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Structure of Energized Microlamps in Micrometric Scale

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Abstract

This work presents a study about the structure of thin films, deposited to be a protection layer against oxidation of microlamps, as well as chemical and structural modifications induced by their heating under operation. The studied microlamps (fig. 1) were produced by Plasma Enhanced Chemical Vapor Deposition (PECVD) and sputtering, over silicon substrates, and have applications in microelectromechanical systems. The analyzed protection layer is a film on top of a small Cr filament. Four different materials were used as protection layer: a-SiC, a-SiOxNy, AlN and TiO_2. The intensity and time interval of the electric current applied in the device were varied (up to 50 mA and during 10 s to 1,0 h). The beamline LUCIA of the SOLEIL synchrotron (France), that was used in this work, has a microfocus beam (3 x 3 μm^2), allowing the evaluation of the micro region thermally affected, exactly on top of the filament, using X-ray absorption spectroscopy (XANES). The results demonstrated that the a-SiOxNy and TiO_2 (rutile) films are the indicated ones for this application, because, besides their thermal stability, they dissipate less heat. The AlN and a-SiC (fig. 1) protective films showed structural changes caused by the heating related to the device operation. To improve the studies of these materials additional thin films samples, deposited over ordinary large flat substrates, were produced and analyzed by X-Ray Absorption Spectroscopy (XANES and EXAFS region), Grazing Incidence X-Ray Fluorescence (GIXRF) and Rutherford Backscattering Spectroscopy (RBS). The a-SiC films showed an intense and increasing oxidation as the intensity and duration of the applied current in the microlamps were raised. In addition, structural differences in the a-SiC film were observed in the micro area over the filament, compared with a reference film deposited over Si (fig. 1). The results achieved with the additional thin films revealed the diffusion of Cr and O into the a-SiC. Theoretical XANES spectra of a-SiC structures, constructed by molecular dynamics, were calculated by the Finite Difference Method Near Edge Structure (FDMNES) code, aiming to study the modifications induced by the presence of Cr and O into the material. The conclusion was that the microlamp design induced the growth of a PECVD silicon carbide far from the best conditions, probably due to the presence of a cavity under the filament that reduced the substrate temperature during the deposition.

Figures

Figure 1: (left) microlamp filament. (right) XANES spectra used to study the a-SiC protective layer.