

07.2-19 A HIGH RESOLUTION X-RAY DIFFRACTOMETRIC AND TOPOGRAPHIC STUDY OF ELECTRON-LATTICE INTERACTION DURING TWO DIMENSIONAL CONDUCTION IN SILICON MOSFETS (KLITZING ELEMENTS). By Krishan Lal, Peter Thoma*, S. Niranjana N. Goswami, Vijay Kumar, S.K. Halder and M. Thiemig*, National Physical Laboratory, Hillside Road, New Delhi 110 012, India.

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Charge carrier-lattice interaction during normal conduction in silicon single crystals has been successfully studied by using high resolution X-ray diffractometry and topography (e.g. Krishan Lal and S. Niranjana N. Goswami, Material Science and Engineering A85, 147 (1986)). Here, results of a similar study on Si MOSFETs by using the same techniques are reported. The specimen MOSFETs were parts of $3 \times 4 \text{ mm}^2$ chips with nine devices and dimensions: $3.6 \times 0.36 \text{ mm}^2$. The flat surfaces of the silicon substrates were along (001) planes.

During operation of the device a gate field of 26V and a source to drain current of $70 \mu\text{A}$ were applied. Triple crystal X-ray diffractometers were used in the configuration (+,-,+). The first two crystals are plane Si monochromators with diffracting surfaces along (111) planes. These help in obtaining highly collimated and monochromated $K\alpha$ exploring X-ray beams. The specimen is the third crystal aligned in the Bragg geometry. Experiments were performed with (004) [for $[\text{Cu}K\alpha]$] and (008) [for $\text{Mo}K\alpha$] diffracting planes. Diffraction curves, curvature plots and high resolution traverse topographs were recorded before, during and after the two dimensional conduction. Different azimuthal orientation of the chip were used. The diffraction curves show a small but measurable change in the shape when the device is conducting. In the topographs, small changes in the contrast could be observed. The changes in the contrast have been evaluated by microdensitometric examination of the topographs. These results show that there is a strong coupling between the charge carriers and the crystal lattice even when a small ($70 \mu\text{A}$) two dimensional electric current flows through the device. Traverse topographs were also recorded while maintaining the glancing angle of the crystal at the half intensity point of the diffraction curve, before and during conduction. This leads to higher sensitivity and, therefore, stronger changes in the contrast are observed.

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07.2-20 X-RAY DIFFRACTION ANALYSIS OF DIFFUSION IN Mo/Si MULTILAYERS. By O.B. Loopstra, Th.H. de Keijser, E.J. Mittemeijer and S. Radelaar*. Delft University of Technology, Laboratory of Metallurgy, Rotterdamseweg 137, 2628 AL Delft, The Netherlands. *Delft University of Technology, Centre for Submicron-technology, Lorentzweg 1, 2628 CJ Delft, The Netherlands

Sputtered amorphous Mo/Si multilayers, with a composition modulation period of $\sim 0.8 \text{ nm}$ and a Mo/Si atomic ratio of ~ 0.6 , were annealed at temperatures between 200 and 1000°C . Part of the specimens had a polycrystalline Si layer between the oxidized $\langle 100 \rangle$ -Si substrate and the Mo/Si multilayer. The changes in the amorphous and crystalline state were studied by X-ray diffraction and Rutherford backscattering. From the multilayer only the (000) first order satellite, originating from the composition modulation, was observed. Diffusion coefficients of the amorphous state were derived from the decay of the integrated intensity of the satellite after annealing at temperatures below the crystallization temperature (350°C); structural relaxation was taken into account. Above 350°C , hexagonal MoSi_2 , Mo_5Si_3 and tetragonal MoSi_2 were formed sequentially on increasing the temperature. RBS suggested a homogeneous nucleation of hexagonal MoSi_2 , whereas Mo_5Si_3 developed only at the polycrystalline Si/multilayer interface and at the outer surface. Si from the polycrystalline Si layer diffused into the multilayer and eventually a complete conversion of Mo_5Si_3 into MoSi_2 occurred. The microstructural perfection, indicated by diffraction-line broadening, improved considerably during the anneals. The decrease of the electrical resistivity (to $0.6 \mu\Omega\text{m}$) correlated with the formation of crystalline phases in the multilayer and with the improvement of the crystalline perfection.

07.2-21 X-RAY DOUBLE CRYSTAL ROCKING CURVES AND INTERFACE SHAPE IN III-V HETEROSTRUCTURES. By C. Bocchi, C. Ferrari, P. Franzosi, Istituto MASPEC-CNR, Parma, Italy.

The double crystal diffractometry (DCD) is a powerful X-ray technique for assessing III-V compound heterostructures. DCD was mainly used to measure the lattice mismatch between epilayers and substrate and to evaluate in a qualitative way the epilayer crystal quality. Recently, theoretical models for the calculation of DCD rocking curves (RCs) have been developed (H.A.G. Halliwell et al., J. Crystal Growth 65, 672 (1983)). By comparing experimental and calculated RCs, quantitative information on the layer thickness, sample curvature and composition gradient along the growth axis can be obtained. In the present work, the possibility of studying the interface shape by DCD measurements has been tested. Computer simulations of 004 RCs, following the Halliwell's method, show that Pendellosung fringes strongly depend on the transient composition layer close to the interface. More precisely, when an abrupt interface is considered, nearly symmetric fringes are found at both sides of the epilayer Bragg peak. On the contrary, when a graded interface is assumed, the fringe appearance is asymmetric. Simple criteria to deduce from the fringe asymmetry the interface shape have been determined. 004 DCD RCs have been experimentally measured in GaAlAs/GaAs and InGaAs/InP single heterostructures grown by molecular beam epitaxy. A good fit between experimental and calculated RCs has been obtained when the correct interface shape was assumed.