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Influence of Annealing on Elastic Properties of LPCVD Silicon Nitride and LPCVD Polysilicon

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The effect of annealing on Young's modulus E and residual stress σ of thin films made of LPCVD silicon nitride and LPCVD polysilicon was investigated. The films were annealed at 850°C, 1000°C and 1100°C each for one, two and four hours. Then, Young's modulus and the residual stress were determined by the method of membrane deflection. An extended analytical theory for the membrane deflection was developed, and the FEM analysis of Pan *et al.* (Technical Digest, IEEE Solid-State Sensor and Actuator Workshop, Hilton Head Island (IEEE, New York, 1990) p. 70) was confirmed. The results show that annealing not only influences the stress but also Young's modulus of the films. Silicon nitride was produced with a SiH_2Cl_2 flow rate of 20 sccm and an NH_3 flow rate of 100 sccm at 780°C. Before annealing, the silicon nitride film had a Young's modulus of 250 GPa and a tensile stress of 980 MPa. Polysilicon, which was deposited at 620°C, showed a Young's modulus of 162 GPa and a compressive stress of –470 MPa. After a short anneal at 1000°C the residual stress of silicon nitride showed a maximum of 1000 MPa. Above 1000°C and for longer annealing times the residual stress decreased due to the beginning of viscous flow while Young's modulus increased to 265 GPa. The compressive stress of polysilicon relaxed nearly completely after annealing at 1100°C for 1 h. For long annealing times Young's modulus decreased with increasing temperatures but returned to the original value after annealing for 4 h at 1100°C.