Nanotechnology: revolutionizing our way of thinking physics and materials.

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From the first discovery of carbon nanotubes (CNTs) [1], to the emergence of the two dimensional materials such as graphene [2], nanoscience and nanotechnology have been reshaping our knowledge and understandings of materials and physics in nanoscale for over three decades. We have observed that nanotechnology has already achieved commercial successes in many fields and addressed many challenges that the world is facing today.

One of the fields that nanotechnology has achieved the commercial success is the energy storage industry. Most super capacitor manufacturers nowadays use carbon black, a nano-sized carbon material made from coconut shells, as their active materials. Nanostructured materials have very high surface area and porosity and are cheap in high volume, and these characteristics make them of particular interest for the batteries and supercapacitors applications. Researchers have found that metal oxides nanoparticles such as TiO_2, NiO_2 make it possible to introduce new active reactions, decrease the transport path lengths and thus improve the performance of lithium ion batteries [3]. Studies have also shown that by incorporation of graphene nanoparticles with polymers, the supercapacitors' energy and power densities as well as the cycle life, stability and other electrochemical properties can be greatly enhanced [4]. These nanomaterials have distinct characteristics in terms of electronic, mechanical, structural properties compared to the bulk materials, and thus could lead to new development of energy applications of nanotechnology.

When it comes to the matter in the nanoscale, the standard theory and physics are often not applicable. One example lies in the light-trapping scheme: the standard theory first developed by Yablonovitch [5] states that the absorption enhancement of a medium cannot exceed $4n^2/\sin 2\theta$, where n are the refractive index and θ is the light incident angle. However, by employing properly designed nanostructures, one can observe absorption enhancement far exceeding the conventional limit. Solar cells fields have been benefited much from the burgeoning of the application of nanotechnology: silicon based solar cells with nanostructures such as nanoholes, nanodomes, nanopillars, nanowires, etc., have shown improvement of the conversion efficiency by 20-25% [6-8].

Another example is the recently developed photon-trapping high speed silicon based photodetector [9,10]. Traditionally, silicon is not considered as a good material for a photodetector to use in data communication applications because very thick layers are needed to absorb light efficiently. However, thick layers prevent the photodetector from having a fast data transmission rate. By using photon-trapping nanostructures, the silicon photodetector can have both features of high efficiency and high speed. This development gave us new incentive for reconsidering silicon to replace costly III-V materials such as GaAs for the short-distance data communication systems.

We now find nanotechnology has continued to rise and expand in the aforementioned and many other fields. The development on the nanoscience and nanotechnology not only benefit the scientific communities from understanding new materials and physics, opening up new research areas, but also have great impact on everyday life. We hope to see that nanotechnology can continue playing an important role on the scientific development and impact more people in terms of getting new products of better quality, lower cost, etc.

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