Ge Nanostructures in High-K Materials

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Ge has attracted a wide interest over the last decade. The improved hole mobility in comparison to Si and the bandgap energy of 0.6 eV makes it attractive for photonic and electronic applications. For this application a good passivation of the Ge surface is mandatory. As the Ge oxides show an unstable behavior high-K dielectrics for surface passivation are a promising candidate. In the past Ge nanostructures has been investigated in superlattice structures by the phase separation of GeO_x/SiO_2 superlattices [1,2]. Usually a luminescence in the blue region attributed to defects at the Ge nanocrystals surface has been reported [3]. We will summarize our work on the phase separation of $GeZrO_2/ZrO_2$ superlattices prepared by rf-co-sputtering. By high temperature annealing a crystallization of the layers occur resulting in nanocrystalline tetragonal ZrO_2 and 5-10 nm thick and a few µm wide single crystalline Ge clusters. These elongated crystalline structures occur due to the simultaneous crystallization of the ZrO_2 layer and the segregated Ge at about 625°C annealing temperature. In addition, this leads to an orientation relation between the crystallized ZrO_2 and nc-Ge. The described simultaneous phase separation and crystallization of ZrO_2 and Ge is the first step towards an in-situ passivation of the Ge surface. For comparison Si nanostructures in ZrO_2 were formed in a similar way and wet chemically prepared infrared emitting nanoclusters were introduced into the ZrO_2 matrix by the sol-gel method. All samples prepared by the different techniques were investigated for their optical and electrical properties. This work is assisted by a detailed characterization of the electrical properties of the high-k dielectrics itself in order to investigate deep traps in the dielectric material as well as trap and dipole related relaxation processes.

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