Semitransparent, mechanically flexible, ultrathin silicon solar microcells

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**Broader Context:** Silicon continues to represent one of the most compelling materials for solar energy conversion; it remains the dominant choice for commercial photovoltaic applications. Research in this area focuses mainly on enhancing the conversion efficiency of non-crystalline Si, reducing the materials usage per unit power output and relaxing the requirements on purity. Thin films of amorphous or microcrystalline Si and thin sheets of single crystalline Si enable efficient material utilization. Recently, we reported an alternative strategy that involves production of ultrathin and small Si solar cells (i.e., μ-cells) from bulk, commodity wafers by use of lateral, anisotropic etching techniques, followed by assembly of these μ-cells into interconnected arrays by use of soft, transfer printing methods. Here we describe modules that exploit large collections of such μ-cells printed to allow series electrical interconnection for compact modules (0.95 cm X 0.63 cm) that are capable of producing high voltage outputs. When formed on thin sheets of plastic in optimized neutral mechanical plane designs, these modules can bend to radius of curvature as small as ~2 mm without any measurable changes in the mechanical or electrical properties. These devices provide a relatively simple route to low-cost, high-voltage flexible photovoltaic devices, suitable for portable and wearable electronic applications.

**Summary of Technical Accomplishment:** A type of compact (~cm²) high voltage photovoltaic module that utilizes large collections of ultrathin (~15 μm), small (~45 μm wide, ~1 mm long) silicon solar cells was fabricated and characterized. Integration of thin sheets of plastic yielded small, flexible modules with per-cell efficiencies of ~8%, voltage outputs > 200 V and maximum power outputs > 1.5 mW.

**Impact of this project:** Flexible silicon solar cells, which can be mounted on clothes, automotive bodies, building (windows, walls) and many other surfaces, will significantly boost the use of solar energy in our daily life. This project has generated important preliminary results for three proposals we submitted in the past 10 months on flexible solar energy cells.

The project has also resulted a publication as the cover article in Energy & Environmental Science (publication 1). In an invited review by Science (publication 2), we also summarized the recent breakthrough in flexible silicon solar cells. We are currently writing an article on this topic for Advanced Materials.

**Publications**