Abstract

With emerging technological advances, the industrial highlight and extensive research on Ni-Ti thin film SMA have now shifted from the bulk domain to the micro- and nano-scales, with novel applications such as micropositioners, microvalves and microactuators. Sputter deposited Ni-Ti thin film found to be of great interest as powerful actuators in Nano-electro-mechanical-system (NEMS), since these SMA thin films possess a large force and displacement compared to the electrostatic, electromagnetic and piezoelectric actuators. In the present investigation, single-bi-layer and double-bi-layer of Ni/Ti thin film were synthesized and characterized. Nanoscale layers in the order of Ni as the bottom layer and Ti as the top layer were deposited on Si(100) substrate. Ni and Ti depositions were carried out using DC and RF power respectively, in magnetron sputtering chamber. Four different types of bi-layers (each bi-layer containing bottom Ni layer and top Ti layer) were formed by varying the deposition time of each layer (i.e. 15 min, 20 min, 25 min and 30 min). These amorphous as-deposited thin film were heat treated for one hour at four different annealing temperature; 300 ºC, 400 ºC, 500 ºC and 600 ºC to achieve the diffusion in between the layers of thin film. This observation provides an opportunity to control the diffusition by adjusting the annealing conditions. Microstructures were analysed using FESEM and HRTEM. Analyses of phase formations were performed using GIXRD. It is found that, with the increase in annealing temperature from 300 ºC to 600 ºC, the extent of solid state diffusion increases between the layers. The surface finish is better at higher annealing temperature. Phase analysis shows the formation of intermetallic compounds with little amount of silicide phases. It also shows that the interdiffusion of the four layer-constituents results either in amorphization or in crystallization across the cross-section of the double bi-layer, after annealing. The reaction between Ni/Ti layers and substrate layer results in a compositional difference and suppresses heterogeneous nucleation at these interfaces. The crystal growth rate shows film thickness dependence. Uniform microstructure and shape memory properties were locally introduced in the films by annealing. AFM and profilometry were used for observation and analysis of surface profile. Nanoindentation and nanoscratch measurements were carried out to know about the mechanical properties of the thin film. LAMMPS molecular dynamics simulator was used to investigate both metallic transformation and amorphization by diffusion in Ni/Ti multilayer. The VMD plot indicates the preferential angular diffusion at the interface. It

reveals the increase in diffusion with the amount of vacancies. By concentration profile it was observed that the concentration of Ni is more than that of Ti which is due to the higher mobility of Ni. As a whole the simulation results are well matched with the experimental output.