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Abstract

TITLE: Hybrid Nanocrystalline / Amorphous Silicon Schottky Diodes for Large Area Electronic Systems

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ABSTRACT BODY: We are developing large-area sensing systems that integrate thin-film electronics and CMOS VLSI [1]. In order to capacitively and inductively transmit power and signals between the planes (physical layers) of the system we employ thin film rectifiers. Previously, we fabricated rectifiers using amorphous silicon (a-Si) Schottky diodes with a high ON-to-OFF current ratio [2]. However, these diodes suffered from low ON currents, which meant that to drive large currents they had to be sized over large areas, and correspondingly had large terminal capacitances. To overcome these limitations we have developed hybrid nanocrystalline / amorphous silicon Schottky diodes, which use a-Si Schottky contacts to obtain low OFF currents and bulk nanocrystalline (nc-Si) thin films for high ON currents. These hybrid diodes yield a forward current density of 5 A/cm^2 at 1V, which is ~1000x higher than our previous a-Si diodes. The high current density results from avoiding the space charge limited current of their a-Si counterparts because of the very high conductivity of the nc-Si. We exploit the high ON current of the hybrid diodes to fabricate devices with smaller terminal capacitances, which enables diode-based circuits with significantly improved frequency performance. For example, when comparing a half-wave rectifier with a 10 kΩ resistive load, an a-Si rectifier (1mm^2 diode) gives a circuit with an AC-to-DC power conversion efficiency of 9% at 10 kHz and fails to rectify at higher frequencies, while a hybrid rectifier (0.01 mm^2 diode) yields an efficiency greater than 30% at 1 MHz.

In this talk we will: (1) describe the structure and processing of the hybrid diode, including the integration of multiple diodes to fabricate circuits; (2) compare the DC and AC behaviours of isolated hybrid and a-Si Schottky diodes, and discuss how they relate to the underlying device operating principles; and (3) compare the frequency performance of half-wave and full-wave rectifier circuits composed of a-Si and hybrid diodes.

The hybrid diode is made by plasma-enhanced chemical vapor deposition with a frequency of 80 MHz at 180°C. It does not require p-type doping, which makes it compatible with n-channel TFT processing. The diode structure consists of a chrome Schottky contact, 750 nm undoped nc-Si, 120 nm n+ nc-Si, and a chrome ohmic contact. The Schottky metal is in contact with the a-Si incubation layer, formed before the nucleation of the nc-Si film. Measurements show that the undoped nc-Si layer is n-type with a background donor density of 10^16 cm^-3. Not only does the hybrid diode have a high current density, but it also has a high ON-to-OFF current ratio (>1000 for +1V /-8V), making it well suited for diode circuits for large-area systems.

[1] Y. Hu et al. VLSI Symp., 2012.
[2] J. Sanz-Robinson et al. DRC, 2012.

(No Table Selected)
