Indian Scientists Developed Functionally Graded Nanocrystals for Improved Solar Cells

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The world population is about 7.4 billion and is growing with an average estimated rate of 1.18% annually. With increasing population, demand of energy is also increasing at a fast pace. Coal and petroleum have the largest share in energy sources but have serious environmental impact and global warming due to significant increase in average earth temperature. Therefore, world leaders decided to come together to reduce dependence upon these traditional energy sources by gradually switching to alternative and green energy sources which have minimum impact on the environment. From Kyoto to Paris, many protocols and agreements have been signed and finally, it was decided to invest more in solar, wind and nuclear energy. Wind energy sources have their own limitations and alone are not sufficient for complete energy requirements of the world which is 3.1 thousand kWh per capita as per World Bank's electric power consumption report. Though nuclear sources have great potential but they have severe risk and world has already seen brutal accidents of Chernobyl (1986) and Fukusima (2011) in the near past. So, we have only one good alternative to traditional energy sources: Solar Energy.

Silicon-based solar cells were developed because of easy availability of silicon and low-cost technology. We have seen the installed silicon solar cells on the rooftops of houses and buildings. These solar cells have limitation of converting the sunlight to energy of about 15 % only because the light conversion depends on the absorption of light in solar cell. Solar light falls on the earth

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* Mr. Ankit Goyal, Ph.D. Scholar from Malaviya National Institute of Technology, Jaipur, is pursuing his research on "Development of Nanocrystalline Silicon Thin Film Solar Cells via Powder Metallurgy." His popular science story entitled "Indian Scientists Developed Functionally Graded Nanocrystals for Improved Solar Cells" has been selected for AWSAR Award.

in energy packets named as photons. These photons have specific energy corresponding to the wavelength of light. For example, when we see a rainbow in the sky, every color of the rainbow represents a different wavelength and energy of sunlight. The bandgap of silicon is 1.12 eV which does not allow a major part of it to get absorbed in the solar cell and that's why bandgap is very important. The photons having energy more than this bandgap lost their extra energy as heat which not only increases resistance to electron flow but also degrades solar cells. In parallel, India does not have the technology to make solar cells and almost most of the cells/wafor is imported from China.

In view of this, researchers at Malaviya National Institute of Technology (MNIT), Jaipur decided to put their efforts in this direction. The work presented here is being done by a PhD scholar, AnkitGoyal under the supervision of Prof. PR Soni of Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology, Jaipur. The writer is a PhD scholar who performed the experiments and wrote the paper.

Si powder of 99.999 % purity was purchased for the study. The purchased powder was then ball milled in a high-energy ball milling unit for 4h, 12h and 20h, respectively in argon gas atmosphere to avoid oxidation of powder particles in it. It was considered carefully before the experiments that no contaminants shall enter in the mill. The mill chamber was coated with tungsten carbide and balls of tungsten carbide were used to avoid iron impurity in the silicon. Tungsten carbide is harder than silicon so it won't go in silicon lattice but can mill silicon very easily. The milled powders were then degassed to remove entrapped gases. The purity of the milled powders was checked by synchrotron X-ray florescence (XRF) facility at Beamline-16, RRCAT, Indore. The prepared powders were then characterisation to study their particle and crystallite size, and optical bandgaps in it. It was found that milled powders have smaller size than the initial powder. The crystallites size in the milled powder was of nanometer range as confirmed by transmission electron microscopy. The size of the powder particles was inversely proportional to the milling hours. The optical bandgap is measured and calculated by UV-Vis-IR spectrophotometer.

The results were encouraging as there was a logarithmic relation between bandgap and milling duration which suggest that by controlling the milling parameters, bandgap of the semiconducting materials can be controlled. The tuning of bandgap in infra-red region is possible by just varying the milling hours. Thus, the resultant powders can be used to capture the solar light efficiently in solar cells. This can improve the efficiency of solar cells by many folds. The prepared powders can be used in other silicon based opto-electronic devices and technologies too. The prepared powders were then used in fabrication of the functionally graded solar cell with grading of bandgaps to efficiently absorb major wavelengths of the sunlight. These powders can be used for fabrication of low-cost ultra-sensitive devices.

It is very important for India to work in the direction of solar energy as we have abundant sun energy available at most of the time in a year. Our government has set a target of 200 GW solar energy power by 2020 which can be achieved early if we have a technology which can provide higher solar power conversion efficiency. The indigenous technology will also help us to become independent and reduce imports from China.

Powder Metallurgy Lab at the Department of Metallurgical and Materials Engineering, MNIT Jaipur is working on the problems which can address and affect the masses. This is a contribution in the direction of solar energy research.

The research findings stated here is being published by a repute international journal "Materials Letters" in 2018. A part of the work was presented at the international conference PM'17 organized by Powder Metallurgy Association of India and got reputed 'GS Tendolkar' award for work done in the field of fundamentals of powder metallurgy.

The research team includes Ankit Goyal (MNIT, Jaipur) and Prof. PR Soni (MNIT, Jaipur). The research work was supported by Indian Nano-electronics User Program, IIT Bombay, Central Electronics Engineering Research Institute (CEERI), Pilani, and RRCAT, Indore by providing necessary characterisation facilities.