn), Ga(Mn)As	Long diffusion length for spin excitons	Low T requirements, low speed, surface magnetic interactions

Advanced interconnects and native device listed in ITRS 2013

References

[1] International Technology Roadmap For Semiconductors Edition 2013 (ITRS2013), Interconnect.