Changing the Temperature Dependence of Electrical Conductivity on the Opposite in Si Nanocluster Containing Structures

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Nowadays, silicon (Si) nanocrystals embedded into SiO_2 matrix have perspective of wide applications as the active layer in various electronics and optoelectronics devices. To use this layer in devices the detailed information about the electrical characteristics of Si nanocrystals in SiO_2 matrix is needed.

The main purpose of this study was to investigate the mechanisms of conductivity of the MIS structures with nanocomposite SiO_2(Si) films obtained by ion-plasma sputtering for subsequent use as a medium for capture and storage of electric charge in the nonvolatile memory structures.

At the beginning SiO_x films have been deposited by ion-plasma sputtering of silicon target in the vacuum on p - type c-Si substrate in argon and oxygen atmosphere. The main parameters of the process were: gas pressure during deposition $P = 8 \times 10^{-4}$ Torr, substrate temperature T=150°C, deposition rate v = 20-25 nm /min. For transformation of silicon enriched SiO_x film into nanocomposite SiO_2(Si) film containing silicon nanocrystals embedded into SiO_2 dielectric matrices, high temperature annealing at T = 1100 °C for 30 min in the nitrogen atmosphere has been performed. To measure the electrical characteristics of the films the MIS capacitors have been formed. As aluminum and titanium electrodes were deposited by sputtering of the appropriate target. The MIS capacitors metal electrode square was 7×10^{-3} cm^2.

Measurements of current-voltage (I-V) characteristics were carried out using automated complex consisting of a controlled voltage source and ampermeter Keithley-6485. To elucidate the mechanisms of conductivity the measurements of I - V characteristics were carried out in the temperature range 82 K - 350 K.

Fig. 1 shows the temperature dependence of conductivity of n-Si / SiO_2 (Si) / Ti MIS structure. The stoichiometry index in initial SiO_x film was x = 1.3. As it can been seen the current through the nanocomposite SiO_2(Si) film strongly depends on the temperature. In fields more than 10^5 V/cm conductivity type changes from the semiconductor to the metal type. The model for explanation this effect has been proposed.

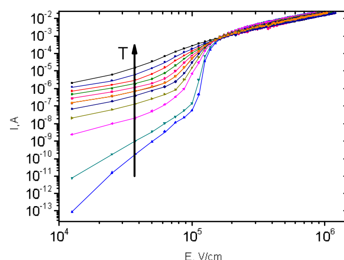

Fig.1. Typical I-V characteristic of n-Si / SiO_2(Si) / Ti MIS structure in the temperature range from 83 K to 350 K. The direction of the arrow shows the temperature growth.