Fabrication of Interdigitated Electrodes for use in a Homebuilt Electron Force Microscope

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Primary CNF Tools Used: Hamatech Hot Piranha Cleaner, Class II Resist Spinners, Edge Bead Removal System, ABM Contact Aligner, Hamatech Wafer Processor, SC4500 Odd-Hour Evaporator, DISCO Dicing Saw

Abstract:

Interdigitated electrodes are under development for applications in electron force microscopy. These devices will be employed in the investigation of charge recombination dynamics in organic photovoltaic devices.

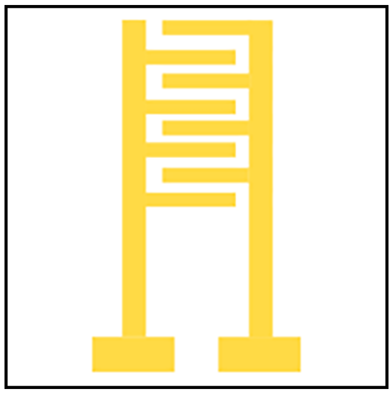

Figure 1: An Interdigitated Electrode. Interdigitated electrodes (IDEs) have a comb-like structure that increases the sensitivity of charge detection.

Summary of Research:

The fabrication of interdigitated electrodes (IDEs) for application in the homebuilt electron force microscopes (EFMs) of the Marohn group will be facilitated by the tools provided by the Cornell NanoScale Facility (CNF). The electrodes will be made utilizing basic photolithography and thin film deposition techniques. These devices will be used in the analysis of charge recombination dynamics in organic photovoltaic (OPV) films using a novel EFM method invented in the Marohn Lab: phase kick electron force microscopy (pk-EFM) [1]. The comb-like structure of the IDEs as shown in Figure 1 will greatly enhance the sensitivity of the new method, allowing us to make measurements with space-charge limited current.

The process of fabricating the interdigitated electrodes will begin in photolithography room 106. Lift-off resist (LOR) will be spin-coated on a cleaned, dehydrated 100 mm quartz wafer. A soft bake will be performed at 150. by direct contact on a hot plate. Once the soft bake is complete, a compatible imaging resist will be spin-coated on top of the LOR resist and will be baked per the imaging resist's requirements. Edge beads will be removed after each spin coating step and film uniformity will be checked with the Filmetrics F50.

The IDE pattern will be written using the ABM Contact Aligner. Rachel Cohn of the Marohn Group has already written the mask for this application, so the Heidelberg Mask writers will not be utilized. Exposure conditions for this application have yet to be optimized; therefore an exposure array will be performed to determine the optimal conditions for writing the IDEs onto the stack. Once the optimal conditions have been determined, exposed stacks will be placed in the SC4500 Odd-Hour Evaporator where chromium and gold will be deposited into the pattern left behind by the mask. Microchem Remover PG will lift the resist stack and excess gold from the quartz wafer, leaving behind the gold IDEs. The devices will be removed from the wafer using the DISCO dicing saw and will be brought back to Baker Laboratory for thin film deposition. No thin film deposition onto the IDEs will be conducted in the CNF cleanroom.

Fully fabricated interdigitated electrodes will be used as substrates for the deposition of OPV materials. One particular system of interest is the known OPV blend of poly-(3-hexylthiophene) (P3HT) and [6,6] phenyl-C61-butyric acid methyl ester (PCBM), which has been studied with time-resolved microwave conductivity (TRMC) [2][3], time-resolved photoluminescence spectroscopy (TRPL) [4] and has shown to have power conversion efficiency of up to six percent when thermally annealed [5]. The added sensitivity provided by the IDEs will allow our group to better compare the experimental results of the EFM method – shown

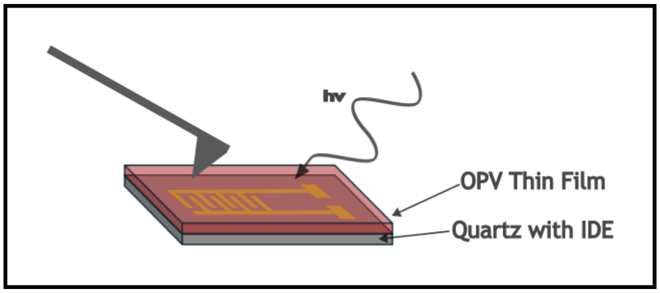

Figure 2: Schematic of Electron Force Microscope Experiment Using Interdigitated Electrodes. Interdigitated electrodes deposited on quartz substrates (bottom layer) will have an organic photovoltaic layer deposited on top of them (top layer). A conductive cantilever tip is brought close to the sample surface as it is irradiated with light. The cantilever's motion is modified by the electrostatic forces arising from the generation of charge carriers within the sample.

in Figure 2 – to those of other methods and potentially allow for the screening of promising OPV materials for incorporation into devices.

Conclusions and Future Steps:

Organic photovoltaic materials will be spin-coated on quartz substrates containing the fabricated IDEs. These samples will be inserted into Marohn Group microscopes where pk-EFM experiments will be conducted. The incorporation of the IDEs into the experiment will allow for space-charge-limited measurements of conductivity to be collected, improving the sensitivity of the experiment.

References:

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