Nanostructured surfaces

Self-patterning of epitaxial Ni-Mn-Ga/MgO (001) thin films

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Ni-Mn-Ga thin films grown on a heated single-crystalline MgO (001) substrate exhibit a low-hysteresis martensitic transformation in the vicinity of -50 ºC, between the cubic and orthorhombic phases. During martensitic transformation, the unit cell volume undergoes an inverse to the bulk jump-like behavior due to the stress imposed by the substrate. The surface layer of the film presents a naturally formed selforganized morphology, being formed by the elongated bar-like shaped crystal grains parallel to the [100] and [010] directions of the substrate. The formation of this surface layer is explained in terms of the change of the growth conditions: after achieving of some thickness the epitaxial continous growth is interrupted by a descrete formation of out-of-plane 110-type oriented crystallites as a result of surface stress relaxation. Meanwhile, these crystallites exhibit in-plane directional growth which has been explained in terms of the unidirectional lattice correspondence. Magnetization measurements show essentially larger magnetic anisotropy of the martensitic phase compared to the austenitic one. The columnar-type of growth of the top layer is reflected in the noticable out-of-plane contribution seen in the perpendicular magnetization curve of the austenite. FMR measurements in the cubic phase clearly discern magnetic states of the main body of film and upper layer.

The film studied in the present work shows unusual properties and can be considered as a first example of FSMA with the self-assembled patterned surface system interesting for possible smart nanoscale applications. As epitaxy is lost when certain thickness limit is exceeded, further experiments are in progress to determine this limit and its relation with the growth conditions.