Comparison of Focused Electron Beam Induced Deposition of transparent oxides for nano-optics

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Nano-optical devises require high quality and contamination free local nano-productions in order to match the outstanding near field properties computed by theoreticians. Focused Electron Beam Induced Deposition (FEBID) is today's only nano-structuring candidate technique for the local deposition of low roughness and pure materials [1].

In this work, we present the FEBID of three different transparent oxides (SiO_2, TiO_2 and Al_2O_3), obtained by injecting simultaneously a controlled oxygen flux to the precursor vapors in order to oxidize in real time the contaminants in the growing material. A two channel symmetric gas injection system was installed in our deposition equipment (see figure 1) and allows for the simultaneous injections of two different gases.

The precursors used were tetraethoxysilane $Si(OCH_2CH_3)$, tetramethoxysilane $Si(OCH_3)$, tetramethylsilane $Si(CH_3)_4$ and tetraisocyanatosilane $Si(NCO)_4$ for SiO_2 deposition, the titanium nitrate $Ti(NO_3)_4$ for TiO_2 deposition and diethylaluminum ethoxide $(C_2H_5)_2AlOC_2H_5$ for Al_2O_3 deposition.

The change in chemical compositions as function of the additional molecular oxygen flow was investigated by electron dispersive x-Ray spectroscopy. A similar observation can be done for each of the precursors: the contaminants concentration decrease with increasing oxygen flux. A specific threshold $[O_2]$ / [precursor] ratio – above which no more contaminant can be detected by EDX – was determined for each precursor molecule. Fourier Transform Infrared Spectroscopy microscopy confirmed the absence of water or hydroxyl groups – responsible for high optical absorption coefficient in UV– in the deposited materials. Oxygen incorporation reactions from residual chamber gases or water revealed to be significant in room temperature high vacuum deposition processes. Possible decomposition path ways are discussed.

193 nm wavelength transmission measurements of 100 nm thick SiO_2 deposits obtained from TMS resulted in a 99% transmission [1] (see figure 2), which satisfies the requirements for photolithography mask repair. Optical properties of the TiO_2 and Al_2O_3 films are investigated.

[1] Perentes A et al. Accepted for publication in CVD

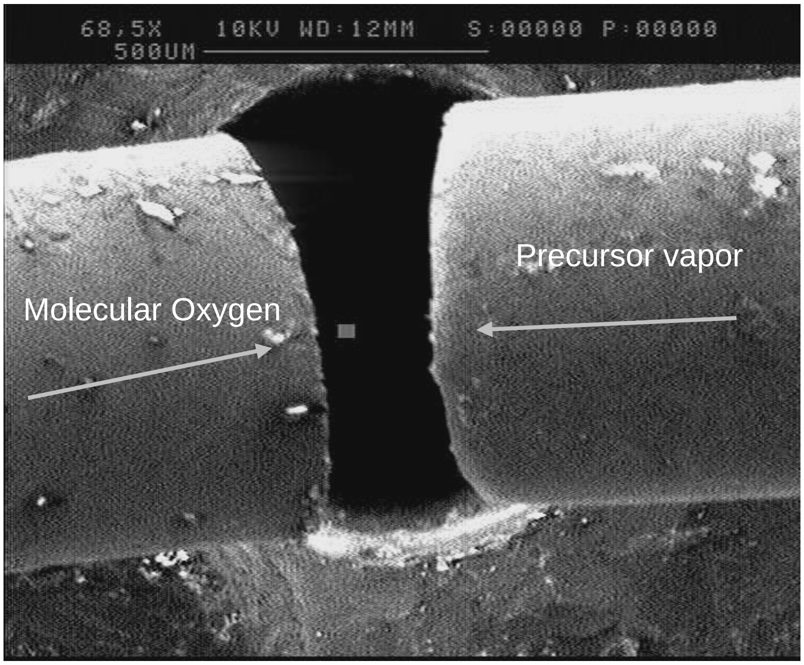

Figure 1: Scanning electron microscope micrograph of the two channel gas injection system

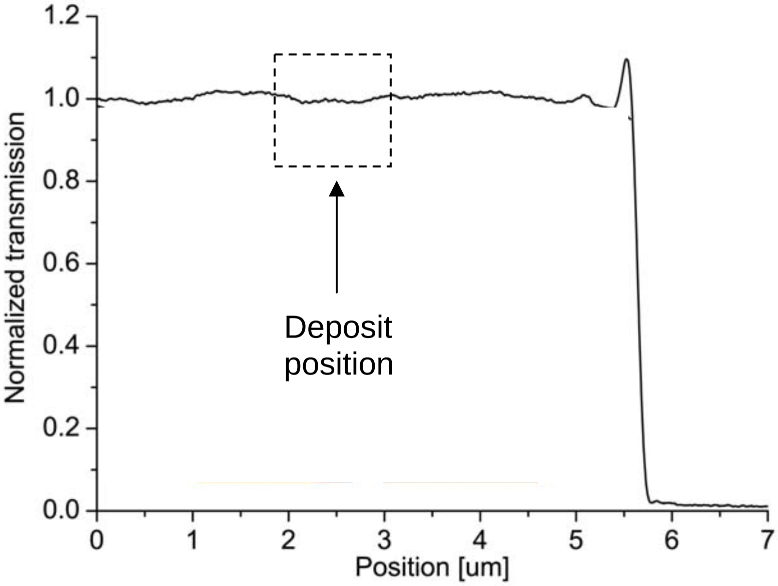

Figure 2: Optical transmission at 193 nm wavelength of a SiO_2 thin film (160 nm thick) obtained from TMS and oxygen.