

Thermal Stability of Amorphous Ion Beam Sputtered Refractory Oxides for AR/HR DFB Coatings and Low Loss Optical Waveguide Purposes

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Thin films of high band gap oxides were prepared by reactive ion beam sputtering of Hf, Nb, Ta and Zr-targets with CO_2 as working gas (1)(2).

When deposited on substrates at room temperature non stoichiometric oxide layers with a certain content of carbon were obtained, which proved to be amorphous. (Fig. 1a). The clear visibility of oscillations in the x-ray reflection spectrum at glazing incidence is an evidence for the excellent surface and interface quality as well as for the volume homogeneity (Fig. 1b).

For practical application to optical interference coatings and wave-guides on III-V compounds the amorphous state should be preserved at least up to the highest possible operation temperature of the device material ($\sim 350^\circ\text{C}$ for InP). Otherwise excessive optical losses by crystalline grain boundary scattering and surface/interface roughening would occur.

We, therefore, studied the influence of thermal annealing on the optical properties (refractive index, band gap, and extinction coefficient k) by spectroscopic ellipsometry in the range $\lambda=0.38\text{-}1.7\ \mu\text{m}$. XRD, SEM and EPMA - methods were applied to evaluate the material properties (crystalline structure, density, composition and surface topography). In addition, optical losses of double heterostructure waveguides Hf-oxide/Nb-oxide/Hf-oxide prepared on InP and Silicon substrates were measured under the same conditions.

The oxide films studied show a densification under annealing with a concomitant increase in refractive index due to the onset of crystallization. The extinction k , however, remains $\leq 10^{-4}$ up to a temperature of 500°C .

1.) B. Kempf, H.W. Dinges and H. Burkhard, Extended Abstracts of the SSDM Yokohama, Japan, 1994 P. 815
2.) B. Kempf, H.W. Dinges and A. Pöcker to be published at Proceedings of the MRS Fall meeting, Boston 1994

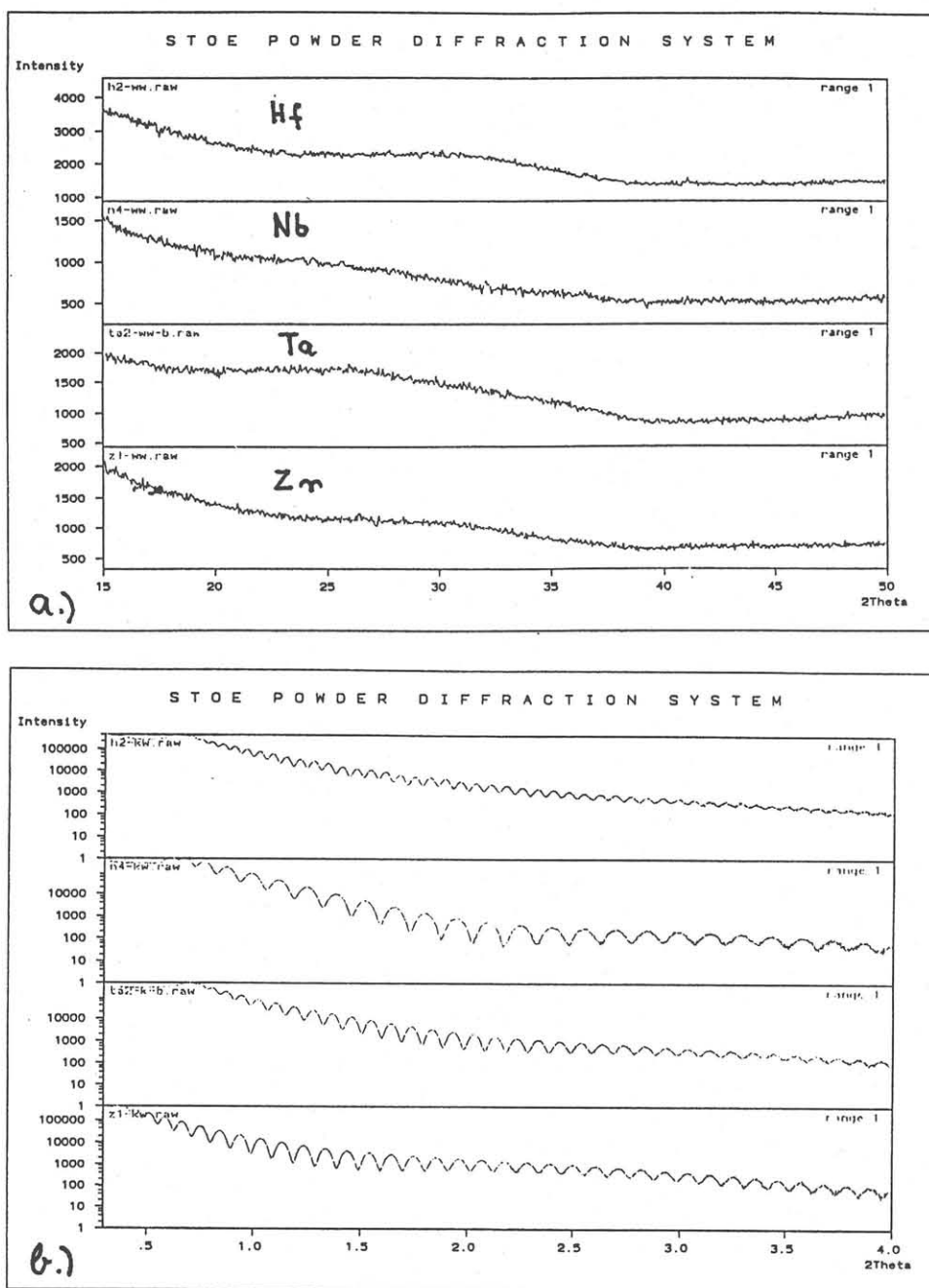


Fig.1: x-ray spectra of oxides obtained by
a.) diffraction
b.) grazing incidence reflectometry