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Nanotechnology for Electronics & Photonics

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In the area of electronics, continued evolution of nano-electronics beyond the scaling limits of Moore's law for Si-CMOS technology is an urgent quest that requires broad thinking across multiple disciplines. Issues of quantum fluctuations and energy dissipation are among some of the major challenges. There is consensus that new developments of nano-electronics must ensure compatibility with Si-CMOS technology because it is unlikely to find one alternative system that can completely replace all aspects of Si-CMOS technology. Additionally, functional integration of nano-electronics with clever three-dimensional stacking and interconnect technologies can help optimize the electronic performance. To address the issue of energy-efficient nano-electronics, exploitation of low-dissipative functional materials such as graphene, topological insulators, superconductors and spin-dependent electronics (also known as *spintronics*) may provide new solutions to the challenges. The combination of nano-materials and nano-electronics has also enabled advances in many applications, including energy (*e.g.*, photovoltaic and fuel cells, light-emitting diodes, batteries), biotechnology and medicine. Regarding the error-prone nature of nano-electronics, new methodology for designing computational architectures that adapt to the unique properties and the error-prone nature of nano-devices should be as important as the hardware development.

In the area of photonics that deals with the interaction of light and matter, it is acknowledged that many new developments based on nanotechnology and clever designs of artificial structures with high accuracy in fabrication have enabled applications in such areas as quantum dot lasers for optical communications and efficient light trapping systems for better solar cells. While current nano-photonics have largely based on well known semiconductors such as silicon and III-V compounds, advances in novel functional materials have also stimulated new directions of photonic applications beyond those based on conventional semiconductors, although in principle photonic structures are generally quite flexible in the specific choice of materials. In the context of efficient computation technology, nano-photonics appear to be superior for interconnects whereas nano-electronics are more efficient in data processing. Therefore, integration of nano-electronics and nano-photonics for labs-on-a-chip applications is an important technical direction for exploration.

In addition to the technical aspects, it is important to consider how to ensure nanotechnology best serves humanity. The application of nanotechnology to commercial products will require tough standards of reproducibility, reliability and safety. It is therefore important to establish a common scientific standard for safety in diverse products based on nanotechnology. Active dialogues between scientists and engineers, academics and industries, researchers and policy makers are also essential to optimize the benefits and at the same time minimize the risks of nanotechnology. Policies of regulation, either self-regulation or governmental regulation, should be carefully considered. Overall, we believe that cross-disciplinary and cross-national collaborations are critical to advance nanotechnology for the sake of mankind. Finally, long-term investments in curiosity-driven basic research and education will be essential to sustain the momentum of advances in nanotechnology.