Investigation of nanostructured materials of topography free surface by ScanningThermal microscopy

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Nanotechnology requires characterization technics for nanosystems and nanomaterials. Development in new materials requires advanced knowledge of nanoscale heat transfer and thermal properties of nanostructured materials. Between many micro and nanostructures, special attention has been taken to thin layers due to their wide range of applications in multilayer coatings, data storage devices and microelectronics. So that thermal properties of thin films have been extensively investigated for a variety of materials. Scanning thermal microscopy (SThM) based on Atomic Force Microscopy (AFM) technique is a tool for investigating material's thermal measurements and heat transfer mechanisms at the micro/nanoscale. This project aims to investigate local thermal properties of nanostructured materials. For that, a buried nanostructured sample was specially designed and fabricated by VTT [4]. The sample consists of silicon dioxide step of triangular shape deposited on Silicon substrate and covered by polished CVD SiO2. The interface of SiO2/Si layer is linear and it thickness is upgradable between 400 to 2150 nm. We note that in the literature there is no information concerning the thermal conductivity for SiO2 at nanometric scale.

Obtaining thermal information about nanostructured materials using Scanning Thermal properties requires the use of probe with thermal sensor (thermos-resistive) at the tip. It allows us obtaining topographic and thermal images simultaneously with sub-micrometer spatial resolution. Although various types of SThM probes have been developed so far, the probe selection is of great need. The present study deals with Wollaston resistive probe (micro probe).For a comprehensive interpretation of experimental results obtained by SThM, we developed a physically consistent and numerically solved heat transfer model of the probe-sample system[5] in order to: (i) study the influence of sample structure on the thermal signal of the probe, (ii) characterize and estimate the effect of probe volume on thermal conductivity measurements. From the numerical model we applied an inverse technique that allow us the investigation of thermal conductivity of a scanned area from the dissipated power. This was achieved by comparing the experimental results to the developed model in order to deduce the local thermal conductivity of SiO2 layer that has variable thickness deposited on Silicon substrate. The numerical model of probe/sample based on electro-thermal coupling permits evaluating the flux dissipated by the thermal resistive wire and into the sample. Comparing simulation to experimental measurements shows that the developed model was able to reproduce experimental thermal profiles for the sample having variable thickness of SiO2. We have to note that the sample design allows to have the same contact thermal resistance at each point of measurement. From this numerical model and the experimental result we applied an inverse technique that allowed us to determine local thermal conductivity for SiO2 at nanometric scale. The results verified that the thermal conductivity decreases with respect to the layer thickness of the material. As the layer thickness of SiO2 decreases the thermal conductivity decrease and we found a value of 1.023 W/m.K for 576 nm layer thickness of SiO2. This value is close enough to that found by Yamane et al. [6] For low pressure chemical vapor deposition LPCVD.