Focused-Electron/Ion-Beam-Induced nanodeposits studied with Transmission Electron Microscopy

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Focused-Electron/Ion-Beam-Induced Deposition (FEBID and FIBID respectively) of metallic materials is one major application of "Dual Beam" systems, which integrate electron and ion columns. FEBID and FIBID allow local deposition in the targeted place with controllable nanometric lateral size and thickness [1]. FEBID and FIBID of materials is a Chemical Vapour Deposition (CVD) induced by focused electron and ion-beam, respectively [2, 3].

Previous studies on FEBID Pt deposits have shown the decrease of the deposition rate as a function of the beam energy [2-4]. However in the case of FIBID Pt deposits, the deposition rate was found to vary little [2-4]. The microstructure of the Pt deposits have been studied by means of transmission electron microscopy (TEM) [4]. These studies showed that the deposits consist of Pt-rich inclusions in a carbonaceous matrix.

In this contribution we present a systematic study of the volume per dose and microstructure of FEBID and FIBID Pt nanodeposits as a function of the beam energy and current [5]. Our experiments were performed in a Dual Beam equipment (Nova 200 NanoLab). For Pt deposition, an automatized gas-injection system (GIS) was used with $(CH_3)_3Pt(CpCH_3)$ as the precursor material. The volume per dose was calculated after performing cross-sections of the deposited material measuring the deposit thickness. Finally, the microstructure was investigated on Pt nanodeposits grown on Cu TEM grids with a supporting carbon membrane and by inspection of a typical < 100nm thin lamella prepared after deposit growth by HRTEM (JEOL 2010F, 200 kV).

The volume per dose (FEBID) dramatically decreases by a factor four as a function of the incident electron-beam energy as shown in fig. 1(a). This can be explained by the decrease in the amount of secondary electrons reaching the sample surface. For FIBID, the volume per dose increases as a function of the incident ion-beam energy as illustrated in fig. 1(b), which would be explained by the slight changes in the energy dependence of the secondary electron yield. In the inset of fig. 1(b) for deposits at 10 kV, the volume per dose decreases as a function of the beam current, which is explained by the lack of full refreshment of the precursor molecules adsorbed to the sample surface at high beam currents. For the microstructure study of the Pt nanodeposits, two different methodologies have been followed. First, several lamellae were prepared out of the deposits grown on Si substrates. Second, the FEBID and FIBID Pt deposits (thickness in the range 20-50 nm) were directly grown on Cu TEM grids with a supporting carbon membrane. Both approximations show a similar microstructure, formed by independent Pt nanocrystals (3-5 nm) embedded in an amorphous carbon matrix (see fig. 2).

References:

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Figures:

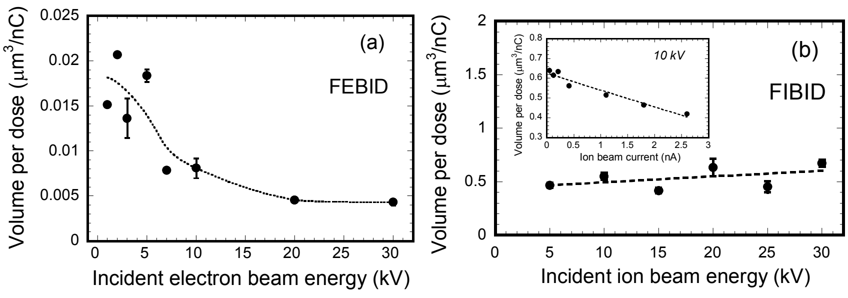

Figure 1: Average volume per dose versus incident electron beam energy in the investigated Pt deposits by FEBID (a) and by FIBID (b). The inset shows the volume per dose versus ion beam current in the investigated FIBID deposits at fixed incident beam energy of 10 kV.

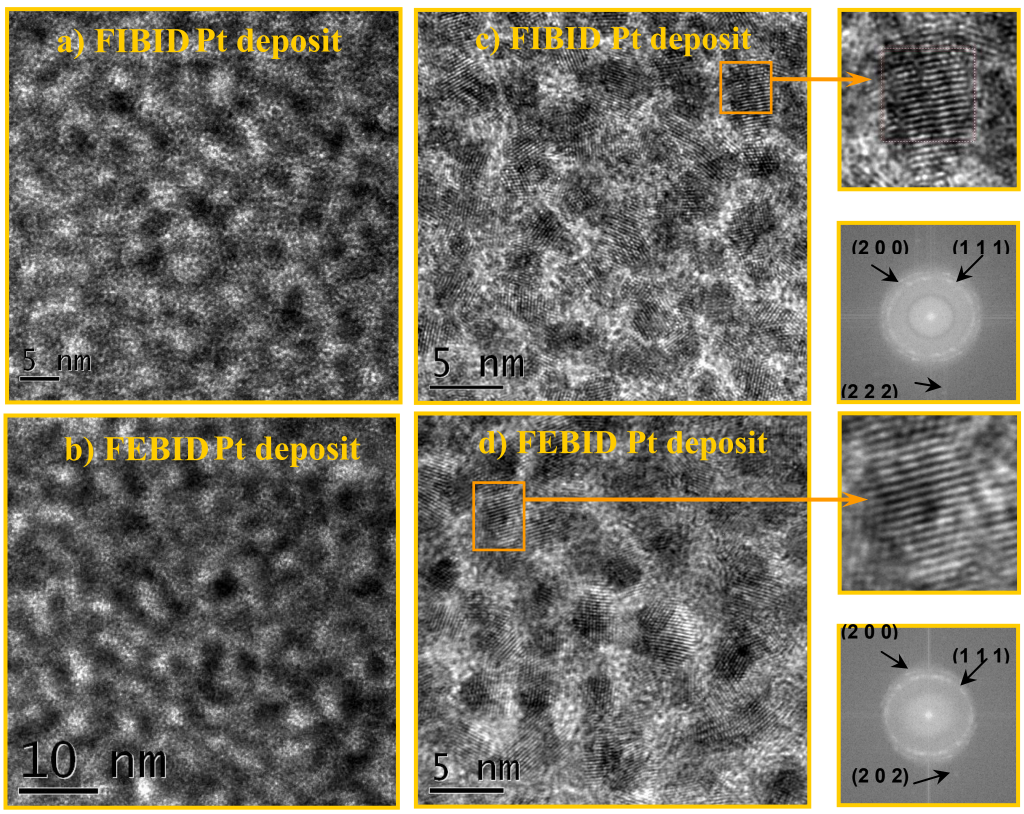

Figure 2: HRTEM images obtained out of lamellae fabricated respectively from a Pt nanodeposit by FIBID (a) and by FEBID (b), in both cases grown at 5 kV beam energy. HRTEM images of a Pt nanodeposit by FIBID (c) and FEBID (d), in both cases grown at 30 kV beam energy on top of a TEM Cu grid covered with a thin supporting holey carbon membrane. One Pt grain has been selected in each case for magnification and clear observation of the corresponding atomic planes. The Fast-Fourier-Transform of the full image gives diffraction spots that correspond to the (200), (111), (222) and (202) atomic planes of fcc Pt.