CHANGES OF ELECTRIC AND MAGNETOTRANSPORT PROPERTIES OF δ-LAYERS DUE TO SWIFT HEAVY IONS IRRADIATION

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Dopant distribution profiles in semiconductors (known as δ-layers) are the subject of interest for fabricating nanoscale electronic devices as well as for the study of carrier transport in low-dimensional structures [1]. *Sb* δ-doping of *Si* by molecular beam epitaxy (MBE) has received much attention in view of their application in such devices as tunnel diodes and heterojunction bipolar transistors. The creation of sharp *n*-type dopant profiles in *Si* during MBE growth is challenging due to the pronounced surface segregation of the mostly used dopants like *Sb*, *P* and *As*.

The δ-doped layer was formed using the selective doping technique described in [2] and the growth procedure is described in brief below. After standard cleaning of *Si* substrate a 100 *nm* thick *Si* buffer layer was deposited at 550 in order to obtain an atomically flat *Si* surface. Then temperature was dropped down to 350^oC and a certain amount of *Sb* was deposited and then capped by a 2 *nm* thick *Si* layer at such a low temperature. This allowed us to obtain a sharp rise in doping concentration. In order to obtain a sharp drop in *Sb* bulk concentration the growth was inter-rupted, temperature was raised up to 535^oC and a 75 *nm* thick *Si* capping layer was deposited at this temperature. Due to the very high value of segregation ratio at 535 [2], the *Sb* incorporation is negligible that allowed obtaining the sharp decrease in *Sb* bulk concentration.

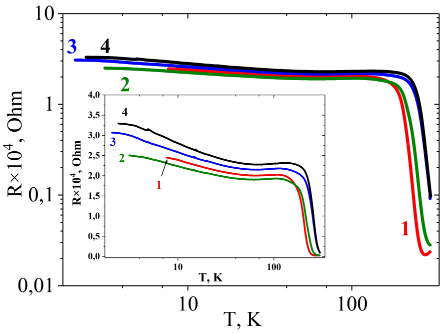

Fig. 1. Resistance $R_{Sq}(T)$ before (1) and after SHI irradiation *D*: $1{\cdot}10^8$ (2), $1{\cdot}10^9$ (3), $1{\cdot}10^{10}$ (4) and $5{\cdot}10^{10}$ ion/cm^2 (5).

Temperature and magnetic field dependences of the electrical resistance$R(T,B)$ in the temperature range of $2 < T < 300$ *K* and magnetic induction $B{\leq}8T$ before and after the SHI irradiations were measured. After initial electric characterization, the samples were irradiated with the fluence of $D = 1{\times}10^8$ ion/cm^2 at room temperature by 167 *MeV* Xe^{+26} ions at the IC-100 cyclotron at FLNR JINR, Dubna (Russia). This procedure is repeated two more times with $D = 1{\times}10^{10}$ cm^{-2}, $5{\times}10^{10}$ cm^{-2}. The ion beam homogeneity to 5 % on irradiating specimen surface has been reached using the beam scanning in horizontal and vertical directions. Average Xe ion flux was about $5{\times}10^7$ $cm^{-2}s^{-1}$ thus excluding any target heating.

Electron transport in $Si < Sb > \delta$-layer grown by MBE was studied in detail at temperatures lower than 15 *K* and in magnetic fields *B* up to 8 *T* before and after three acts of the 167 *MeV* Xe^{+26} ion irradiation with ion fluence $1{\times}10^8$ cm^{-2}, $1{\times}10^{10}$ cm^{-2}, $5{\times}10^{10}$ cm^{-2}. It was shown that the low temperature conductivity in δ-layer is described by the theory of 2D quantum corrections to conductivity in the case of weak localization Eq. 1.

$$MR = \frac{\Delta R_{sqr}(B,T)}{R_{sqr}(B,T)} = R_{sqr}(B,T)\frac{e^2}{2\pi\hbar}\left\{\psi\left[\frac{1}{2}+\frac{B_i}{B}\right]-ln\left[\frac{B}{B_i}\right]\right\}. \quad (1)$$

where R_{sqr} - sheet resistance, B - magnetic induction, ψ - digamma function, $B_i = \frac{\hbar}{4eD_d\tau_{Th}} = \frac{\hbar}{4eL_{Th}}$, D_d - diffusion coefficient of carriers, τ_{Th} - the phase failure, L_{Th} - Thouless length.

In so doing, SHI irradiation results in decrease of Thouless length from 14.08 to 5.17 *nm*.

[1] Y. Imry, Nanostructures and Mesoscopic Systems, (Academic, New York, USA 1992).
[2] D.V. Yurasov et al., Usage of antimony segregation for selective doping of Si in molecular beam epitaxy, J. Appl. Phys. *109*, 113533 (2011).