IN SITU MONITORING OF THIN FILM OXYGEN DIFFUSION BY MACROSCOPIC CURVATURE

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We have demonstrated Coherent Gradient Sensing (CGS) in a metal organic chemical vapor deposition (MOCVD) reactor by monitoring the response of the macroscopic curvature of a 50 mm wafer of $YBa_2Cu_3O_{6+\delta}$ (YBCO) (500 and 700 nm) on MgO (50 x 0.5 mm) with step changes in the oxygen partial pressure in the temperature range of 485-680 °C. Corresponding changes in the average wafer curvature and the oxygen stoichiometry, as determined by ultraviolet reflection absorption spectroscopy (UVRAS), are consistent with the one dimensional diffusion equation. The time constants for desorption are found to be larger than adsorption over the temperature range studied.

The mechanical properties of the YBCO film are affected by oxygen absorption (desorption). As oxygen absorbs or desorbs in the YBCO film there is a volume change, and because the film is constrained laterally by the substrate, a corresponding change in the stress state. Experimentally, film stress can be inferred from measuring structural changes in the lattice (XRD) or in some cases, changes the lattice vibrational modes (Raman) or by the macroscopic curvature of the film-substrate. For diffusion studies of thin films, these methods are either difficult to apply *in-situ* and in real time (x-ray diffraction) do not give an instantaneous full-field map of the curvature tensor (beam bending) or are sensitive to external vibrations (interferometric methods).

Rosakis [1] developed Coherent Gradient Sensing (CGS) to study dynamic fracture and static stresses of solids and thin films. The technique images the sample and measures distortions in the slope of reflected wavefront, which result from sample curvature. CGS is a diffraction-based, common-path, beam shearing technique that provides a real-time map of the individual components of wavefront slope. Sample curvature is directly related to the fringe density of the interferogram, Figure 1. The common path nature of CGS allows it to be easily implemented into a reactor environment, Figure 2, and somewhat more insensitive to external vibrations than other types of traditional interferometry.

In this paper, we demonstrate *in situ* CGS in a working MOCVD reactor. We monitor the response of the macroscopic wafer curvature with step changes in oxygen background pressure and confirm the corresponding oxygen absorption and desorption with UVRAS, Figure 2. Over a range of temperatures, we compare the CGS response of 500 and 700 nm films with the one dimensional diffusion equation.

REFERENCES

[1] Y. J. Lee, J. Lambros, and A. J. Rosakis, Optics and Lasers in Engineering **25**, 25 (1996).

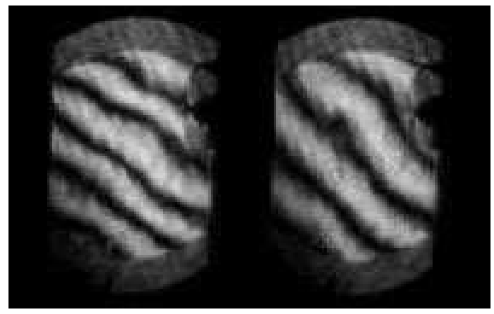

Figure 1: *In situ* CGS interferograms of thin film YBCO (700 nm) on MgO (0.5 mm) before (right) and after deoxygenation of the YBCO film. The image on the right shows a 23% lower level of stress. The image is of a 50 mm diameter wafer, however the edges (right and left) of each image are obscured. The image of the UVRAS mirror can be see in the middle right.

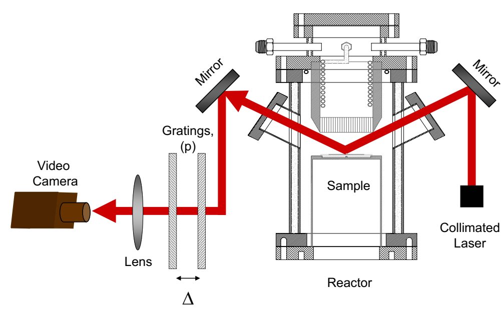

Figure 2: A schematic of the CGS optical arrangement and the MOCVD reactor.

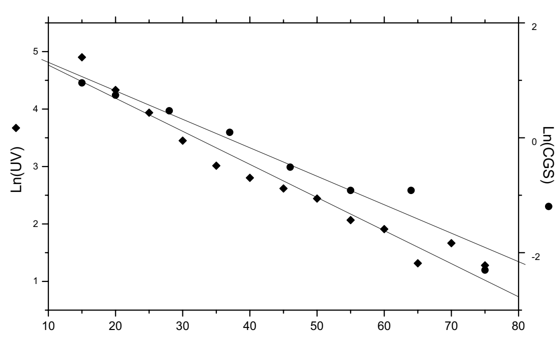

Figure 3: Plot of change in the CGS fringe density (right axis, cicles) and UVRAS integrated peak absorption at 310 nm (left axis, diamonds) versus time. Time t = 15 starts the removal of gas phase oxygen from the 500 nm thick film surface at 590 °C.