Thermal stability of dielectrics on germanium: role of the substrate

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There is a current research effort to investigate high-mobility semiconductors due to their potential applications in future high performance metal-oxide–semiconductors field effect transistors (MOSFET). Germanium (Ge) is of particular interest since it presents electron and hole mobilities higher than those of Si, being a promising candidate for next generation devices[1]. However, the formation of a stable, chemical and electrical passivating layer on Ge surfaces with a low density of electrically active defects is still a challenge. Many high-k dielectrics have been proposed as possible gate insulators for Ge-based devices such as HfO_2, Al_2O_3, TiO_2, and La_2O_3 [2]. An adequate high-k material must fulfill many requirements like thermal and chemical stability with Ge. It has been reported that HfO_2 films on Ge can react during the deposition process and/or during post-deposition annealing. However, beneficial effects of this reaction were observed, such as the increase of the HfO_2 permittivity and decrease of oxygen diffusion in the film, but deleterious effects in the electrical characteristics of the interface also took place. In this way, it is mandatory to understand the atomic transport of different species during the deposition process and/or annealing steps in order to achieve acceptable low density of interface states. In the present work, we investigated the effect of thermal annealing on the physico-chemical properties of dielectrics films deposited on p-type Ge(100) and Si(001) wafers. After deposition, samples were submitted to annealing steps in different atmospheres using gases enriched in rare isotopes, which enabled us to identify species incorporated due to thermal annealing or to air exposure. The amount and depth distribution of ^{18}O, ^{2}H and ^{15}N were determined by nuclear reaction analyses (NRA). The chemical ambient and the surface atomic composition were determined by X-ray photoelectron spectroscopy and low energy ion scattering, respectively. The total amounts of heavy elements were determined by Rutherford Backscattering spectrometry and the microstructure of the films was observed by transmission electron microscopy. Constrating differences concerning thermal stability were observed for films deposited on Si and Ge.Mechanisms of Ge and O diffusion and reaction based on the observed results will be discussed.

[1] R. Pillarisetty, *Nature* **479**, 324 (2011).
[2] Y. Kamata, *Materials Today* **11**, 30 (2008).