THREE-DIMENSIONAL ELECTRON BEAM INDUCED DEPOSITION TO OVERCOME EDGE EFFECTS IN WIRING OF NANO STRUCTURES

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Electron Beam Induced Deposition (EBID) has been successfully applied to wiring of nano structures like carbon nanotubes [1, 2]. Moreover the development of easy to handle precursors yielding good conductivity of the deposit is very promising for further improvements of this technique [3]. Basically, a focused electron beam in combination with a gas injection system supplying a vapour precursor is used for direct patterning of conducting leads.

In general, creating a connection from a nano object to the outside world in the millimetre dimensions represents a challenge, whereas one would like to achieve this wiring easily, *in-situ* and with good electrical quality. Therefore all parts of the connection including wire bonding or electrical probes, metal electrodes fabricated by optical or e-beam lithography and the final wiring of the nano structure as well as the interfaces of these parts have to be examined carefully. Particularly the integrated combination of a nano manipulator, EBID and pre-patterned electrodes provides excellent flexibility. Moreover for suspended or 3-dimensional structures like in Nano Electro-Mechanical Systems (NEMS) (Fig. 3) direct patterning EBID can be used for wiring even during one of the final process steps [2].

Bonding or probing contacts show a good ohmic contact and the conductivity of metal lines is sufficient at a thickness of 100 nm to 200 nm. Fine line deposition however generates structures of 20 nm to 50 nm in thickness, and the connection to the metal pad is known to be a critical part of the rather high resistance of various EBID leads [2, 4]. In addition most gas injection systems deliver the precursor from one or several nozzles to the sample, resulting in a directed beam of precursor molecules and thus shadow effects. Figure 1 illustrates the adsorbed precursor layers on a 3-dimensional connector environment in cross-sectional view. In the semi or complete shadow region close to the step, the deposition rate is reduced and a different material quality is generated. To overcome these limited conditions an additionally fabricated connecting bridge pier and arc structure is designed here and serves as a height compensation regarding the edge scattering effects and precursor flux. The arc can thus be fabricated using the unshadowed adsorption rate of the precursor. A micrograph of such a special connecting structure made by deposited Pt/C lines for a 2-point (or 4-point) measurement is shown in Figure 2. The resistance of the additional parts with respect to their position to the nozzle is measured in 2-point and 4-point measurements. Results for various exposure and deposition parameters will be presented and a comparison with connections made by conventional EBID structures will be drawn.

References:

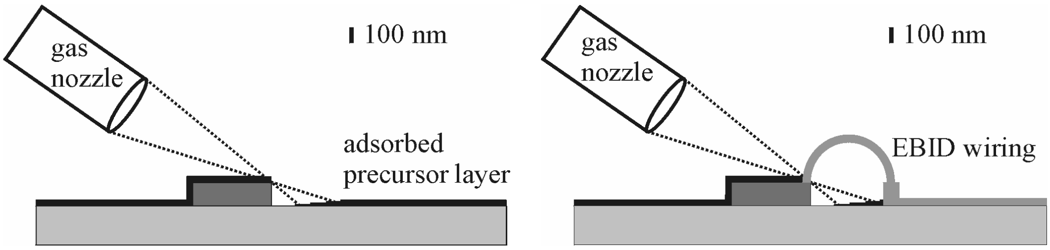
[1] T. Brintlinger et al., JVST B 23, 3174 (2005)

[2] S. Bauerdick et al., extended abstract at EIPBN 2006, Baltimore

[3] J. D. Barry et al., extended abstract at EIPBN 2006, Baltimore

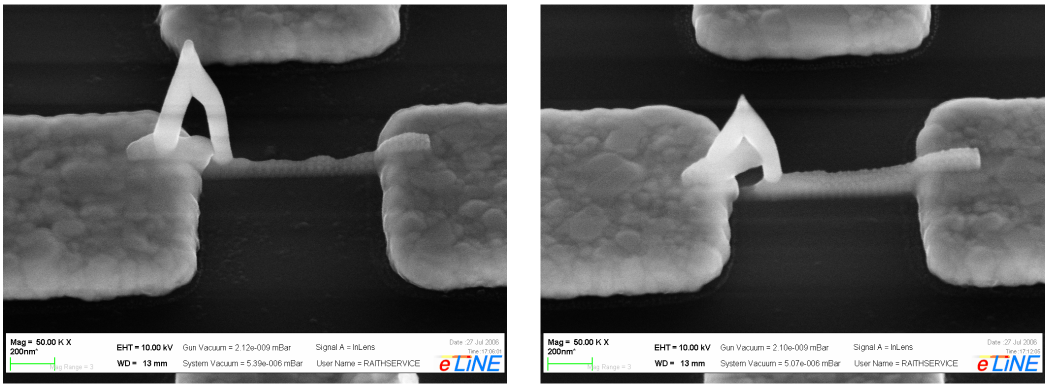
[4] M. D. Croitoru et al., JVST B 23, 2789 (2005).

Figures:



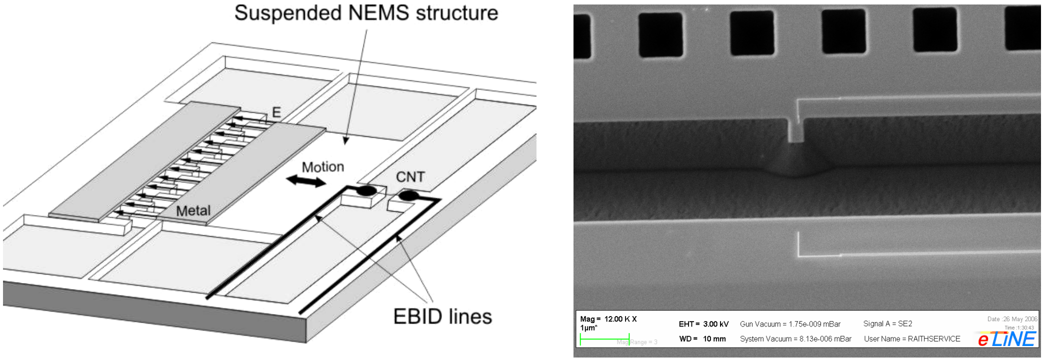
(a) (b)

Fig. 1: Schematic setup of gas injection system and sample with micro electrodes for wiring of nano structures showing (a) the distribution of the adsorbed precursor layers and (b) the 3-dimensional EBID structure to overcome step and shadow effects.



(a) (b)

Fig. 2: Scanning electron micrographs of 3-dimensional platinum EBID nano structures providing an improved contact to the pre-patterned electrodes.



(a) (b)

Fig 3: Nano electro-mechanical system (NEMS) with EBID leads used for wiring of nano structures: (a) schematic and (b) scanning electron micrograph.