Structure changes of protective layers in microlamps under polarization

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This work reports the production of microlamps and their structural properties after modifications induced by the heating process. Their production consists on films deposited by Plasma Enhanced Chemical Vapor Deposition (PECVD) and sputtering over silicon substrates. The filament, composed by a thin chromium wire, is protected against oxidation by a top thin layer. Four different materials were used as protective layer: a-SiC, a-SiO2N2, AlN and TiO2. The protective film is heated by the metallic filament and their chemical and structural properties may change, depending on the time interval and intensity of the applied current (up to 2 h and 50 mA). X-ray absorption near edge spectroscopy (XANES) measurements allowed investigating changes on the properties of the microlamps protective films heated under different polarization conditions. The LUCIA beam line of the synchrotron SOLEIL (France), used in this work, has a microfocus spot (3 x 3 μm²), permitting to evaluate the small thermally affected zone. The results showed that the SiO2N film is thermally stable with negligible changes on the XANES spectra. A slight AlN oxidation is observed as heating rises, which is particularly evident for the sample heated at extreme conditions. TiO2 XANES spectra showed that the material is crystallized with rutile structure and is also thermally stable. a-SiC thin films were widely affected, showing an oxidation process as the time interval and intensity of the current increased. In addition, once the films were deposited over the Cr filament, their XANES spectra are quite different from the standard sample (deposited over Si), even for the non-polarized microlamp, indicating a Cr contamination on the a-SiC structure. In order to study this contamination, new XANES results were obtained at LNLS (Brazil) in the SXS beam line as well as grazing incidence XRF analysis (GIXRF) at the same synchrotron facility. Rutherford Backscattering Spectrometry (RBS) completed the evaluation of the Cr mixture with the a-SiC films.

Key words: microlamp, X-ray Absorption Spectroscopy, Grazing Incidence X-ray Fluorescence

The aim of this work was to study the structural properties of microlamps under polarization, which can be used for many microelectromechanical systems (MEMS), such as waveguides light source and micro source for infra-red spectroscopy [1,2]. The microlamps are made by a chromium filament with a bridge shape, protected by isolating films. When energized the resistive filament heats by Joule effect and emits light. Figure 1.1 shows as squematic view of the microlamp and Figure 1.2 shows a picture of the produced device. Over the silicon subtrate a 2.43 μm SiO2 film is deposited and on top of it the chromium film is placed with a thickness of 240 nm, forming trails, pads and the filament. Figure 4.1(c) shows a microscope image with the filament in detail. In order to prevent the premature oxidation of the filament during the heating process, a thin protective layer of about 120 nm in thickness is deposited over the filament. This last layer, composed by a-SiC and a-SiO2N2, deposited by Plasma Enhanced Chemical Vapor Deposition was the main subject of investigation, as well as AlN and TiO2 films, deposited by sputtering. The structural changes were monitored in microlamps energized with different current and time, by means of X-ray absorption spectroscopy (XAS) with a microprobe beam (3 x 3 μm²) in the LUCIA beamline of the SOLEIL synchrotron in France. Extra samples prepared on large silicon substrates and submitted to heat treatments were also analyzed at the Brazilian Synchrotron Radiation Facility (LNLS) in order to better understand the
contamination of chromium in the a-SiC film, also confirmed by grazing incidence XRF analysis (GIXRF) and Rutherford Backscattering Spectrometry (RBS), by modelling these results.

Figure 1.1 - Schematic representation of the microlamp

Figure 1.2 - Produced microlamp

The a-SiC XANES spectrum of the non-polarized microlamp is quite different than the a-SiC standard sample. This fact indicates that the chromium substrate provides structural changes on SiC protective layer deposited over it. The edge displacement for lower energy values suggests that Si-Si or Si-Cr bonds are present on the sample. After polarization the oxygen presence in the film is evident by the increasing peak at 1847 eV. The analysis of the AlN XANES spectra by the heating process indicated a slight oxidations and the crystallization of the film. The similarity of the XANES spectra of the a-SiO$_x$N$_y$ protective film under severe thermal conditions revealed its stability (see Figure 2). The same result of excellent stability was obtained for the TiO$_2$ film, which has XANES spectra similar to rutile structure (see Figure 2). For the technological purposes the a-SiO$_x$N$_y$ and the TiO$_2$ protective layers are more suitable to avoid damage in the chromium microlamp, probably because these films have oxygen in its structure, allowing microlamp long-term operation even at severe polarization conditions.

Figure 2 - XANES spectra of (left) a-SiO$_x$N$_y$ films and (right) TiO$_2$ films and rutile standard, under polarization

Acknowledgements. Thanks are due to CNPq and FAPESP for the financial support and SOLEIL Synchrotron Radiation Facility. I. Pereyra, M. C. A. Fantini, M. N. P. Carreño, M. I. Alayo and R. M. Cunha Junior are CNPq fellows and acknowledge its support.

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