## Nanocomposites and nanomaterials

# Effect of Ge content on the formation of Ge nanoclusters in magnetron sputtered $GeZrO_x$-based structures

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Memory structures with Ge-nanocrystals (NCs) embedded in $SiO_2$ provide a larger memory window than the devices based on Si-NCs. However, Ge-NCs embedded in "high-k" matrix have attracted attention just recently. In this work, the effect of Ge content on the formation of $GeZrO_x$ solid solution and on thermo-stimulated phase separation followed by the formation of Ge-NCs in $ZrO_2$ matrix is investigated.

The composite $GeZrO_x$ films as $GeZrO_x/ZrO_2$ multilayers, fabricated by confocal RF magnetron sputtering of pure Ge and $ZrO_2$ targets in Ar plasma, were studied by means of spectroscopic ellipsometry, Raman scattering, FTIR and TEM methods versus deposition conditions and annealing treatment.

As-deposited $GeZrO_x$ films were found to be homogeneous whatever Ge content. Thermal treatment stimulated a phase separation and a formation of Ge and $ZrO_2$ phases. The "start point" of this process depends significantly on Ge content in $GeZrO_x$ films and/or Ge-doped sublayer thickness in multilayer structures. Although the phase separation begins at about 600-700°C, the higher Ge content and/or thicker Ge-doped sublayer result in the lowering of the annealing temperature caused phase separation, nucleation of Ge nanoclusters and their crystallization. Along with this the formation of tetragonal $ZrO_2$ occurs that offers an achievement of higher dielectric constant. The mechanism of phase separation will be discussed in details and the ways to control the Ge-NCs formation in amorphous $ZrO_2$ host will be proposed.