EBIC and voltage contrast of transport properties of V_2O_5 and DH4T nanometer sized devices

J. Seekamp[1*], A. Kam[1], V. Lavayen[2], A. Goldschmidt, V. Solovyev[1], C. Clavijo Cedeño[1], G. Gonzalez Moraga[2], C. M. Sotomayor Torres[1]

[1]Bergische Universität Wuppertal, Elektrotechnik und Informationstechnik, Institut für Materialwissenschaften, 42097 Wuppertal, Germany

[2]Departamento de Quimica, Faculdad de Ciencias, Universidad de Chile, Santiago, Chile

[*]seekamp@uni-wuppertal.de

Organic semiconductors and nanotube materials are promising candidates for future electronic devices. The first for slow disposable electronic circuits, the second as wiring for increasingly smaller electronic devices, possibly, down to the molecular scale. In this contribution the use of scanning electron techniques is proposed to characterise the electronic properties of either material for the first time. The techniques chosen were electron beam induced current (EBIC) and voltage contrast secondary electron microscopy (VC). These techniques were chosen as extension and alternative for scanning tunnelling microscopy experiments because of shorter measurement times, i.e., below 8 min. for a full frame, simpler sample preparation and their ability to cover the size range from the mm scale to the tens of nm size.

Challenges to these measurements were to reach the 100 nm scale resolution for EBIC measurements and to link the VC measurements to actual current flows in the devices. Most importantly, the unavoidable modification of the conducting material by the electron beam had to be assessed and minimised.

These investigations were performed on electrodes separated between 40 µm and 100 nm. Interdigitated electrodes with separations of 800 nm and below were fabricated using nanoimprint lithography (NIL) and metal lift off. The materials investigated were primary alkylamine filled V_2O_5 nanotubes (VONTS) and dihexylquarterthiophene (DH4T). The range of electrode separations covers the channel length of recently published organic semiconductor transistor designs. The smaller electrode separations go down to dimensions necessary to address single multiwall V_2O_5 nanotubes and justify hopes for higher mobilities in organic semiconductor devices.

The work presented indicates that electron beam induced changes are tolerable, i.e., the changes of transport properties remain within the variation limits observed for unexposed devices. The changes occurring and the optimal window of parameters to apply electron beam techniques to the two sample materials are presented and discussed for the first time.

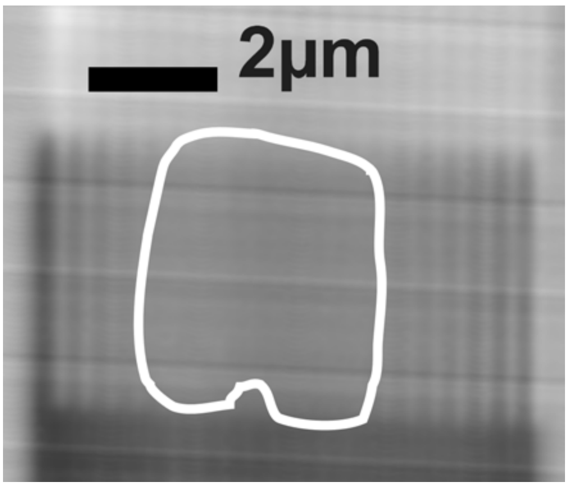

Figure 1: EBIC image of a FET structure of DH4T covered gold electrodes with 100nm separation on silicon oxide. Only areas inside the white shape show conductance between source and drain.