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PICTS Characterization of Zn Doped Si: *Vladimir Privezentsev*[1]; [1]Institute of Physics & Technology, Russian Academy of Sciences

The Si doped by impurity of double acceptor Zn is traditionally used for development of IR-converters.[1] Recently n-type of such material was investigated by SEM-EBIC method.[2] Have been observed the microdefects with micron size. They have been connected with dislocations or/and zinc precipitates. Now we have investigated Si, doped with phosphorus and then compensated with Zn by PICTS method. Zn impurity concentrations was $N_{Zn}=1x10^{14}cm^{-3}$ and were carried out parity $N_{Zn}<N_p<2N_{Zn}$. After compensation by Zn the electron concentration in Si was $n\tilde{}5x10^{11}cm^{-3}$ (at 300K). In the result of PICTS measurement the activation energy for deep levels 0,55, 0,26, 0,20 and 0,18eV below conductivity zone bottom Ec were revealed. Also the electron capture cross sections for Zn levels in Si were obtained. [1]H. Willebrand, Yu. Astrov, L. Portsel, S. Teperick, T. Gauselmann. IR Phys. Technol., 36, 809 (1995). [2]E.B. Yakimov, V.V. Privezentsev. J. Mater. Sci.: Mater. Electron., 19, S277 (2008).

Structure Analysis of InGaN-Based Light-Emitting Diodes Grown on Patterned Sapphire Substrates and Unpatterned Sapphire Substrates: *Hung-Ling Tsai*[1]; Wei-Chin Li[1]; Jer-Ren Yang[1]; Min -Jang Chen[1]; Makoto Shiojiri[2]; [1]National Taiwan University; [2]Kyoto Institute of Technology

InGaN-based alloy compound semiconductors are useful for optoelectronic devices such as light-emitting diodes (LEDs) in blue and ultraviolet regions. However, due to the large difference in the lattice constant and thermal expansion coefficient, GaN layers grown on sapphire substrate exhibit high dislocation densities. Therefore, how to further reduce the dislocation density is an important issue. In this paper, the InGaN-based blue LEDs were fabricated on patterned sapphire substrate (PSS) and unpatterned sapphire substrate (UPSS) by MOCVD. The quality of the grown GaN epilayers was compared. The microstructure characteristics were investigated by high resolution transmission electron microscope (HRTEM) and high angle annular dark field scanning TEM (HAADF-STEM). From the TEM observations, the PSS was confirmed to be an efficient way to reduce the threading dislocation density and suppress the defect propagation in the GaN epilayer. Finally, better reliability of the PSS LEDs performance was also observed.

Study of Electrical Properties for Electron Irradiated 4H-SiC MESFETs Evaluated by Channel Resistance: *Kenichiro Takakura*[1]; Hidenori Ohyama[1]; Manabu Arai[2]; Satoshi Kuboyama[3]; Sumio Matsuda[3]; [1]Kumamoto National College of Technology; [2]New Japan Radio; [3]JAXA

In this work, we studied the radiation damage in 4H-SiC MESFET. The devices have been irradiated at room temperature with 2-MeV electrons by an electron accelerator. The electron fluence ranged from 1x1013 to 1x1017e/cm2. The electrical characteristics before and after irradiation have been examined to identify the deterioration mechanism. From the current-voltage characteristics, it was derived that the drain current increased with low fluence and decreased at high fluence. In addition, three electron capture levels are observed after irradiation in the DLTS spectra. To verify the sheet resistance in the channel region, the TLM (Transfer Length Method) was performed. The resistance decreased by the electron irradiation because of the increase in the carrier density. The carrier are supplied by nitrogen impurities, with the ionization rate depending on the density in the SiC. The carrier density by irradiation changed the active nitrogen density. In these circumstances, we examined the deterioration mechanism mainly by a change of carrier density.

Tellurium Inclusions and Carrier Trapping Times in Detector Grade Cadmium Zinc Telluride: *Ezzat Elshazly*[1]; Gary Tepper[1]; [1]Virginia Commonwealth University

Carrier trapping times and tellurium inclusions in Cadmium Zinc Telluride (Cd1-xZnxTe, x ~0.1) crystals grown using both the High Pressure Bridgman and Modified Bridgman methods were measured. A pulsed Nd:YAG laser of wavelength 1064nm and a pulse width of 7 ns was used to excite carriers and microwave reflectance was used to probe the carrier trapping time. Infrared microscopy was used to measure the tellurium defect densities in CZT crystals. Tellurium precipitates with diameters = 20 μm were found to be the dominant crystallographic defect. Spatial mapping of carrier trapping times and defect densities in CZT was performed to determine the relationship between defect density and electronic decay. A direct and strong correlation between trapping time and defect density of tellurium inclusions was observed.

Temperature Dependence of Liner Thermal Expansion of $AgGaSe_2$ Crystals: *Akira Nagaoka*[1]; Kenji Yoshino[1]; [1]University of Miyazaki

Undoped $AgGaSe_2$ crystals are grown by hot-press (HP) method at 400 ~ 700°C for 1 h under high pressure (10 ~ 40 MPa). All samples indicate chalcopyrite structures, nearly stoichiometry and n-type by means of X-ray diffraction (XRD), electron probe microanalysis and thermoprobe analysis, respectively. However, the sample grown at 400 °C has a secondary phase. According to increasing temperature, the sample does not have secondary phase. A single phase $AgGaSe_2$ crystal can be successfully obtained at 700 °C. The $AgGaSe_2$ crystal is high quality because a free exciton emission is clearly observed in the photoluminescence at low temperature. Furthermore, temperature dependent XRD and PL are carried out at less than 70 K. A liner thermal expansion decreases and the free exciton peak increases with increasing temperature

The Use of Spatial Analysis Techniques in Defect Studies: *Michelle Moram*[1]; Colin Humphreys[1]; [1]University of Cambridge

Spatial analysis techniques are commonly used by ecologists, biologists, epidemiologists and geographers to analyse spatially varying data. However, although such techniques have the power to reveal underlying spatial correlations and patterns, they have not yet found widespread use in physics. In this work, we show how such techniques can be applied to any experimental data which reveals the positions of crystallographic defects, such as that obtained from atomic force microscopy, transmission electron microscopy, cathodoluminescence microscopy or related techniques. In particular, we show how the point patterns produced by the intersection of threading dislocations with a film surface can be used to monitor and quantify the extent of dislocation clustering and array formation in GaN films. Such analyses enable us to discriminate between competing theories regarding dislocation origin in GaN films and to understand the interactions between defects better.

Thermal Etching of 6H-SiC and CVD Poly-Crystalline SiC: *Frezghi Kibrom*[1]; [1]University of Pretoria

The process by which SiC crystals decompose and both silicon and carbon atoms sublimate revealing defects at the surface by annealing is called Thermal etching. 6H-SiC and CVD Poly-crystalline SiC samples were annealed in computer-controlled Webb 77 vacuum at several temperatures ranging from 500ºC for 10hrs to 1800ºC for 10hrs. Images of Gemini Ultra 55 Zeiss SEM were taken. A significant difference was observed for the thermal etching behaviour of these two samples. Annealing of 6H-SiC at temperatures above 1400ºC exhibited step-bunching. The micro-pipes at this annealing temperature exhibited well-defined faceted openings related to the symmetry of the crystal. The SEM images of Necsa poly-crystalline SiC samples annealed from 1600ºC for 3hrs showed cavities and holes at defects on the surface. Whereas annealing of Necsa poly-crystalline-SiC at 1600°C for 3 hrs at cross-sectional investigation, severe thermal etching was observed at grain-boundaries and twins.

Tight Binding and LCAO Methods for Tin Oxide Deposited by Chemical Vapour Deposition and Spray Pyrolysis Techniques: *Nazia Kesri*[1]; [1]University of Sciences and Technology Houari Boumediene

This work outlines the fabrication by chemical vapour deposition (CVD) and by spray pyrolysis and the characterisation of transparent undoped tin oxide layers . The thin films were grown on glass substrates at atmospheric pressure. Deposition parameters, such as substrate temperature, time of deposition and oxygen flow (CVD) or nitrogen flow (spray) have been varied. Tin oxide crystallise in the rutile structure. X-ray diffraction study shows that the films were polycrystalline, with (110) preferential direction for deposition temperature at 400°C. For different deposition parameters, (101), (211) and (200) orientations become predominant. The optical band-edge absorption was studied experimentally by transmission and reflection spectra. The calculation of electronic structure of SnO2 was carried out using a semi-empirical tight binding method (LCAO). Nearest neighbour (tin oxygen) and second nearest neighbour parameters are included into s and p-states. The calculated and measured band gaps are compared to other theoretical and experimental values[1-4] .

Ultrasound Influence on the Recombination Centers in Silicon p-n-Structures: *Oleg Olikh*[1]; [1]Taras Shevchenko Kyiv National University

Recently the acoustic waves are used for controlled modification of the defect subsystem. This work is devoted to experimental investigation of the deep levels in *Cz*-Si *p-n*-structures under ultrasonic loading with the help of the method of the current-voltage characteristic differential coefficients. The longitudinal acoustic

waves with frequency 4-26 MHz and intensity up to 0.6 W/cm^2 were used. There levels with activation thermal energy 0.44, 0.40, 0.37, 0.48 and 0.46 eV were detected. It is suggested that these levels related to the E-centre, the bistable complex B_sO_{2i} and interstitial atoms captured on dislocation loops respectively. It is revealed that ultrasound induces the increase of the shallow levels contribution into carrier recombination and this process depends linearly on sound wave strain. The decrease of the defects activation energy under ultrasound action is observed too. The possibility of the acoustoinduced reversible changes of the B_sO_{2i} configuration is analyzed.

X-Ray Diffraction Imaging of Improved Bulk Grown CdZnTe (211) and its Comparison to Epitaxially Grown CdTe Buffer Layers on Si and Ge Substrates: *Justin Markunas*[1]; Tony Almeida[1]; Randolph Jacobs[1]; Joe Pellegrino[1]; Syed Qadri[2]; Nadeem Mahadik[2]; Jas Sanghera[2]; [1]US Army Night Vision Laboratory; [2]US Naval Research Laboratory

Large area, high quality (Hg,Cd)Te sensing layers for infrared imaging in the 8-12μm spectral region are typically grown on (Cd,Zn)Te substrates. Research efforts have focused on growing high quality bulk CdZnTe. Much of this bulk grown CdZnTe showed defects, small angle grain boundaries, high dislocation densities and other extended defects. Recent progress in bulk growth by the liquid encapsulation Czochralski method has produced substrates with a rocking curve full width half maximum under 20 arc seconds. Alternatively, epitaxial CdTe grown on Si or Ge has been used as a buffer layer for high-quality epitaxial HgCdTe growth. The best epitaxially grown CdTe with thicknesses in the 8-10μm range had a rocking curve full width at half maximum on the order of 70 arc seconds. In this paper, x-ray topographs will be presented of recent high-quality bulk grown CdZnTe, epitaxial CdTe buffer layers and previous bulk grown substrates for comparison.

X-Ray Diffraction Study of MBE-Grown CaF2-CdF2 Superlattices on Si(111): *Gleb Valkovsky*[1]; M. Baidakova[1]; S. Konnikov[1]; A. Krupin[1]; R. Kyutt[1]; N. Sokolov[1]; S. Suturin[1]; M. Yagovkina[1]; [1]Ioffe Physical-Technical Institute of the Russian Academy of Sciences

Structure of CaF2-CdF2 superlattices (SLs) grown by MBE on Si(111) with the period ranging from 1.5 to 20 nm has been studied by x-ray diffraction methods. High-resolution x-ray diffraction analysis has revealed, that a partial strain relaxation occured in the SLs with the period $t > 20$ nm. The SLs with $t < 20$ nm can be grown pseudomorfically, but x-ray diffraction analysis has demonstrated the presence of transition layers in these SLs. The layers in our case could be due to roughness of CaF2-CdF2 inner interfaces. The amount of interfacial roughness, its evolution, the degree of correlation has been obtained from a fit of small-angle x-ray scattering data. The results of our investigation have been provided a coherent picture with AFM data. A possible mechanism of inheritance of roughness has been considered.