Abstract

Ni-Ti based thin films offer a unique combination of novel characteristics, such as shape memory property, super-elasticity, biocompatibility and high damping capacity. The thin film shape memory alloy (SMA) has the potential to become a primary point of attraction for its actuation mechanism in micro-actuators. But the required properties can only be generated in case of equiatomic Ni-Ti system. To reduce the compositional sensitivity, a general trend has been observed to add the third element into the Ni-Ti matrix. In this study, Ni-Ti-Hf and Ni-Ti-Cu films were successfully prepared by co-sputtering, using the individual Ti and Ni targets along with Hf and Cu targets as the third element targets. For the development of the high temperature effect and the stability of the alloy during change in temperature and under mechanical loading, the third elements were added into the Ni-Ti matrix. The third elements, like Hf and Cu were added to fabricate the Ni-Ti-Hf and Ni-Ti-Cu thin films with varying hafnium contents (6 to 30 at. %) and varying copper content (5 to 15 at. %), respectively. The films were fabricated by DC and RF magnetron sputtering techniques using simultaneous sputter deposition from individual elemental targets. The required film compositions were achieved by adjusting the power of the targets. Basically, the RF source was used for Ti and DC sources were used for Ni and (Hf/Cu). The as-deposited films were amorphous; a post deposition annealing was performed at 1048 K and 873 K to crystallize the Ni-Ti-Hf and Ni-Ti-Cu films, respectively. The crystalline structure, residual stress, phase transformation properties, nanomechanical behavior and surface resistivity of the Ni-Ti-Hf and Ni-Ti-Cu films were investigated using surface profilomerty, field emission scanning electron microscopy (FESEM), high resolution transmission electron microscopy (HRTEM), grazing incidence X-ray diffraction (GIXRD), curvature measurement method, nanoindentation and resistivity measurement. Effects of the processing parameters on the film composition, phase transformation and shape-memory effects were analyzed. Average thickness achieved during the sputtering process was nearly 0.5 µm to 1 µm. The compositional analysis of the film was performed using energy dispersive spectroscopy (EDS) attached with the scanning electron microscope.

Adhesion and biofilm formation by bacteria on metal surfaces enhance fouling significantly. Inhibiting bacterial adhesion helps to control biofouling. In this research work, copper has been incorporated in Ni-Ti thin films using magnetron sputtering system on glass substrates. Grazing incidence X-ray diffraction (GIXRD) and field emission scanning electron microscopy (FESEM) provided the intermediate phases present into the material and the microstructure of the as deposited film, respectively. Film thickness, surface roughness and 3D view of the biofilms formed on the thin films were assessed by surface profilometry. The biofilm biomass was quantified by the semi-quantitative crystal violet staining and the surface morphology of the biofilms was studied by scanning electron microscopy. Adhesion assays on $Ni_{50}Ti_{50}$ and $Ni_{43}Ti_{49}Cu_8$ films were performed to evaluate the bacterial attachment with those film surfaces. Based on the findings, it can be demonstrated that $Ni_{43}Ti_{49}Cu_8$ thin film surface is more effective in preventing biofouling as compared to the $Ni_{50}Ti_{50}$ thin film surface.

Experimental characterization of $Ni_{43}Ti_{49}Cu_8$ films deposited under different substrate temperatures and substrate bias voltages suggest that increase in the substrate temperature promotes film crystallinity, whereas, enhanced substrate bias degrades the same. The film thickness also decreases with substrate bias voltage. These trends could be explained by simulating the interaction of atoms in the plasma with the surface of the Ni-Ti-Cu thin film and the stability of crystalline structure of the film upon creation of excess vacancy due to re-sputtering. The interaction of atoms was assumed to be governed by embedded atom method (EAM) interaction potential.