Study of structures deposited by focused ion beam induced deposition on membrane

Hervé Dallaporta[1], *Alan Reguer*[1], *Frédéric Bedu*[1], *D. Tonneau*[1] *and A .Houël, P. Sudraud*[2]

[1]CRMC-N-CNRS 163 Avenue de Luminy case 901 13288 Marseille Cedex 9 France,

[2]Orsay Physics, 95 Avenue des Monts Auréliens - ZA Saint-Charles - F - 13710 Fuveau

dallaporta@crmcn.univ-mrs.fr

1 – Introduction

We will show that using the local decomposition of molecules induced by focused ion beam (FIBID), it is possible to constructed nanostructures on very thin membranes. The interest of using very thin membranes is that it allows the study by transmission electronic microscopy. We have tried different membranes on which we are able to deposit an electrical circuit and follow the modification of deposited FIBID wire when a high current density flows through it. The behavior of FIBID nanowires in tungsten and platinum will be compared. We will show that on such membranes new phenomena can take place: for tungsten nanowire connected to gold pad the high current density can induced migration of gold around the nanowire.

2 –Experimental setup:

II.1. Nanofabrication station

The experimental setup is a cross-beam system coupling a JSM 5910 Scanning Electron Microscope (SEM, JEOL) and a Canion 31+ Focused Ion Beam (FIB, Orsay Physics), equipped with a gas injection system (GIS, Orsay Physics). The two beams are focused on the same point of the sample. This allows real time simultaneous FIB machining and non-destructive non-contaminating SEM imaging. The FIB column operates at an accelerating voltage of Ga+ ions ranging from 10 to 30 kV with a minimal Gaussian beam diameter around 7 nm. The beam current can be varied from 1 pA for the lowest current to few nA. The precursor vapor is delivered via a Gas Injection System composed of 5 heated reservoirs coupled to the injection lines driven by a 3-axis microstage. The system is equipped with an in situ electrical measurement allowing the deposition between pads

II.2. Supports

We have designed two type of supports for this study. The first one is composed of a thin aluminium foil (width:10µm) stuck on a ceramic disc. The foil is cut by laser ablation creating two macroscopic electrodes separated by a 10 µm wide groove. A FIBID carbon membrane is deposited between the two aluminium electrodes. Then a FIBID nanowire can bridge the electrodes. The other support consists of a silicon nitride membrane window specifically designed for TEM. This support consists of a 2.65 mm x 2.65 mm, 200 µm thick silicon frame which contains a single 0.5 mm x 0.5 mm silicon nitride membrane (thickness 50nm). Thermally evaporated Au was deposited, through a mask, onto the surface as electrodes. We obtained four electrical contacts separated by 30 µm. Like for the former support we can bridge the electrodes by a FIBID nanowire.

3 –**Results**

Both tungsten and platinum nanowires has been treated by applying a slow ramp voltage to the electrodes from 0 to 2,5V. The resistance of the tungsten nanowire drops by a factor 25 after this electrical treatment while for platinum the resistance increases. SEM image of treated nanowire shows that for W the gallium incorporated during the deposition process is rejected outside the wire forming one gallium droplet, for platinum we observed the formation of droplets along the wire. From the transmission electron microscopy studies the as deposited FIBID nanowires are always amorphous while on treated nanowires we obtained diffraction pattern and resolved high resolution images. The treated W nanowire is mostly a bcc crystalline structure of tungsten mixed with tungsten carbide structure. The treated Pt nanowire is formed by platinum crystalline clusters with droplets of $PtGa_2$.