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Chemical characterization of optical data storage materials by EPMA

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Phase change material, like GeSbTe, has proved to be an excellent material for optical data storage. Due to optical reasons a film of this material is embedded in thin dielectric and metallic films. The performance of the multilayered disc depends strongly on the chemical composition [1]. Sensitive analysis methods are essential in order to characterise the chemical structure, which is important for the process control as well as for the development of new multilayered discs. EPMA is a proven technique in microbeam- and surface layer analysis. The measurements deliver calibrated X-ray intensities which can be converted into mass coverage of elements in thin layers with high accuracy [2,3].

In the present work EPMA was applied to a multilayered coating Al/ SiO_2/ GeSbTe on a SiO_2-wafer(fig.1), a system similar to industrial products. Each film was deposited by magnetron sputtering in a DC argon plasma. Separate Ge-, Sb-, Te-targets were used for the deposition of the phase change film resulting in lateral compositional gradients of up to 10 at% , around the stoichiometric phases $Ge_2Sb_2Te_5$ [4]. These gradients allow a rapid investigation of the relation between chemical composition and performance. The focus of this work will be on the chemical analysis. Resolving two dimensionally concentration gradients in buried layers, quantitative mappings of characteristics X-ray intensities were acquired. The quantification of the measured intensities is carried out by a thin film algorithm [5] under the assumption of a laterally homogeneous multilayer system on a substrate with constant composition in each layer. Despite of the large information depth of the measured X-ray intensities we succeeded in quantifying the chemical composition and mass coverage of the GeSbTe-layer as well as the thickness of the Al-film in a two-dimensionally array. Assuming a density of 3.8 g/cm³ the mass coverage of the GeSbTe-layer could be also converted into thickness. Fig. 2 shows the result of a line scan measurement through the middle of the two-dimensionally array. To check the validity of the results the measurements were performed at three different electron beam energies. The results agree very well. For example, at a distance of about 13 mm the mean composition is Ge 21.4 Sb 22.0 Te 56.1 (in at %) with an error of 3 % rel.. Furthermore the sensitivity to resolve concentration gradients is remarkable. The sensitivity depends on the statistics of X-ray counts. With a statistical certainty of 95,45 % the sensitivity of Ge, Sb and Te is 0.6, 0.7 and 1.0 at%.

At a next step a real life multilayered disc, i.e. Al/ $(ZnS)_8(SiO_2)_2$/ InAgSbTe/ $(ZnS)_8(SiO_2)_2$ on a polycarbonate substrate, was analysed by EPMA. The varnish was removed by dimple grinding to uncover the Al-surface. Intensities of Al $K\alpha$, In $L\alpha$, Ag $K\alpha$, Sb $L\alpha$ and Te $L\alpha$ were measured on top of the uncovered surface and the evaluation was performed in the same manner as described above. For the additional determination of the thickness of each dielectric layer a deeper dimple was grinded to uncover the whole multilayered structure (fig.3). Calibrated X-ray intensities were measured versus distance across the wedge of the dimple (fig.4). Assuming a defined multilayered structure, intensity-profiles can be calculated by means of a Monte-Carlo-Simulation program [6] and compared with the experimental data [7]. The thickness of each $(ZnS)_8(SiO_2)_2$-layer was adjusted in order to obtain best agreement between calculated and experimental data. Both techniques, the surface- and depth profiling technique, deliver a reliable characterization of commercially available discs (Table 1).

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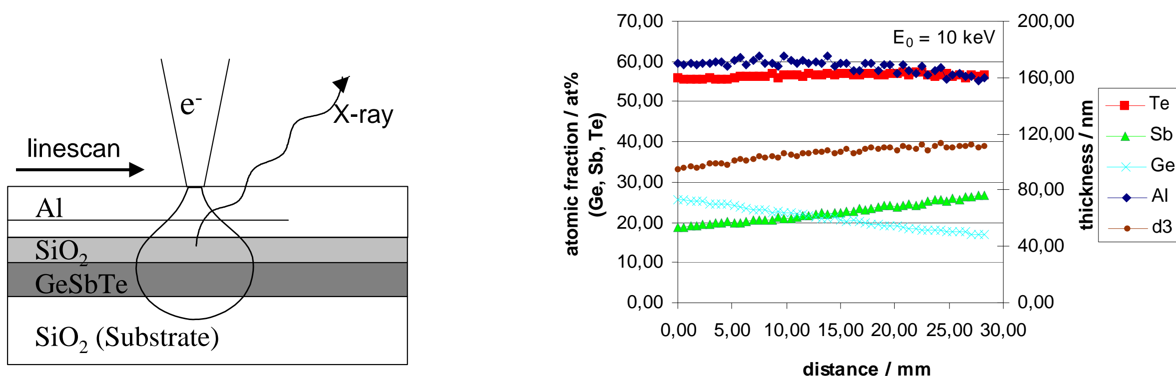

Fig. 1. Schematic presentation of the line scan measurement

Fig. 2. Quantitative results of the line scan measurements through the middle of the coated wafer

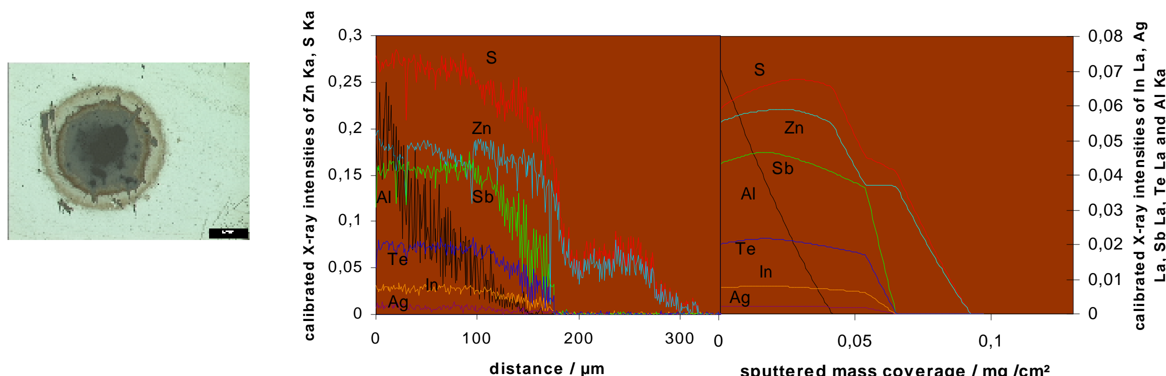

Fig. 3. Uncovered multilayer system by dimple grinding

Fig. 4. Comparison: a) Measured X-ray intensities versus distance from the crater-edge, b) calculated X-ray intensities versus sputtered mass coverage

Table 1:

$(ZnS)_8(SiO_2)_2$	AgInSbTe(ρ=6.65g/cm³)					$(ZnS)_8(SiO_2)_2$	Al
Thickness / nm	Thickness / nm	Ag / at%	In / at%	Sb / at%	Te / at%	Thickness / nm	Thickness / nm
71.8	17.0	3.5	6.4	62.0	28.1	32.2	154.0

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