LD-1-4

Production of Single Crystalline Cubic-SiC with 2-inch Diameter by CVD and Characteristics of MOS Diodes

Shigehiro Nishino, Kentaro Shibahara, Shinichi Dohmae and Hiroyuki Matsunami
Department of Electrical Engineering, Kyoto University
Yoshidahonmachi, Sakyo, Kyoto, 606, Japan

Cubic type SiC has high electron mobility of 1000 cm^2/Vsec at room temperature in spite of the wide band gap (2.2 eV). The saturation electron drift velocity is calculated to be 2.7×10^7 cm/sec almost the same as the peak value in GaAs. The breakdown electric field is around 5×10^6 V/cm based on the experimental results in 6H-SiC. Thus cubic-SiC is a promising semiconductor for high temperature, high power and high frequency electronic devices. However, crystals of cubic-SiC obtained by sublimation process (Lely method) have small sizes and irregular shapes, which has prevented this material from electronic applications. We reported rather thick and large-area epitaxial layers of cubic-SiC on Si substrates by CVD method with the aid of a buffer layer to release the large lattice mismatch of about 20 %.[1,2] On the basis of the previous study,[3] we have obtained large-area epitaxial layers of cubic-SiC on 2-inch Si wafers. As the preliminary study for device application, MOS diodes were fabricated using a thermally-grown oxide on the cubic-SiC. Inversion characteristics were observed for the first time. In this report, epitaxial growth of cubic-SiC with large area and electrical characteristics of the Al-SiO_2-cubic SiC MOS diode are described to make perspective for SiC devices.

Chemical vapor deposition was carried out in a vertical reaction tube using SiH_4-C_3H_8-H_2 system. Single crystal growth of cubic-SiC layers on Si consists of the three processes: i) etching at 1000 ^oC for 5 min with H_2 containing 0.5 % HCl, ii) carbonization at 1360 ^oC for 2 min with H_2 containing 0.04 % C_3H_8, and iii) crystal growth at 1330 ^oC with $SiH_4 \simeq 0.3$ cc/min, $C_3H_8 \simeq 0.24$ cc/min and $H_2 \simeq 3$ l/min. The growth rate was typically about 160 Å/min. Undoped grown layers show n-type conduction. The whole surface of the grown layer is almost mirror-like and flat as shown in Fig. 1.

Thermal oxidation was carried out in a flow of dry O_2 with 200 cc/min at 1050 ^oC for 5 h. The cubic n-type (100) SiC of about 10 μm thick was used. The electron concentration of the cubic-SiC was $10^{17} \sim 10^{18}$ cm^{-3}. Using Auger electron analysis, the oxide was confirmed to be SiO_2 without any inclusion of C.

For the MOS study, the oxide was annealed at 1050 ^{o}C in Ar gas for 20 min after oxidation. To make ohmic contact, Au-Ta alloy was evaporated on the back side of the cubic-SiC film. The Al gate electrode with a diameterof 0.4 mm was evaporated on the oxide layer. The resistivity of the oxide was 8.5×10^{15} Ωcm, and the breakdown field was 2.5×10^{6} V/cm.

C-V curves of MOS diodes in the dark at room temperature at 1 MHz show deep depletion characteristics with some hysteresis as in Fig. 2. As the sweep rate becomes slower, the C-V curve approaches to that of the high-frequency MOS characteristics. The curve under illumination with a 100 W tungsten lamp shows inversion characteristics with an injection type hysteresis as in Fig. 3. The flat band shift is around -0.41 V and the minimum surface state density is 3.8×10^{11} $cm^{-2}eV^{-1}$. Even under illumination, for the faster sweep rate (ex. 5 V/sec), the C-V curve shows deep depletion characteristics shown with solid lines in Fig. 4. When the sweep of the bias is stopped at about -40 V, the capacitance recovers and the inversion characteristics appear 1 min after as shown with a dotted line in Fig. 4.

The hysteresis and the capacitance recovery can be explained with the very small number of the intrinsic carriers and generation rate due to the wide band gap of cubic-SiC, which will be described at the conference.

1) H.Matsunami et al., IEEE Trans. Electron Devices ED28 (1981) 1235.
2) S.Nishino et al., Appl. Phys. Letters 42 (1983) 460.
3) S.Nishino et al., Extended Abst. 15th Conf. SSDM (1983) 317.

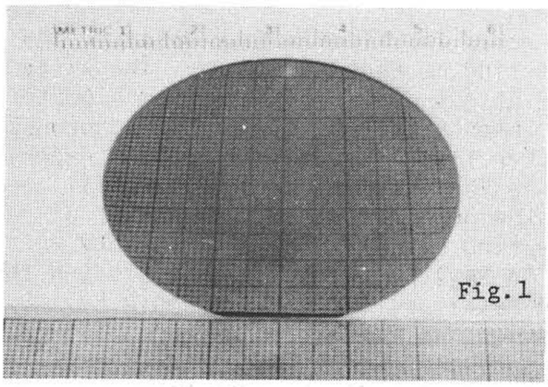

Fig.1

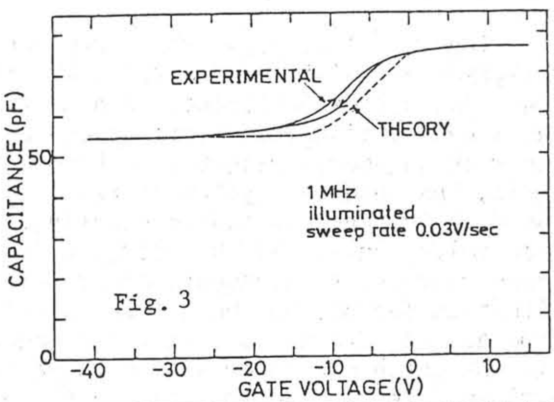

Fig. 3

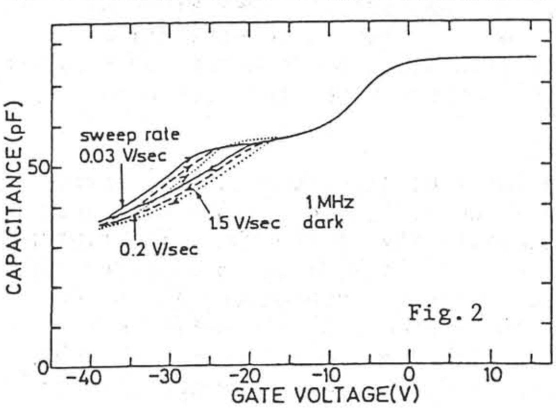

Fig. 2

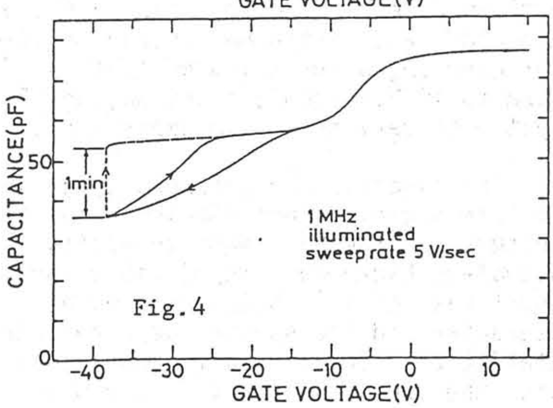

Fig. 4