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Semiconductor Materials for Photovoltaic Applications

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Intellectual Property Status

Patent Pending

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Background

Crystalline Si has enjoyed spectacular success in the solar cell industry for various reasons including the ability to benefit from technological breakthroughs in the microelectronics industry and the close proximity of the 1.1 eV band gap value of Si to the optimal theoretical 1.3 eV band gap value for which the thermodynamically limited single-cell efficiency reaches a maximum value. Since modern single-cell crystal solar technology appears to be approaching the maximum expected efficiency, efforts to increase the competitiveness of these cells have focused on decreasing the cell thickness and thereby reducing silicon consumption. Still, ultra-thin Si cells face a fundamental limitation. The lowest energy direct optical transition in this material occurs at 3.5 eV, and therefore, its absorption below this threshold is very low because only phonon-assisted transitions are possible. On the other hand, thinner films have certain advantages because the ratio of carrier diffusion length to thickness is larger, thereby increasing the collection efficiency of minority carriers. The ideal compromise for maximum efficiency is estimated to be approximately 150 µm. Consequently, the industry is also approaching a fundamental limit when it comes to savings by reducing the Si thickness.

Invention Description

Researchers at Arizona State University have developed a method to fabricate Si/GeSn and/or Si/Ge tandem cells that take advantage of chemical vapor deposition (CVD) techniques allowing growth of Ge and GeSn on silicon substrates. The resulting potential efficiencies substantially exceed that of traditional Si solar cells and represent the most promising approach to advance Si-cell technology.

Potential Applications

- **Commercial Electronic Devices**
- **Satellites, Spacecraft, Space Probes**
- **Remote and Grid-Tied Power Generation**
- **Remote Radiotelephones and Water Pumps**
- **Clothing**

Benefits and Advantages

- **Offers Substantially Increased Efficiency** – traditional Si cells offer maximum thermodynamic efficiency of ≈35% (requires thick Si) compared to ≈40% efficiency offered by new method for ultra-thin Si; traditional Si operates at ≈21% for actual commercial values and down to ≈15% at a 25µm thickness
- **Allows Dramatic Reductions in Material Thickness** – GeSn/Ge thicknesses below 10 µm and even below 1 µm for certain applications sufficient for 90% light absorption compared to the optimal 150 µm value needed for traditional Si solar cells
- **Eliminates Need for Light Trapping Features** – traditional methods require special texturing or rear surface reflectors; significance of advantage increases as thickness decreases