ISSN 0027-1349, Moscow University Physics Bulletin, 2020, Vol. 75, No. 2, pp. 133–136.

Recrystallization of the Structure of Silicon Carbide under Ion Irradiation

A. A. Shemukhin[1,2,3*], A. M. Smirnov[1], A. P. Evseev[1,3], E. A. Vorobyeva[3], A. V. Kozhemiako[1], D. K. Minnebaev[1,3], Yu. V. Balakshin[2,3], A. V. Nazarov[3], and V. S. Chernysh[1,3]

[1]*Department of Physics, Moscow State University, Moscow, 119991 Russia*

[2]*Center for Quantum Technologies, Moscow State University, Moscow, 119991 Russia*

[3]*Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, 119991 Russia*

Received December 10, 2019; revised January 14, 2020; accepted January 20, 2020

Abstract—Silicon carbide was irradiated with aluminum ions at an energy of 190 keV with fluences of 2×10^{13}–5×10^{14} ion/cm^2. The temperature of the target during irradiation was 300–500°C or it was kept at room temperature. It is shown that the presence of nitrogen in the structure of silicon carbide erodes the edge of the interband absorption. After irradiation at room temperature, the structure is disordered to form Si–Si and C–C compounds, as well as 3C–SiC. According to the absorption spectra, when the target temperature is increased during irradiation to 500°C, the structure of silicon carbide recrystallizes up to the initial state.

Keywords: silicon carbide, ion implantation, Raman scattering, defect formation.

DOI: 10.3103/S0027134920020113

INTRODUCTION

Silicon carbide (SiC) is a compound of group IV elements, that is silicon and carbon. In the field of physics of semiconductors, SiC is known as a material with a wide bandgap compared to that of silicon. A number of beneficial features in the properties of silicon carbide, compared to those of silicon, makes it the preferred material for power semiconductor devices, which are able to operate with large current powers at high temperatures [1].

A wide bandgap and high temperature stability allow one to exploit certain types of SiC devices at 300°C or higher during long periods of time without degradation of performance. The resistances of power devices based on SiC in a switched-on state are orders of magnitude lower than that for silicon devices at a given blocking voltage, which leads to much higher efficiency of power conversion. In addition, SiC is a unique compound semiconductor, whose native-grown oxide is SiO_2. This allows one to manufacture an entire family of electron devices based on MOS structures with SiC [2].

It is also worth mentioning that materials with a wide bandgap have a higher degree of resistance to the impact of particles with high energy, which reduces the complexity of the creation of devices that are needed for operation in a medium subjected to the effect of radiation [3]. A study of the effect of irradiation with protons on properties of various forms of silicon carbide in comparison with each other is presented in [4]. Thus, for example, it was demonstrated that the epitaxial 3C–SiC layers grown in the study have approximately the same radiation resistance under irradiation with protons as 6H– and 4H–SiC.

For most of the manufacturing stages, modifications and development of new technologies are needed, since SiC is a much harder material than silicon. However, since ion implantation provides excellent control of the distribution of a dopant, both laterally, by means of lithography, and in depth, by choosing the energy and dose of ions, ion implantation is as widely used for manufacturing of SiC devices as before. Moreover, since ion implantation is not a thermodynamically equilibrium process, the implanted concentration of the dopant per unit volume can exceed the solid-state solubility of implanted doped forms in 4H–SiC. However, during implantation, the fact should be taken into account that the character of defect formation in near-surface layers becomes nonmonotonic with increasing fluence and

*E-mail: shemuhin@gmail.com