SCANNING PHOTO-INDUCED IMPEDANCE MICROSCOPY – IMPROVEMENTS IN LATERAL RESOLUTION

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A method for spatially resolved impedance measurements, Scanning Photo-induced Impedance Microscopy (SPIM), has been developed [1]. It is based on photocurrent and photovoltage measurements at field-effect structures. The polymer film under investigation is deposited onto a silicon-silicon dioxide substrate. A thin metal film or an electrolyte solution with an immersed electrode serves as the gate contact. When the structure is biased towards inversion, a modulated light beam that is focused into the space charge region of the semiconductor will produce a photocurrent, which is directly related to the local impedance of the polymer film.

The lateral resolution of the photocurrent is comparable to that of other techniques using the photo-effect in semiconductor/insulator structures such as light-addressable potentiometric sensors (LAPS) or scanning light pulse technique (SLPT). This lateral resolution was found to be in the range of several 10 to some 100 µm when using silicon wafers as the semiconductor material [2]. The main reasons for the limitation in resolution are the lateral diffusion of charge carriers in the semiconductor and charges in the insulator.

This problem can be solved by choosing different semiconductor substrates. We investigated thin Si-layers (SOI and SOS), GaAs [3] and amorphous silicon with the aim to improve the lateral resolution. For all these field-effect structures a much better resolution than for bulk Si was achieved. However, the quality of the insulator prepared on GaAs has not been sufficient for large area investigations.

The best results were obtained using thin layers (0.3-1.5 µm) of amorphous silicon. Thin amorphous silicon (a-Si) films were prepared on corning 1737 glass substrates. First Al (500 nm)/ZnO (700 nm) was deposited as the ohmic contact. Afterwards, a-Si and SiO_2 (30 nm) and Si_3N_4 (50 nm) insulator layers were deposited by PECVD (plasma-enhanced chemical vapor deposition). The thickness of the a-Si was varied in the range of 0.3 to 1.5 µm. In our basic studies, it was shown that photocurrent measurements can potentially be carried out with a resolution in the sub-micrometer range. The choice of a-Si as a thin layer semiconductor material allows a strong improvement compared to single crystalline Si. Further improvement of the optical properties of the multilayer system and the optics are necessary to take the full advantage of the semiconductor properties.

The potential of visualization using this photocurrent method can be seen comparing Fig. 1 and 2 showing the e-beam microscopy and the photocurrent graphs of a 400 nm grid structure, respectively.

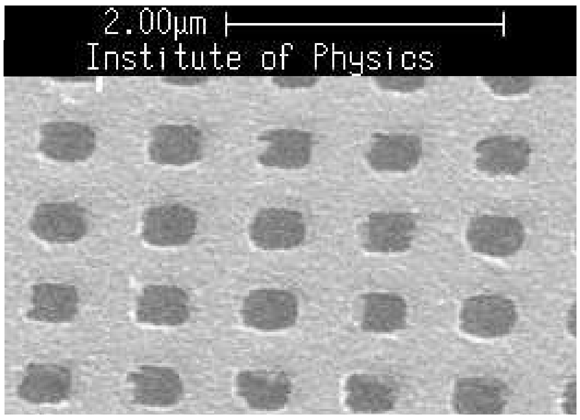

Fig.1 E-beam graph of a 400nm grid gate electrode

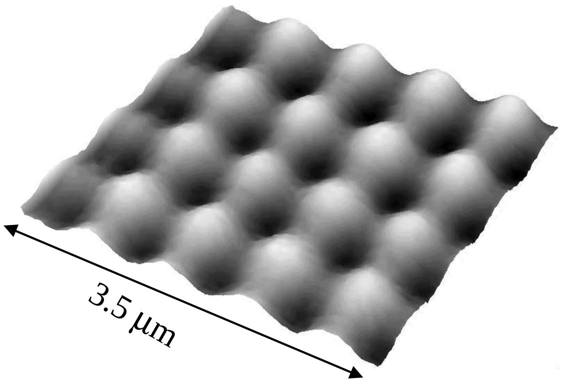

Fig.2 Photocurrent measurement, same structure

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