Variation of TiO_2/SiO_2 transition layers induced by ion irradiation

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Abstract

Ion beam mixing (IBM) is a processing technique recently developed and used for modification the structure and composition of thin layers of materials. A large number of studies on effects induced by IBM in metal/metal or metal/semiconductor bilayers have been presented for understanding atomic transport mechanisms and phases formation processes. IBM for these structures is well understood but the same is not the case for metal/ceramic or ceramic/ceramic systems. Moreover, by mixing models the mixing amout depending on the ion fluence or temperature can be predicted, but mixing degree is not a simple function for energy and mass of incident ions. Therefore this correlation could be determined only by experimental investigation. In our work, mixing of the TiO_2/SiO_2 bilayers have been produced by the noble gas ions. The main objectives are to determine how mixing depend on energy, mass of the incident ions and how it different from thin and thick systems. There were 2 groups of studied TiO_2/SiO_2 samples, in which layers thickness of the samples in the group1 is lower than that of the sample in group 2. The samples were irradiated by the Ne^+, $Ar^{+,}$ Kr^+ and Xe^+ ions at four diffrent energies 100, 150, 200 and 250 keV. The atomic mixing at TiO_2/SiO_2 interface was characterized by the spectra of Rutherford Backscattering Spectrometry (RBS) method. Mixing amount indicated by relative thickness of the TiO_2/SiO_2 transition layers which was deduced from the elemental depth profiles. It has been found that mixing amount increase linearly with increasing of the ions energy while mixing increase strongly as a function of ions mass. By use of SRIM simulation the effects could be interpreted by changing of the ion energy loss, energy tranferred to the recoils as well as number of ions interact at the interface. Displacement per atom (DPA) was calculated for comparing mixing degree of different-thickness structures. Although the ion loss more energy after penetrate the thicker TiO_2 layers, the penetration depth and number of interacted ions were higher, as a consequence the higher value of DPA was observed for transition layer of thick structure. The thickness obtained from the RBS is in good agreement with that measured using the Ellipsometry Spectroscopy method. Based on these obtained results, the optical constants of implanted and non-implanted TiO_2/SiO_2 structures were also investigated.

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