High Voltage with Si Series Photovoltaics

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A monolithic crystalline Si photovoltaic device, developing a potential of at least 500 volts, is demonstrated. The monolithic device consists of a large number of small photovoltaic cells, combined in series and produced using standard CMOS processing on SOI wafers. SOI and trenches etched to the buried oxide (BOX) depth are used for cell isolation. Each cell produces approximately 0.5 volts, and these cells are connected together in series.

A schematic cross-section view of the device is shown in Fig. 1. The photovoltaic cell is a Si pn junction device with the n surface region forming the front surface diffused region upon which most of the light impinges. Contact is formed to the deeper diffused region at the cell edge. The p+ deep-diffused region forms the contact to the p-type base region. Electrons and holes generated by light are separated and collected by the properties of the pn junction. For the devices studied, the base region was 5 or 10 μm deep. A sample IV curve for a 262 volt PV device is shown in Fig. 2.

The series connection scheme allows for the voltage to range from approximately 0.5 volts for a single cell to several thousand of volts for strings of thousands of cells. The voltage is limited by fabrication and electrical isolation techniques. The primary fabrication issue is the prevention of dielectric breakdown in high voltage devices. Each cell is isolated from the adjacent cells through trench isolation, the substrate through the SOI buried oxide, and the metal wiring by the deposited pre-metal dielectric. If any of these dielectrics fail (whether due to thickness or inherent defects), the photovoltaic device will not produce the desired potential. We have used ultra-thick buried oxide SOI and several novel processes, including an oxynitride trench fill process, to avoid dielectric breakdown. These processing techniques will be discussed in detail.

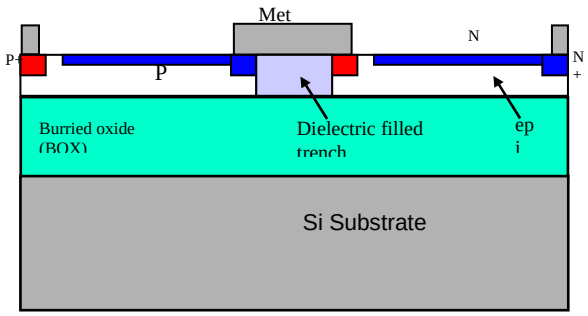

Fig. 1 SOI with buried oxide layer and trench isolation with dielectric fill provide cell's electrical isolation.

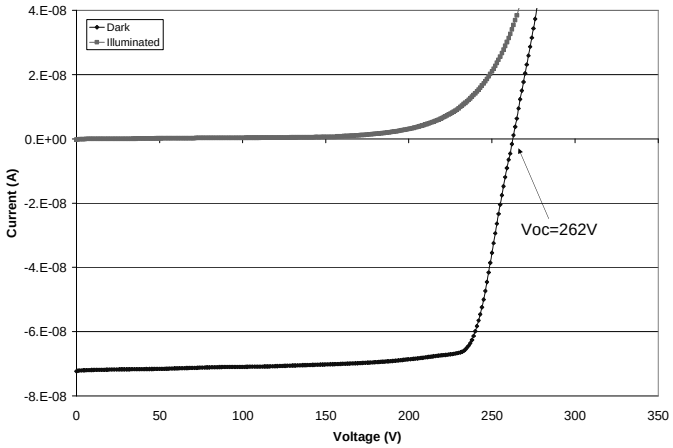

Fig. 2 Dark and illuminated IV curves from series PV.