ECCL Short Time Scientific Mission
Scientific Report

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Beneficiary:	Laurent BERNAU, EMPA – Swiss Federal Laboratories for Materials Testing and Research, Thun (CH)
Host:	Prof. Dr. Petra SWIDEREK, Universität Bremen, Bremen (DE)
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Place:	Bremen (DE)
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Purpose of visit

In Focused Electron Beam Induced Deposition (FEBID), a promising technology for the direct structuring of nanometre-scale features, metal-containing precursor molecules are adsorbed on a surface and dissociated under electron-irradiation in a conventional SEM environment. In this process, low-energy secondary electrons are believed to play a crucial role. The dissociation pathways are however often unknown and parts of the ligands get incorporated in the deposits. Understanding the mechanisms of chemical processes under electron exposure is thus essential to develop more quantitative reactions for the deposition of clean materials in FEBID. The purpose of the research visit to Bremen was to investigate the dissociation of selected precursor molecules relevant to FEBID under low-energy electrons irradiation by High-Resolution Electron Energy Loss Spectroscopy (HREELS).

Description of the work carried out during the visit

We studied the electron-induced decomposition of Tetrakis-trifluorophosphor-platinum ($Pt(PF_3)_4$) and Cobalt-tricarbonyl-nitrosyl ($Co(CO)_3NO$). Molecules were absorbed on a clean Pt foil and the characteristic vibrational peaks identified. The films were subjected to irradiation of electrons with different energies in the 15-500eV range, with increasing doses. Experimental work was carried out at temperatures above the desorption temperature of the ligands in order to simulate the actual FEBID process. HREELS spectra were acquired in order to monitor precursor dissociation and to distinguish which ligands are preferentially released under electron exposure.

Description of the main results obtained

Dissociation of $Pt(PF_3)_4$ was monitored by measuring the evolution of the relative intensities of the vibrational peak attributed to symmetric P-F stretching and the peak attributed to Pt-P stretching. With the higher irradiation energies investigated (100eV and more), a clear shift of the peak attributed to the P-F bond was observed, which points to the appearance of dissociated PF_3 fragments on the surface (see figure 1). This effect increases with increasing energy of the impinging electrons. Thus, ligand decomposition is found to increasingly dominate ligand desorption as the irradiation energy is increased. This offers an understanding of the incorporation of P and F in deposits realized by FEBID of $Pt(PF_3)_4$.

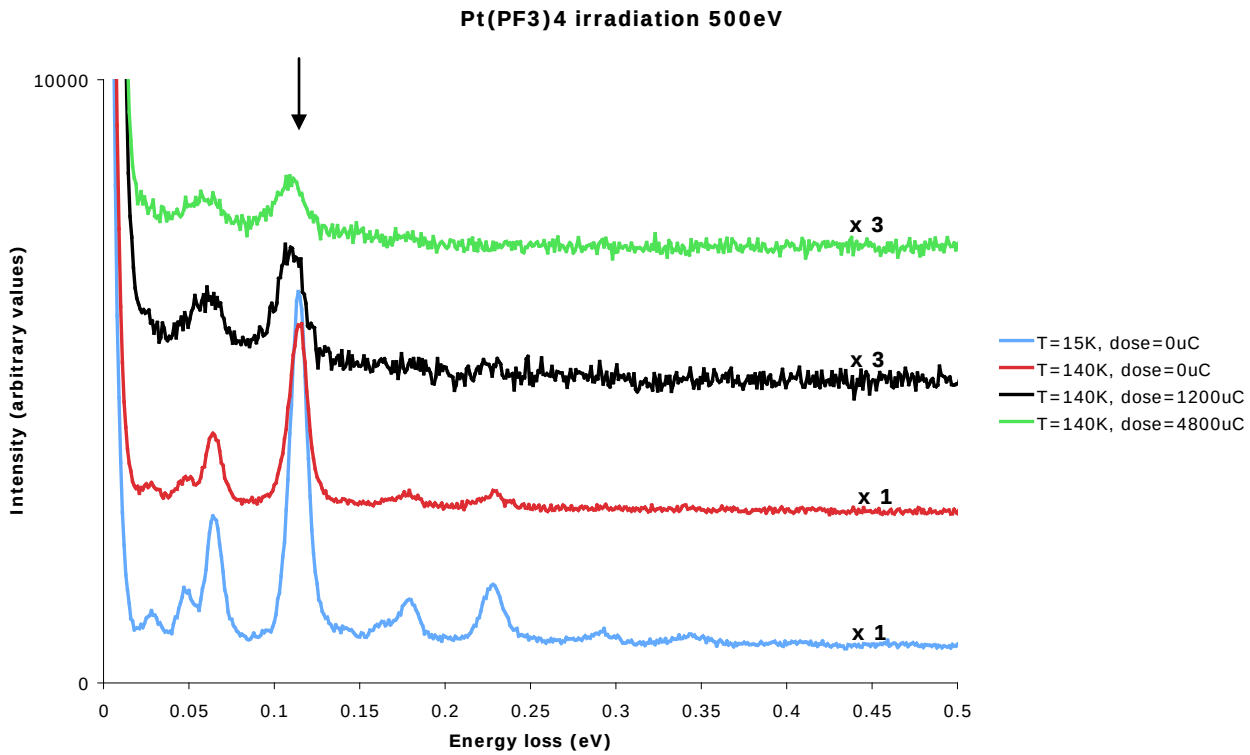

Figure 1: HREELS spectra of $Pt(PF_3)_4$ irradiated with increasing doses of 500eV electrons at a substrate temperature of 140K. The arrow indicates the position of the P-F stretching peak at 114meV.

We performed initial HREELS measurements of electron-induced dissociation of $Co(CO)_3NO$ with energies of 15eV and 500eV. We monitored a decrease in NO signal upon irradiation at both energies, which would possibly point at a preferential NO ligand removal. A more in-depth study would be needed to validate this observation.

Future collaboration with host institution

The interest in the dissociation of precursor molecules relevant to FEBID is high. Future collaboration with the host institution is part of ongoing discussions.

Projected publications/articles resulting or to result from the STSM

While the findings obtained during the stay will not lead to an independent publication, we plan to include them in a publication together with results obtained from studies of electron interactions in the gas phase later this year.