THERMAL INDUCED STRESSES
IN THIN ALUMINUM LAYERS GROWN ON SILICON

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Thin aluminum layers are used in a broad range of industrial applications like coatings, conducting paths and electrodes in micro- and opto-electronics. Residual stresses in these layers can cause mechanical damages of applications. The two main sources of stresses are thermal induced stresses (extrinsic stresses) and manufacturing stresses (intrinsic stresses). Extrinsic stresses result from temperature variation in consequence of different thermal expansions of aluminum and silicon. Intrinsic stresses develop during the manufacturing process of such layer. A detailed knowledge of stress development is important to improve the reliability of thin aluminum layers in applications.

Aluminum layers with a thickness of 2μm were prepared using magnetron sputtering on native oxide silicon wafers. Different substrate temperatures during the deposition process were used: 50°C, 150°C, 250°C and 300°C. The temperature dependence of lattice strain was investigated with a 4-circle X-ray diffractometer (Seifert PTS3000) in combination with a suitable heating stage (Anton Paar DHS 900). The strains are investigated in thermal circles up to a maximum temperature of 450°C. Since the aluminium layers are weakly textured the linear dependence between lattice strain and \( \sin^2 \psi \) could be verified. The calculation of stresses is based on the Reuss-, Voigt- and Hill models using appropriate temperature dependent elasticity tensors of aluminum.

At room temperature a compression stress of about 40MPa is observed in layers prepared at 50°C; layers prepared at elevated temperatures show tension stresses up to 350 MPa. At the temperature of layer preparation stress values (assumed as intrinsic stress values) are in between 40 and 100MPa in compression. Layers prepared at elevated temperatures show even in the first temperature circle reversible stress/temperature characteristics. On the other hand layers prepared at low temperatures show reversibility in the stress/temperature characteristic only after multiple temperature circles.