

Ti-Ni SMA thin film microactuators made on a Si substrate

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Abstract:

Among several types of performance materials proposed for fabricating microactuators, Ti-Ni shape memory alloys have great advantages such as large deformation and recovery force. The intrinsic disadvantage of shape memory alloys, the slow response due to the limitation of cooling rate can be greatly improved in micro size actuators, because the surface/volume ratio of materials will drastically increase in thin films so that cooling becomes efficient. Therefore, the development of Ti-Ni shape memory thin films has been proposed in the field of micromachines.

In the present investigation, Ti-Ni shape memory alloy thin films were deposited by sputtering on Si substrates covered by SiO₂ layer. The Ti-Ni thin films were crystallized by heat-treatment in order to achieve high transformation temperatures. The M_s and A_s temperatures were 340K and 365K, respectively. This M_s is the highest temperature achievable in the binary Ti-Ni alloy and about 50K higher than room temperature, enabling that a high frequency response is achieved. Square diaphragm type microactuators were fabricated by the photolithography method with anisotropic etching applied to the Si substrate. The dimension of the sides of the squares ranges between 100 and 1,000 micronmeters. The structure of the diaphragm consists of a 1.5 micronmeters thick Ti-Ni film and a 1.0 micronmeter thick SiO₂ layer. Joule heating and natural cooling methods were applied to move the actuators. The microactuators moved up and down upon cooling and heating, respectively. The highest position at the center of the actuator was about 30 micronmeters, while the lowest was 0 micronmeters. The highest frequency detected was 100Hz.