Low-Temperature $Cu(In,Ga)Se_2$ Photoconductor for CMOS Imaging

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Experiments have been conducted to assess the feasibility of using copper-indium-gallium-diselenide (CIGS) thin film solar cells for use in near-infrared CMOS image sensors. HNEI has developed a multi-source elemental evaporation system capable of depositing high efficiency solar cells (14%, 4 cm^2 device, NREL-confirmed on metal substrates). In this work the solar cell fabrication sequence was modified to allow diode formation on proprietary CMOS chips. Key issues were compatibility of the deposition process and the sensor, protection of contact pads during chemical bath deposition of the CdS, adhesion of the films, and signal-to-noise (dark current).

CIGS films co-evaporated onto sensor chips at substrate temperatures of 350°C, 450°C and 550°C to determine compatibility of the deposition process and performance. Adjustments were made to a standard two-stage process to ensure adhesion of the films on the sensor chips. Films deposited at substrate temperatures of 450°C and 550°C showed reasonable composition and electrical properties. CIGS films produced at 350°C were found to be copper-poor, resistive and had small grain size. Adding sodium during the co-evaporation increased the grain size and lowered the resistivity of the films deposited at 350C, but the sodium was deemed incompatible with the sensor chips.

Other modifications included optimization of the buffer layer and transparent conducting oxide deposition to address issues of film peeling and high dark currents, and development of masking techniques to protect contact pads during CdS deposition.

Live sensors were produced at substrate temperatures up to 450°C and images were obtained from those chips. A light/dark current ratio of 2000 (at –0.5V bias and AM1.5G) was obtained. At conditions yielding live sensors, a quantum efficiency of 42% at 1 μm wavelength was measured on test photodiodes.

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