Sample Preparation for Study of Space Charge Limited Current

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Principal Investigator(s): John Marohn

User(s): Rachael Cohn, Virginia McGhee

Affiliation(s): Department of Chemistry and Chemical Biology, Cornell University

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Contact: jam99@cornell.edu, rc784@cornell.edu, vem26@cornell.edu

Website: http://marohn.chem.cornell.edu/

Primary CNF Tools Used: Heidelberg Mask Writer - DWL2000, ABM Contact Aligner, Odd Hour Evaporator

CHEMISTRY

Abstract:

Scanning probe microscopy is used to study charge injection from a metal to a pi-conjugated system. Unique capabilities of a custom-built electric force microscope will be utilized to reproduce data collected in Ref. [1]. This report discusses substrate preparation conducted at the Cornell NanoScale Science & Technology Facility (CNF) to enable the study space charge limited current.

Summary of Research:

Organic photovoltaics have been steadily growing in both efficiency and functionality [2]. To design and operate organic electronic devices, it is essential to understand how charge is injected from a metal to a pi-conjugated organic system. Typically, there is an assumption that the electric field is uniform between the source and drain gap. However, studies done by Ng, Silveira, and Marohn, show that the electric field varies with both temperature and source-drain voltage [3]. Furthermore, at the injection site, the electric field differs greatly from the bulk, possibly due to the addition of space charge. The previous assumption has an error that propagates through the calculation of electron mobility and concentrations of free charge carriers [1]. To correct for these errors, space charge limited current in an organic photovoltaic film will be studied.

N,N'-diphenyl-N-N'-bis(3-methylphenyl)-(1,1'-biphenyl)-4,4'-diamine (TPD) / polystyrene (PS) films will be spin-coated on quartz substrates. The quartz substrates contain gold interdigitated electrodes prepared at the CNF. The preparation is based on Ref. [1]. The source-drain gap varies in length at 2, 5, 12, 16, and 20 µm, and the channel width varies at 1.5, 2, and 2.5 mm. There are a total of 68 electrodes per substrate and 15 different substrates with the various source-drain gaps and channel widths that can be made on one wafer.

A mask was designed in L-edit and printed using the Heidelberg mask writer. The substrate making process was begun by cleaning quartz wafers with hot piranha, spin coating resist, and exposing the wafer. An exposure matrix using the ABM contact aligner was done to determine the optimal exposure time.

Conclusions and Future Steps:

Users will expose a wafer using the determined exposure time, deposit a 50 Å Cr adhesion layer and 500 Å Au using the odd hour evaporator, lift off to remove excess Au, and dice the wafer to make 1 cm × 1 cm substrates. Once the substrates are completed, users will deposit TPD:PS films and study space charge limited current.

References:

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[3] T. N. Ng, W. R. Silveira, and J. A. Marohn, Dependence of charge injection on temperature, electric field, and energetic disorder in an organic semiconductor, Phys. Rev. Lett., 2007, 98, 066101, URL http://dx.doi.org/10.1103/PhysRevLett.98.066101.