07.X-1 HETEROSTRUCTURE AND QUANTUM WELL DEVICES GROWN BY MOLECULAR BEAM EPITAXY.

By G. Weimann, Forschungsinstitut der Deutschen Bundespost, D-6100 Darmstadt, Fed. Rep. Germany

The two-dimensional atomic layer by layer crystal growth in molecular beam epitaxy allows tailoring of compositional and doping profiles on an almost atomic scale. This band structure or wave function engineering is leading to a new semiconductor technology based on ultra thin layers. The spatial separation of dopant atoms and free carriers in modulation doped heterostructures gives enhanced mobilities of the two-dimensional electron and hole gases confined at the heterointerface. "High electron mobility transistors" with improved device and noise properties are one application of these heterostructures. Superlattices and multiple quantum wells with monoatomic interface transitions led to novel laser diodes with tailored emission wavelengths and far fields. Low threshold current densities, reduced temperature dependence of threshold currents and improved polarization stability are characteristics of MQW lasers. Ultrafast resonant tunneling devices are finding increasing interest.
The epitaxial growth of GaAs-AlGaAs heterostructures and quantum well structures by conventional MBE, their electrical transport and optical properties, and device applications will be reviewed.
The growth of phosphorus containing compound semiconductors of device quality, problematic with solid sources, is possible with chemical beam epitaxy; recent results will be briefly reported.

07.X-2 RECENT DEVELOPMENTS IN THE GROWTH OF EPITAXAL LAYERS WITH METAL ORGANIC COMPOUNDS.

By K.W. Benz, Faculty of Physics, University of Paderborn, D-4790 Paderborn, Germany FR

In the past metalorganic vapour phase epitaxy (MOVPE) has been successfully applied to many anorganic compounds, especially to III-V and II-VI semiconductors. MOVPE has a high technological importance for the production of various electronic devices due to the following reason: simple pyrolysis reactions by using alkyls of the group III (II) metals and hydrides of the group V (VI) elements or by taking Lewis acid-base adducts of e.g. group III and group V alkyls. These adducts have a higher degree of safety compared with normal alkyls.

Recently MOVPE has been applied to the growth of ultrathin epitaxial layers (GaAs: 2 nm) and quantum well structures with novel physical properties. The following paper will describe the main growth features of MOVPE in connection with physical properties of epitaxial layers.

07.X-3 HIGH RESOLUTION X-RAY DIFFRACTOMETRIC, TOPOGRAPHIC AND DIFFUSE SCATTERING CHARACTERIZATION OF DEFECTS IN SILICON CRYSTALS.

By Krishan Lal, National Physical Laboratory, Hillside Road, New Delhi - 110 012, India.

Recent results of diffuse X-ray scattering measurements made on dislocation free silicon single crystals, as grown by the Czochralski and the float zone methods, will be discussed. A three- and a four-crystal X-ray diffractometers have been used. Reciprocal space very close to reciprocal lattice points has been explored with nearly parallel $K\alpha_1$ beams. The size, the shape and the nature of the point defect aggregates in the crystals has been determined. In the as grown CZ crystals, generally, platelet like clusters of vacancies lying on 111 planes have been observed. Defect structure in the FZ crystals is different from that in the CZ crystals. Heat treatment produces remarkable differences on the defect structure.

Deposition of thin films, such as oxide and polysilicon layers on silicon crystals, produces large changes in the shapes of the diffraction curves and the contrast in topographs recorded on a double crystal X-ray diffractometer. The strain has been found to be in the range 4.5-5.5 x 10^{-5} at the interface for polysilicon deposits on (111) planes of silicon.

A four crystal X-ray diffractometer has been developed and used for characterization of defect structure in nearly perfect crystals of silicon and other materials by high resolution diffractometry, topography and curvature measurements. With two plane crystal monochromators, a nearly parallel $K\alpha_1$ exploring beam is obtained. The specimen is, generally, the third crystal. An analyser at the fourth crystal position monitors variations in the lattice parameter of the specimen. High resolution traverse topographs can be recorded even when the specimen diffraction curves have half widths of about 3 seconds of arc. Traverse topographs have also been recorded when μt is large ($\sim$ 6).

A new type of experiment has been performed for direct observation of the effect of the external electric fields on the real structure of silicon and other crystals. Remarkable changes in the traverse topographs and diffraction curves are observed when an electric current is flowing through the specimen. Images of filaments which conduct more than the surrounding medium have beensuccessfully recorded for the first time. Threshold value of the electric power density p for appearance of these images in the traverse topographs was 0.01 Wmm^{-3} for silicon. At this value of p, no significant change in the temperature of the crystals, monitored through the lattice parameter evaluation, could be detected. There are strong indications that these defects are clustersof point defects like oxygen rich aggregates. At high values of the electric fields, the observed fluctuations in the electric current through the crystals show an excellent correlation with the simultaneous fluctuations in the diffracted X-ray intensity. These experiments have been performed at different frequenciues of the field, ranging from dc upto microwave region. Anomalously large changes in the diffracted X-ray intensity were observed at 2.45 GHz, suggesting a coupling between the microwave and the diffracted X-ray wave fields. Recently, a small electron-lattice interaction has been observed during two-dimensional conduction in Si MOSFETs by using the same techniques.