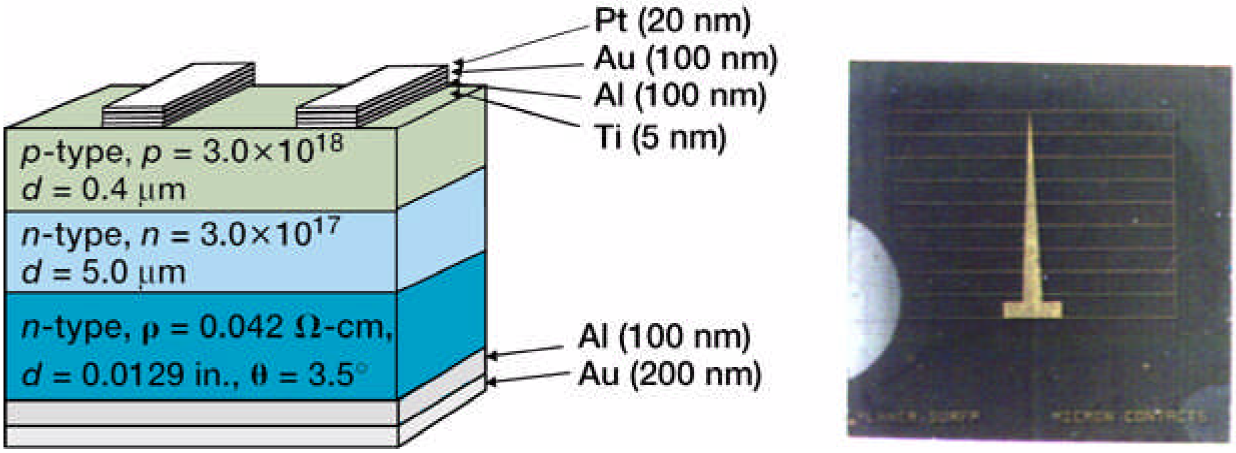
Silicon Carbide Solar Cells Investigated

The semiconductor silicon carbide (SiC) has long been known for its outstanding resistance to harsh environments (e.g., thermal stability, radiation resistance, and dielectric strength). However, the ability to produce device-quality material is severely limited by the inherent crystalline defects associated with this material and their associated electronic effects. Much progress has been made recently in the understanding and control of these defects and in the improved processing of this material. Because of this work, it may be possible to produce SiC-based solar cells for environments with high temperatures, light intensities, and radiation, such as those experienced by solar probes (ref. 1).

Electronics and sensors based on SiC can operate in hostile environments where conventional silicon-based electronics (limited to 350 °C) cannot function. Development of this material will enable large performance enhancements and size reductions for a wide variety of systems--such as high-frequency devices, high-power devices, microwave switching devices, and high-temperature electronics. These applications would supply more energy-efficient public electric power distribution and electric vehicles, more powerful microwave electronics for radar and communications, and better sensors and controls for cleaner-burning, more fuel-efficient jet aircraft and automobile engines.

The 6H-SiC polytype is a promising wide-bandgap ($E_g = 3.0$ eV) semiconductor for photovoltaic applications in harsh solar environments that involve high-temperature and high-radiation conditions. The advantages of this material for this application lie in its extremely large breakdown field strength, high thermal conductivity, good electron saturation drift velocity, and stable electrical performance at temperatures as high as 600 °C (ref. 2). This behavior makes it an attractive photovoltaic solar cell material for devices that can operate within three solar radii of the Sun (ref. 3).

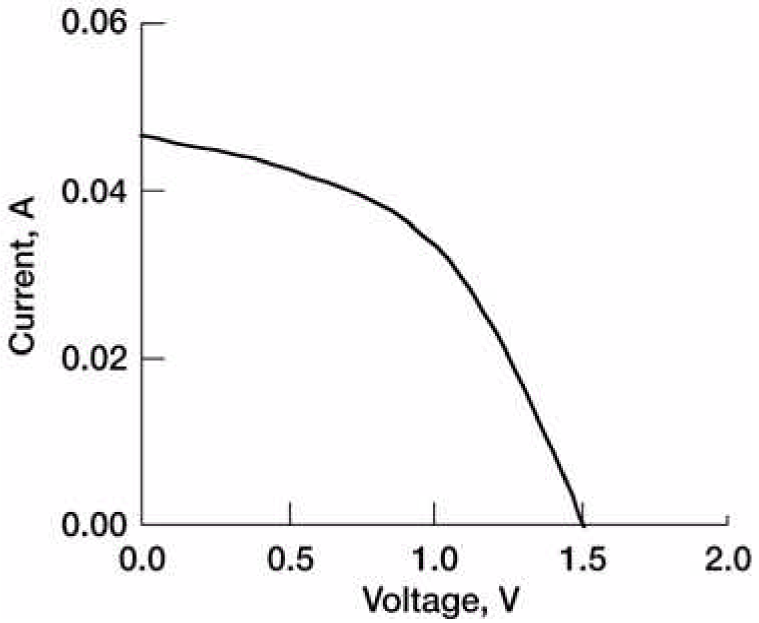


Left: SiC solar cell schematic. Right: 0.48 cm^2 *SiC solar cell.*

Schematic showing five layers and electrodes of solar cell. Electrode layers: Pt (20 nm), Au (100 nm), Al (100 nm), Ti (5nm); top layer: p-type, $p = 3.0\times10^{18}$, $d = 0.4$ µm; second layer: n-type, $n = 3.0\times10^{17}$, $d = 5.0$ µm; third layer: n-type, $\rho = 0.042$ Ω-cm, $d = 0.0129$ in., $\theta = 3.5°$; fourth layer: Al (100 nm); fifth layer: Au (200 nm).

At the NASA Glenn Research Center, several solar cells were fabricated on both thin *n*-on-*p* and thin *p*-on-*n* SiC epilayers grown by Cree Semiconductor, Inc. The contacts were made using alloys made by the sequential deposition of various metal layers followed by a rapid thermal anneal at 800 °C. The cell schematic and a resulting device are shown in the preceding figure.

The photoresponse of the cells was measured under simulated air mass zero (AM0) conditions. The current-versus-voltage behavior of the device showed a good photoresponse and diode characteristics, especially considering there is very little intensity in the solar spectrum above 3.0 eV (see the following figure).



AM0 photoresponse of a thin n-on-p SiC solar cell.

References

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