

**Title:** A Critical Analysis of Materials for Photovoltaics

**Authors:** Kester Heeraman  
Melissa Jagroop

**Supervisor:** Indra Haraksingh

Photovoltaics, which is the transformation of solar energy directly into electrical energy, is a possible alternative to conventional sources of power generation. Solar energy research, development and commercialization in this century have been driven by a variety of factors. Among these are vision and entrepreneurship, the need to break the current overdependence on fossil fuels and the growing emphasis on minimizing environmental degradation.

All photovoltaic cells require a light absorbing material contained within the cell structure to absorb photons and generate electrons via the photovoltaic effect. The materials used in photovoltaic cells tend to have the property of preferentially absorbing the wavelengths of solar light that reach the Earth's surface; however, some solar cells are optimized for light absorption beyond Earth's atmosphere as well. Light absorbing materials can often be used in multiple physical configurations to take advantage of different light absorption and charge separation mechanisms. Many currently available solar cells are configured as bulk materials that are subsequently cut into wafers and treated in a "top-down" method of synthesis (silicon being the most prevalent bulk material). Other materials are configured as thin-films (inorganic layers, organic dyes, and organic polymers) that are deposited on supporting substrates, while a third group are configured as nanocrystals and used as quantum dots (electron-confined nanoparticles) embedded in a supporting matrix in a "bottom-up" approach. Silicon remains the only material that is well-researched in both bulk and thin-film configurations.

This study involved analysis of materials currently being used in the photovoltaic industry, evaluating their advantages and shortcomings. It also highlights research being

done on prospective materials which have the potential to significantly improve the development of photovoltaic technology. The study transgresses from the fundamental use of crystalline silicon semiconductor material and progresses to the more recent materials such as amorphous silicon, thin films and conjugated polymers. It was found that the two major challenges facing the PV industry today are overall cost of manufacturing and low conversion efficiencies, which necessitate research in new materials for the improvement of the technology. It discusses the use of amorphous silicon, an allotrope of the crystalline silicon, in search to overcome some of the shortcomings of crystalline silicon. It also discusses alternatives such as the use of other Group IV elements of the Periodic Table and the most recent innovation of the thin films particularly with respect to ternary compounds such as copper gallium diselenide ( $\text{CuGaSe}_2$ ) and copper-indium chalcogenides ( $\text{CuInX}_2$  (S, Se and Te)).

Based on the research, the study strongly suggests that due to recent advances in the thin-film technology many industry experts believe that thin-film PV cells will eventually dominate the marketplace. Once adequate advancements in the economics of photovoltaics occur and sufficient research and development sectors are implemented, the goals of PV will be realized - an affordable, efficient, environmentally friendly means of generating electrical power.