

# Energy harvesting and nanotechnology

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Energy Harvesting and Nanotechnology | April 28 2011 | Energy harvesting generators are attractive as unlimited replacements for batteries in electronic devices and have been the focus of new researches for past years. This paper reviews the principles behind this technology and their integration to harvest energy. Also proposes a greener alternative for the production of quantum dots before the integration to new technologies. | Nanowires and Quantum Dots | Energy Harvesting with Nanowires and Quantum Dots

## Introduction

Harvesting energy is the core of our modern human existence. We need to power our cars, homes, and personal electronics. To power our technology we need energy. Most electrical energy is harvested in one of two ways. These ways are mechanically harvested or harvested from solar power. Mechanically harvested energy needs moving parts, for example, to turn a generator. Solar energy can be harvested through solar cells via the photoelectric effect. As technology becomes smaller and more compact, power conversion technology needs to also adapt to these changes.

Nanotechnology has shown great promise to become the power generator for future nanotechnology. <sup>1</sup> That is the purpose of this paper to show how this technology works and is integrated to the production of energy.

Nanowires have a diameter in between 20 nm and 100 nm. They can be made from many types of material, however most research is being done on silicon nanowires<sup>1-2 3 4 5 6</sup>; carbon and CdS/CdTe<sup>7</sup> nanowires also are being researched. These nanowires can convert solar energy into electrical energy with enough efficiency to power small devices.

This technology can create self sufficient nanotechnologies that do not need batteries or need to be connected to a power source. This new technology will be completely different to the macro-technology we have today, were we have to change out batteries or plug them into a wall. Self-sustaining technology is very green, because they do not need a non-renewable outside energy sources. Quantum dots are being researched as a viable alternative to silicon based solar cells.

Quantum dots are small particles, or “ nanoparticles”, of a semiconductor material, most common chalcogenides (selenides or sulfides) of metals like cadmium or zinc (CdSe or ZnS), which are usually from 2 to 10 nanometers in diameter. Because of their size, quantum dots display unique optical and electrical properties that are different in character to those of the corresponding bulk material. The most relevant of these is the emission of photons under excitation, which are visible to the human eye as light.

Moreover, Quantum dots can be tuned to certain wavelengths based on their size and are able to produce more than one electron per absorbed photon. These molecules are generally made out of CdSe and are cheap, their synthesis is relatively green, and they have great stability over many years. They do not bleach like other dyes and their efficiency does not fade nearly as quickly as normal dyes. 7 Nanowires and quantum dots have become very interesting topics in chemical research.

They have potential to start a new wave of technology and may be the future power source of almost every technology. This article is about how scientists can harvest solar power on a nanoscale, with quantum dot technology

showing much promise as a green solution. Solar Power. Today, solar power is harvested by large photovoltaic cells (a solid state electrical device that converts the energy of sunlight directly into electricity) that are made of crystalline silicon; the generation of electricity from the sun was a landmark in Green Chemistry.

However, these large panels are bulky and expensive. Silicon nanowires use the same mechanism for power generation, but are smaller and more portable. The coaxial silicon nanowires operate by using coaxial shells selectively doped to absorb photons and produce electrons. 1, 3 Coaxial silicon nanowires have 2 shells and a core, figure 1 shows the nanowire and a view of the cross section of the nanowire. Figure 1. The blue outer shell is the n-type shell, the inner yellow shell is the i-type shell, and the pink core is the p-type core.

The diagram on the right shows how the holes ( $h^+$ ), and the photogenerated electrons ( $e^-$ ) flow across the nanowire. (Adapted from figure 1 in Nature 2007, 449, 885-889) The outer shell is crystalline in structure which enables the wire to absorb photons. The semiconductor material construction made this nanowire operate like a diode. Diodes allow current to flow one way but not another. Diodes are very common in household electronics and circuits. This means that self-powered circuits can be created from these nanowires. , 3-4 Quantum Dots are able to emit three excitons from one photon through an effect called the Multiple Exciton Effect. An exciton is an electron and its hole. Quantum dots can be tuned to many different wavelengths of light, because the wavelength they absorb is based on the diameter of the dot. The material for quantum dots is more cost effective than silicon-based solar <https://assignbuster.com/energy-harvesting-and-nanotechnology/>

panels. Theoretical limits for power conversion efficiency are approximately 60% [7]. This is an amazing efficiency, but there are some debates about how true this efficiency is.

There is not much known about quantum dots still, the organic outer layer that is used to separate these particles seem to have photo-electronic effects as well. Figure 2, shows an experimental power generator utilizing quantum dots and a mechanical piezoelectric generator. Figure 2 This is a power generator that uses both solar and mechanical means to harvest power. The quantum dots are interlaced in the ZnO nanowires. The solar cell power conversion efficiency of this device was 15.8%. Unfortunately, the process of making heavy metal quantum dots is not very green.

Some processes require high temperatures and heavy material loss. Current production methods have seen some LCA assessments of quantum dots. There is a lot of waste developed during the production and purification of quantum dots. Mass-by-mass comparison with silicon solar cells, show that quantum dots require far more energy and solvent. However, since only a small amount of quantum dots are being used in technology and the long lasting and high efficiency of power generation gives quantum dots a better assessment in all environmental aspects except heavy metal emission. Since emerging technologies rapidly change, this assessment could be outdated in six months with a new greener synthesis. Proposal Greener QDs: Cadmium free quantum dots In many parts of the world there are legislation that restrict and in some cases ban heavy metals such as Cd in many household appliances such as Lighting equipment, Electrical & electronic tools, sport telecommunication equipment and entertainment devices. Many reports <https://assignbuster.com/energy-harvesting-and-nanotechnology/>

have shown that cadmium-based QDs were toxic at the tissue and cellular levels when their surfaces are not carefully functionalized. <sup>1, 12</sup> CuInS<sub>2</sub> is a direct band gap semiconductor material with a band gap of 1.45 eV. Thus, by tailoring their composition and size, it is possible to fabricate CuInS<sub>2</sub> QDs that emit from the visible to near-infrared (NIR) region, with high quantum yield. More importantly, CuInS<sub>2</sub> QDs are more suitable for biomedical imaging applications and integration in household devices because the particles are free from toxic elements such as cadmium, lead, mercury.

The properties of these nanoparticles are very similar to those of CdS quantum dots, but the overall efficiency and shifts in spectra are still lower than the ones obtained by cadmium QD's. More research needs to be done to increase the overall properties of these nanoparticles and their integration to electronic devices, but some ideas that are being currently tried are coating CuInS<sub>2</sub> with organic materials that enables the particles to be more efficient and increases their luminescence.

Currently these QD's are being mass produced for example by Nanoco is a nanotechnology company located in Manchester, United Kingdom that uses a molecular seeding method adapted for other compound semiconductor materials, which have similar optical properties to those of CdSe quantum dots (such as the family of III-V materials), but do not contain heavy metals. So the possibilities for the implementation of this technology on devices that are in constant contact with humans are infinite, if new alternatives like this are implemented in future designs.

Conclusion Self-sustaining technology is the end goal for these nanogenerators; this can lead to a green revolution in technology and reduce the emissions into our atmosphere. Currently, quantum dots are beginning to show amazing properties that may one day replace batteries and carbon-based energy production. Unfortunately, the current process for the synthesis of quantum dots generates too much solvent waste and uses too much power, but there is research trying to quantify the environmental impact and reduce it.

Since quantum dots are an emerging technology, the production and utilization may drastically change in the coming years and hopefully a strong emphasis on low environmental impact will be on the forefront. Meanwhile this technology is being introduced in the solar energy production and medical procedures like targeting cell and biomarkers, giving results that promise a change in the way energy is produced. References 1. Tian, B. Z. ; Zheng, X. L. ; Kempa, T. J. ; Fang, Y. ; Yu, N. F. ; Yu, G. H. ; Huang, J. L. ; Lieber, C. M. , Coaxial silicon nanowires as solar cells and nanoelectronic power sources.

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