Peculiarities of Electron Transport through Multilayer SiO_2-ncSi-SiO_2 Structures

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Multilayer structures containing nanocrystalline inclusions (e.g., metalic, or semiconductors particles) in the dielectric matrix are under intensive investigations with aim of their perspective applications in electronics, for example in nonvolatile nanocrystal memory and optoelectronics. One of the significant problems restricting the practical application is to obtain the structures with required electrical parameters.

The purpose of this study was to investigate the electrical properties (conductivity) of layered structures silicon substrate-SiO_2-ncSi-SiO_2. The amorphous silicon (a-Si) or polycrystalline silicon (poly-Si) films were used as an embedded into dielectric semiconductor layer. The LP CVD (Low Pressure Chemical Vapor Deposition) method was used for obtaining these films. During high-temperature annealing thin a-Si and poly-Si films transform into nanocrystalline clusters.

The first ultrathin SiO_2 film was grown on Si wafer by thermal oxidation at T=850°C. Then a-Si or poly-Si films have been deposited by LP CVD at T=500°C and T=680°C correspondingly. The third upper SiO_2 layer was grown by thermal oxidation at T=850°C or deposited by LP CVD at T=400°C. After that the structures were annealed at T=1100°C during 1 hour to form nc-Si between SiO_2 layers. The total thickness of such three layers structure was variable in the range 17 – 30 nm. The following electrical contacts formation as on front and back sides finished the preparation procedure. The circle capacitors were formed on front side by metal deposition through mask.

I-V and high frequency C-V measurements at various temperatures have been used to characterize the electrical properties of the structures. As was determined the value of the current and transport mechanism significantly depend on the obtaining method of upper SiO_2 layer. Based on the analysis of I-V and C-V characteristics the mechanisms of electron transport through multilayered structures have been determined. The important role of traps in dielectric bandgap and tunneling through dielectric layer between Si nanocrystals has been clarified. The thicknesses of dielectric SiO_2 layers and size of Si nanoclusters also determine the electron transport mechanism.