

Nano Technologies and Materials for Photovoltaics. Nanocrystalline Si, Transparent Polymer to Replace Glass and ITO.

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Several nano materials and nano technologies that can increase the conversion efficiency and improve properties of photovoltaic (PV) modules were developed and investigated and will be presented. These include nano crystalline thin film silicon, a high transparency polymer that can replace protective glass in PV modules and be used for encapsulation, and a transparent conductive oxide that combines high transparency and low resistance to cover the surface of nano crystalline silicon solar cells.

Discoveries of new physical phenomena in nano-structured materials provide new opportunities for creation of inexpensive, high performance photovoltaic devices. Thin film nano crystalline silicon technology allows creation of variable sized nano crystals, as well as variable ratios of the nano crystalline silicon phase to amorphous phase silicon. Nano crystalline silicon has a wide range of band gap values, improved electron and hole mobility, higher photosensitivity and greater stability. The production process for this nanocrystalline silicon does not require the use of toxic gases.

Advantages of nano crystalline silicon as compared to amorphous silicon are as follows: a) greater electron and hole mobility; b) lower degradation rates and greater stability; c) higher photosensitivity; d) ease of processing without use of toxic materials; e) control of properties as a function of crystallite size, characteristics of inter-phase boundaries and morphology; f) capability for rare-earth doping to increase spectral range and conversion efficiency; g) readily controlled hetero-structure conversion during the deposition processes such as electron beam evaporation or magnetron sputtering onto flexible substrates.

A new transparent polymer material allows to replace the glass and to develop flexible PV modules. This optically transparent polymer layer can have either a flat surface morphology or crinkle coat surface morphology. The polymer coating materials can be used for hermetic sealing and have important

advantages in that they increase the PV efficiency up to 20% and improve PV module characteristics and performance by: (a) effective utilization of shorter wavelength range of the spectrum, including UV, due to the high transparency of the polymeric coating; (b) more resistant to degradation by UV and ionizing radiation (so-called photon degradation); (c) increased value of the index of refraction as compared to glass provides a reduction in reflection (clarifying effect); (d) capability to form surface relief of various types, including a surface consisting of sets of micro lenses (concentrating properties); (e) capability to be formed with a relief/ crinkle coat surface morphology and to thus change the trajectory of incident photons; (f) high mechanical strength and capability to adhere to various other materials; (g) stability when exposed to high and low temperatures and thermal-cycling, mechanical impact, and high relative humidity; (h) reduction in weight and cost. Current estimations indicate that the cost of the polymer encapsulation for PV modules will be on 20-30 % less than the cost of laminating the PV modules using glass.

Nano structured transparent conductive oxide (ITO) that was developed using a new technology and equipment combines low resistance, high transparency and low cost as compared to competitive materials. Features and advantages of the developed transparent conductive oxides include: a) high transparency; b) high and uniform conductivity; c) resistant to thermal shock and cycling; d) resistance to humidity; e) solvent resistant; f) low cost because no precious metals are used; g) impact resistant and: h) readily available processing equipment.

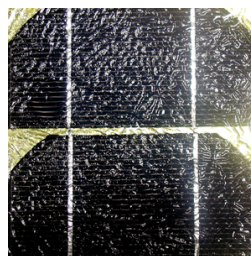


Fig. 1 Enerize solar cell with crinkle morphology polymer coating for replace the glass and increase PV modules efficiency.

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