An EPR studies of $V_C C_{Si}^-$ defect in neutron irradiated 3C-SiC

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Abstract

Annealing the neutron-irradiated 3C-SiC crystals at T = 900 °C leads to full vanishing of silicon vacancies and simultaneous emergence of new paramagnetic defect, called Ky6. New center has spin S = 1/2 and can be described with axial g-factor directed along <111> direction and with principal parameters $g_\parallel = 2.0024$ and $g_\perp = 2.0029$. Ky6 center can be observed at temperatures under 140 K and shows hyperfine interaction (HF) with principal parameters $A_\parallel = 23.9 \cdot 10^{-4}$ cm^{-1} and $A_\perp = 19.3 \cdot 10^{-4}$ cm^{-1}. Based on the HF parameters, annealing processes of defects in crystal and calculations of formation energies [1] center Ky6 was tentatively assigned to $V_C C_{Si}^-$ in 3C-SiC.

Keywords: 3C-SiC, EPR, Intrinsic defect, Thermal annealing

1. Introduction

Due to its remarkable electronic and physical properties, silicon carbide takes a substantial place among all semiconducting materials. High thermal, radiational and chemical endurance makes it a significant substance for developing electronic devices that can be used in severe environments like space or nuclear reactors.

There are over 200 polytypes of SiC, but cubic 3C-SiC has simplest crystal structure and highest electron mobility among all [2]. Unfortunately, due to complexity in growth conditions of 3C-SiC it has not reached vast industrial implementation. Simultaneously the greater commercial success have been reached for hexagonal crystals and therefore they much better studied during past decades (see [3; 4] and references therein). However, recent progress in 3C-SiC growth, especially thin films [5], raised up interest for industrial use of cubic crystals as basis for industrial electronics.

Irradiation of crystal produces high concentrations of various point defects and therefore influences on its electronic properties. Thus perspectives of industrial use of 3C-SiC raises the interest to studying properties of its point defects. Dominant defects in as-irradiated 3C-SiC crystals are negative silicon vacancy [6] and neutral divacancy [7]. Silicon vacancy was observed in crystals irradiated by electrons, protons, neutrons and ions, has spin S = 3/2 and can be described by isotrop g = 2.0029. From another hand, divacancy observed only in neutron irradiated samples, has S = 1 and axial fine structure tensor and isotrop g-factor: $D = 443 \cdot 10^{-4}$ cm^{-1} and g = 2.003 respectively. Annealing at $T_{ann} = 900$ K cause transformations in system of defects that results in almost full disappearence of mentioned above defects. At the same time, new EPR spectrum was emerging. This spectrum was linked to S = 1/2 paramagnetic defect, named Ky6, and the present paper has been dedicated for elucidate properties of this defect.

2. Experimental

All samples were grown by vapor-phase process. Thermal decomposition of methyl trichlorsilane in hydrogen environment at T = 1700 K and conse-

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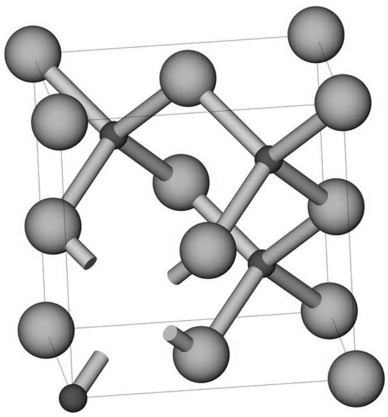

quent precipitation on graphite needles used to obtain required compound during this process. All samples weren't intentionaly doped and n-type of conductivity had been set by Nitrogen donors, that formed during crystal growth. Concentration of this donors were 10^{17} cm^{-3}. Typical sample dimentions were 4 x 3 x 0.7 mm. Neutron irradiation were carried out in nuclear reactor at room temperature with dose of 1 x 10^{19} cm^{-2} exposed to each sample. Due to high neutron penetration ability of SiC [8], the distribution of generated defects can be considered as homogeneous.

X-band spectrometers Radiopan SE/X and Bruker E550 were used to measure EPR spectra. Measurements were carried out at the 300 K, 77 K and 4.2 K with magnetic field rotated in $(1\bar{1}0)$ and (111) planes. For studying of transformations of defects, samples were annealed in inert environment of Helium gas in the temperature range from T_{ann} = 200 to 1100 K with step 100 K and exposure 5 mins. Temperature control performed with thermopair that gave precision about ±1°.

3. Results and discussion

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