A Study for the Electrical Characterization of B-doped 6H-SiC Epitaxial Layers Grown by Step-Controlled Epitaxy

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! Introduction

Recently, as a semiconductor material for electronic and optoelectronic devices, silicon carbide (SiC) has been intensively studied because of its excellent electronic, optoelectronic and other physical properties. The outstanding properties of SiC allow application to electronic devices that can be operated under extreme environmental conditions. In spite of the high potential for such device appliations, the development of electronic devices using SiC has been delayed due to the difficulty in the steady supply of high quality crystals. However, significant advances have been achieved in the last several years in 6H-SiC crystal growth. Recently, homoepitaxial growth of device-quality 6H-SiC at low temperatures has been achieved by step-controlled epitaxy utilizing off-oriented 6H-SiC{0001} substrates.

From a viewpoint of characterization, analysis on defects and deep levels plays an important role in improving the device performance. It is, therefore, an urgent task to investigate the incorporated defect centers in SiC. However, there have been only a few reports on trap centers in SiC. Among them, in 6H-SiC, deep levels in p-n junctions formed by Al ion implantation were observed by deep level transient spectroscopy (DLTS) measurements. Another deep centers in B-doped 6H-SiC grown by liquid phase epitaxy (LPE) were investigated by DLTS, admittance spectroscopy and photoluminescence. Recently, DLTS measurements of p-n junction diodes by LPE revealed that an electron trap center with an activation energy of 0.71eV was detected in an n-type grown layer. However, deep levels in B-doped 6H-SiC epilayers grown by step-controlled epitaxy have not deen investigated at all. B-related levels of B-doped 6H-SiC's have been studied many researchers, but the origin has not been well-defined and espesially no paper was found on the B-doped 6H-SiC that doped Boron during the CVD growth.

! Experiment

In this study, DLTS measurements have been carried out to investigate deep levels in Schottky diode structures of B-doped 6H-SiC grown by step-controlled epitaxy for the first time. The samples used in this study were B-doped p-type 6H-SiC epitaxial layers grown by step-controlled epitaxy on 6H-SiC (0001)Si-faces with 3.5° off angles. As source and carrier gases, SiH_4, C_3H_8 and H_2 were used. The growth temperature and growth rate were 1,500℃ and ~2.5㎛/h, respectively. The thickness of grown layers was ~5.0㎛ and the carrier concentration was in the range of 2×10^{16} - $4\times10^{16}cm^{-3}$ determined by capacitance-voltage (C-V) measurements. For DLTS measurements, Au Schottky contacts with a diameter of 300 - 800㎛ were thermally evaporated on the surfaces and large area ohmic contacts were formed using Al/Ti alloy on the back side of SiC samples.

The measurements of C-V, I-V and DLTS were entirely performed with software control of the system under the conditions established for each measurement. All measurements of the samples were performed in a temperature-controlled system using liquid nitrogen and in a vacuum of 10^{-2} Torr. DLTS measurements were also performed in the temperature range from 150K to 400K for the same samples.

! Results

The characteristics of Schottky structures were considered relatively excellent, and in case of the samples that growth temperature is 1500℃ and C/Si ratio is 2.0, the results surveyed are as follows. The energy level of B-related deep center is ~ E_v+0.7eV, the capture cross section is $4.0\times10^{-13}cm^2$-$3.0\times10^{-12}cm^2$ and the density is N_T ~(1/100)N_a. This deep center is considered donor-like center because its behavior is independent of the electric field intensities.