

STRAIN AND STRESS CHARACTERISATION IN THIN FILMS AND SANDWICH STRUCTURES AT ELEVATED TEMPERATURES

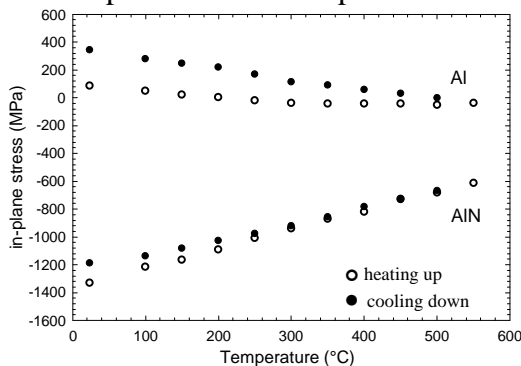
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The structural integrity and electronic parameters of microelectronic devices are strongly affected by thermal stresses. These stresses originate from a mismatch of thermal expansion coefficients between substrate and thin film and, together with growth stresses, contribute to the total stress of coatings. The main aim of this contribution is to demonstrate a possibility to characterise stresses in sandwich-like structures *separately* for each sublayer at elevated temperatures.

In the first part, a mathematical formalism of strain and stress characterisation is derived enabling to refine in-plane stresses and unstressed lattice parameters in thin films (and in sandwich structures separately for each sublayer) as a function of temperature. Thus a contribution of thermal stresses to the total stress and its changes with the temperature can be quantified. A special attention is devoted to the measurement strategy.

In the experimental part, a variety of heteroepitaxial structures (*e.g.* GaN/Al₂O₃, AlN/Al₂O₃, Al/AlN/Al₂O₃, AlN/GaN/Al₂O₃) are investigated using XRD and the development of residual stresses and unstressed lattice parameters is monitored. Within one temperature cycle, the structural properties of sublayers in sandwich structures are always characterised *simultaneously*. The measurements enable to determine temperature-dependent changes of stresses, temperatures of stress free state, annealing-induced relaxation of stresses and temperature regions of yielding in sublayers. The results suggest that the temperature-dependent mismatch of anisotropic thermal expansion coefficients and the deposition temperature



predefine the stress sign and the amount of stress changes in the films with the temperature. In the case of metal layers the results indicate a presence of plastic flow in contrast to nitride layers (AlN, GaN) exhibiting no yielding. In the figure left, an example of stress development in sublayers of an Al/AlN/Al₂O₃ heteroepitaxial structure within one temperature cycle is presented.