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**Archives of Applied Science Research, 2012, 4 (1):94-98**
*(http://scholarsresearchlibrary.com/archive.html)*

**ISSN 0975-508X**
**CODEN (USA) AASRC9**

# One dimensional tellurium in electronic domain-Prognostication

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## ABSTRACT

*The drastic reduction of global $CO_2$-emission with contemporaneously high supply reliability requires strategic changes in the design of future energy system. Renewable energies have a long-term potential to take over the entire global energy supply. National Renewable Energy Laboratory lab tests using CdTe material achieved some of the highest efficiencies for solar cell electric power generation. The future challenge is the integration of the promising nanotechnological approaches into technical innovations for the development of a sustainable energy supply using one dimensional Tellurium.*

**Key words**: One dimensional materials, Te, Renewable Energy.

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## INTRODUCTION

"One place with the prefix "Nano" on its doors might see scientists building entirely new materials. Moving atoms on a surface to see what strange things happen at the nanoscale" – says Keith Dingwall, an analyst at U.K. Institute of Nanotechnology.

The essence of nanotechnologies is the controlled utilization of nano-scale structures. The understanding of the principles, the selective components, the technological improvement of materials demand the size of the fabrication unit, which are effective at molecular or atomic level. The emergence of nanotechnology in India has witnessed the engagement of a diverse set of players, each with their own agenda and role. Nanotechnology in India is a government led initiative.

High demands are placed on a strategy for the recognition of the current energy supply structure. The drastic reduction of global $CO_2$-emission with contemporaneously high supply reliability requires strategic changes in the design of future energy system. Apart from the enhancement of energy efficiency, mainly the quick implementation of Low-emission technologies has to be advanced. Renewable energies have a long-term potential to take over the entire global energy requirement.

The utilization of nanotechnologies in the most important fields of energy supply as building, transport and traffic, portable off grid power applications may contribute decisively towards de-carbonization.

The future challenge is the integration of the promising nano technological approaches in terms of focusing new materials into technical innovations for the development of a sustainable energy supply. The commercial implementation demands through their realization to be cost effective and improved efficiency from the existing materials. Apart from this the size, energy consumption and environment friendly choices are of vital requirements to the global need for future growth of the advanced materials in one dimension.

## One dimensional Te – Prognostication

According to Photon international, March 2007, the market shares, on Cadmium telluride Cd Te solar cell types was about 2.7% worldwide. The major constraint here is the high raw material price of the high purity crystalline of raw tellurium. However without the application of nano technological procedures and components , products of many industrial branches would not be competitive.

According to U.S. Bureau of Mines, commercial grade tellurium are recovered from anode slimes at one electrolytic copper refinery in the United States. High purity tellurium, tellurium master alloys and tellurium compounds are produced by primary and intermediate processors from commercial grade metal and tellurium dioxide. Metal tellurites for semiconductors are made by direct melting after which the excess tellurium is volatized under reduced pressure. The process flow for the production of tellurium can be separated into two stages. The first stage involves the removal of copper from copper slimes. The second stage involves the recovery of tellurium metal and purification of the recovered tellurium.

Purification of tellurium by acid precipitation, first involves dissolving the crude tellurous acid solids in hydrochloric acid. Crude common salt is added to the acidified solution, and tellurium is precipitated by adding sulfur dioxide. The resultant precipitate undergoes filteration washing, drying and melting. In an alternative method, Tellurium is dissolved in a strong nitric acid, hydrolyzed to white $TeO_2NO_3$ and precipitated by diluting and boiling, and separating. The resultant precipitate is washed, dissolved in hydrochloric acid, and reduced with sulfur dioxide. Ultra high purity tellurium is prepared by zone refining in a hydrogen or inert gas atmosphere.

Electrolytic purification involves dissolving crude tellurous acid solids in caustic soda to yield a solution containing sodium tellurite and free caustic soda. The solution then undergoes electrolysis in a cell equipped with stainless steel electrodes. The cathodes are then removed, washed, dried and melted [1- 4].

Tellurium is used in cadmium telluride solar panels. National Renewable Energy Laboratory lab tests using this material achieved some of the highest efficiencies for solar cell electric power generation. Massive commercial production of CdTe solar panels by first solar in recent years high significantly increased tellurium demand [5–7]. If some of the cadmium is CdTe is replaced by zinc then (Cd, Zn)Te is formed which is used in solid – state x-ray detectors [8].

Alloyed with both cadmium and mercury, to form mercury cadmium telluride, an infrared sensitive semiconductor material is formed[9]. Organo-tellurium compounds such as dimethyl telluride, diethyl telluride, di-isopropyl telluride, di-allyl telluride and methyl allyl telluride are used as precursors for metal organic vapor phase epitaxy growth of II – VI compound semiconductors [10]. Di-isopropyl telluride is employed as the preferred precursor for achieving the low temperature growth of CdHg-Te by Metal Organic Vapour Phase Epitaxy (*MOVPE*) [11]. For these processes highest purity metal organics of both selenium and tellurium are used. The compounds for semiconductor industry and are prepared by adduct purification [12,13]. Tellurium as a tellurium sub-oxide is used in the media layer of several types of rewritable optical discs, including rewritable compact disc, rewritable blu-ray discs[14,15]. Tellurium is used in the new phase change memory chips [16] developed by Intel [17]. Bismuth Telluride and Lead Telluride are working elements of thermoelectric devices. Lead Telluride is used in far-infrared detectors.

In recent years, tellurium thin films have been widely used as gas sensors at room temperature. For the detection of nitrogen dioxide and ammonia as cooling devices. Thin film - Tellurium nano particles can be synthesized by solvo-thermal and sono-chemical techniques, microwave heating and laser ablation in water. For ablation, a short pulsed laser is generally used[18].

Nanostructuring usually achieves significantly higher chemical reactivity, since materials broken down to nanoscale substructures show a strongly increased ratio of reactive surface atoms to inert particles in a solid.

The first report about two dimensional tellurium nano structure was comprehended in the year 2006, by studying the growth behavior of tellurium nanocrystals of size about 0.5 $\mu$m in solution system by reduction of tellurium nitrate in reflexing ethylene glycol [19].

A simple hydrothermal reduction method was carried out in the year 2005 by employing sodium Tellurate as tellurium source and formamide as a reductant. Tellurium nanotubes have been synthesized for diameter about 200 nm to 600 nm and length about 4-15 $\mu$m. [20].

In 2006, USA is in the lead, for the investments in the field of nanotechnologies with private and public investments. Today in particular in South Asia, China and India increase their commitment considerably and close up quickly. This enormous public commitment is driven by the high expectations regarding the overall economical benefit in the form of turnovers and employment directly related to nanotechnological developments.

Zhu, Wei group had found an ultrasonic route for the preparation of tellurium nanorods in aqueous solution is established at room temperature, by tellurium nitrate powder as a tellurium source. The as grown nanorods have 30-60 nm in diameter, 200-300 nm in length in the year 2006 [21].

Zhaoping Liu group in the year 2003, found a single crystalline one-dimensional nano structures of trigonal tellurium nonowires in 30-100 nm diameter, by hydrothermal reduction of $Na2TeO_2$ in a mixed solution of ethanol and water at 100°C [22].

In 2007, Baojuan Xi group carried out a facile surfactant – assisted solvo-thermal method which had been employed to selectively synthesize single crystalline tellurium nanowires and nanotubes and realize the circular transformation of wire like and tube like, nanostructures by means of tuning the reaction time. Nanowires having about 10-20 nm diameter were fabricated [23].

In 2008, Ji-Ming Song group achieved single-crystalline trigonal tellurium nanotubes with sloping cross-section and hexagonal cross-section on a large scale by a simple solvo-thermal reduction route using tellurium dioxide as tellurium source with diameter 100-500 nm, wall thickness 50-10 nm and length 150-200 $\mu$m [24].

Chinese academy of sciences and Hong Kong University of Science and Technology in the year 2009, developed a route, without the aid of surfactants or catalysts. One dimensional nanostructures of Te (nanowires with a small quantity of nanotubes and nanoribbons) directly from template free electro deposition (TFED) in an aqueous solution at low temperature[25].

Nanyang Technological University of Singapore, University of Science and Technology of China and Tongji University of China have developed an unconventional hexapod-like tellurium nanostructures in the year 2009, through an easy solution based approach by recrystallizing. Te powder in a mixture of ethylene diamine and hydrazine hydrate at 110$^{o}$C for 72 hour with thickness 12 nm and width ~200 nm [26].

Key Laboratory for special functional materials, Henan University of China and Jilin University of China had reported during 2010, that, however, upto now, the widely used non aqueous methods of synthesize high-quality metal tellurium nanocrystals have had to rely on air-free “glove box” manipulations because of the use of the following air-sensitive compounds as tellurium precursors : alkylphosphine with tellurium powder. Such air free manipulations substantially increase the complexity as well as the cost of the synthesis of metal-telluride nanocrystals. Till now, there is no report on the phosphine-free synthesis of metal telluride nanocrystals due to limited solubility of Te in non-coordinating solvents [27].

In the year 2011, a group from University of Science and Technology Beijing, Chinese Academy of Science and National University of Singapore reported a facile hydrothermal route to synthesis various **one** dimensional tellurium nanostructures including nanotubes, nanowires and nanorods on a large scale. They fabricated nanotubes with a tunable diameter from 200 nm to 2 $\mu$m in NaOH solution. Also with poly (Vinyl pyrrolidone) as the surfactant, ultra thin Te nanowires with a diameter of 5-8 nm are synthesized in NaOH solution [28].

Weidong He and his group in the year 2011, found a new facile route to colloidal Te nanocrystals with binary uniform size distributions at room temperature. The binary-sized Te nanocrystals were well separated into two size regimes and assembled into films by electrophoretic deposition. They provide a new platform for nanomaterials to be efficiently synthesized and manipulated [29].

Trigonal tellurium nanowires bundles have been successfully synthesized from an ionic liquid precursor via a directed growth route by Jianmin Ma group in the year 2011 [30].

## CONCLUSION

Nano structured semiconductors with optimized boundary layer design contribute to increase in efficiency, that could pave the way for a broad application in the utilization of waste heat. Although tellurium exhibits a variety of coordination patterns, accurate crystal structure details are rare even for its simple compounds. By combining own observations with background gleaned from material science, semiconductor researchers may find a way to create unique features in ultra high pure tellurium-potentially leading to improvements in nanometrology. But beyond the creation of virtually indestructible nano rulers, the method could one day lead to the improvement in “a class” of electronic devices useful in solar panels, cell phones and telecommunications.

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