EVIDENCE FOR TWO DIMENSIONAL ELECTRON AND HOLE GASES IN 3C/4H-SIC AND 3C/6H-SIC SILICON CARBIDE HETEROPOLYTYPE JUNCTIONS.

The superior physical properties of silicon carbide (SiC) as compared with silicon make it a promising material for high power, high-temperature and microwave electronics. Due to an extremely high thermal conductivity and breakdown field, SiC-based device structures are capable of operating at much higher voltages and microwave power than their Si equivalents. SiC MESFET devices have been demonstrated to work with a measured f_t of 12-15 GHz. Many of these devices are available in production or limited production. Despite the success of SiC MESFET technology their frequency performance is limited by the lack of a heterojunction system. In this talk we present studies on polytypic heterojunctions. Structures for this work were grown in a rotating disk vertical cold wall style reactor utilizing a H_2-SiH_4-C_3H_8-HCl chemistry. The growth took place at a temperature of 1400°C, a pressure of 200 Torr, an inlet C/Si ratio of 1 and a nominal growth rate of ~0.3 μm/hr typically for 1 hour. The reduced growth rate was employed to promote nucleation of the 3C modification. In all experiments the doping was unintentionale. 3C-SiC films were sucussefully formed on both on either 4H-SiC or 6H-SiC substrates which had been CMP polished. The films were found to be composed of islands which are bounded by DPB's (double position boundaries). 3C/4H-SiC heterojunctions were produced on the Si face of n-type 4H-SiC substrates. 3C/4H-SiC heterojunctions were also produced on the C face of 4H-SiC semi-insulating substrates. In addition 3C/6H-SiC heterojunctions were produced on the C face of high resistivity 6H-SiC Electrical measurements were performed on all heterojunction samples. For the samples produced on the C face of 4H-SiC a sheet carrier density of $n_s=2.5\times10^{13}$ cm^{-2} with an associated mobility of 300 $cm^2/V\text{-}s$ was measured at 77K in large area Hall samples. For samples produced on the Si face of n-type 4H-SiC substrates C-V measurements showed high resistivity for bias voltages of $\pm 20V$. Detailed capacitive and I-V measurements were made on the Si face samples. The results of the electrical measurements of both types of heterojunctions are interpreted in terms of a spontaneous polarization thought to be present in hexagonal SiC. Spontaneous polarizaton in 2H-SiC was calculated by Heine et. al. to be 4.32×10^{-2} C/m^2 in and by extension (based on the hexgaonality parameter) 2.16×10^{-2} C/m^2 in 4H-SiC and 1.44×10^{-2} C/m^2 in 6H-SiC. Based on the presense of a spontaneous polarization we could expect that samples grown on the carbon face would show evidence of a two dimensional electron gas (2DEG) while samples grown on the Si Face could show evidence of a two dimensional hole gas (2DHG). Details of the growth, measurements and interpretation will be presented.