Spatially Resolved Determination of Stress in Thin Films and Devices from Curvature Measurements

Nikolaus Herres
Interstate University of Applied Sciences Buchs NTB, CH-9471 Buchs SG, Switzerland

Residual stress is an important physical property influencing the mechanical characteristics of hard coatings, the optical properties of thin films, the band structure of optoelectronic films, as well as functionality and reliability of electronic devices [1]. The quantitative determination of stresses in thin films can be done with different techniques [2-4].

High-resolution X-ray diffraction using laboratory sources can be applied to probe the curvature and integrity of the lattice planes of a single crystalline substrate, if a translation stage of sufficient straightness is used. Optical curvature measurements have to cope with uneven surfaces and usually require measurements before and after e.g. the film deposition. With X-ray diffraction, the perfect crystal lattices of silicon wafers or chips serve as inbuilt reference, making differential measurements unnecessary. The substrate directly functions as a sensor for what happens to the polycrystalline and amorphous films on top of it.

Corrugated or structured surfaces may be bypassed, if one wants to explore the stress situation inside a sample. Using penetrating radiation, electronic, filter and sensor chips can be monitored within the package. The interaction of the chip with leadframe and mould mass may thus be tracked. Effects resulting from non-ambient conditions and thermal cycling can be studied and used to optimize the device.

The measurement geometry, the evaluation procedure and applications from thin film deposition monitoring, device development and failure analysis will be presented.

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