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# Physical properties of $Ni_2MnGa$, $Ni_2MnAl$, and $Ni_2MnIn$ Heusler alloys

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It is well known that some metallic alloys undergo reversible, crystallographic, thermoelastic, martensitic transformations which are accompanied by a shape-memory effect. In most cases the shape-memory alloys are nonmagnetic, and the methods for influencing their shape and size are limited to the stress and temperature. However, in Mn-containing Heusler alloys an indirect exchange interaction between the magnetic moments of atoms produces ferromagnetism. In this study, the physical properties of magnetically-driven-actuator materials with composition $X_2YM$ were comparatively investigated.

$Ni_2MnGa$, $Ni_2MnAl$, and $Ni_2MnIn$ alloy films were fabricated on the glass and flexible mica substrates by using a flash-evaporation technique. A wide substrate temperature range (from 150 to 720 K) was chosen to prepare the alloy films with significantly different atomic orders. The structural characterization of the alloy films has been performed by using x-ray diffraction and transmission electron microscopy. The resistivity was measured in a temperature range from 4.2 to 400 K by employing a four-probe method. Temperature dependence of the magnetic properties was investigated by using VSM and SQUID magnetometers in the 5 - 395 K temperature range. The magneto-optical (equatorial Kerr effect) and the optical properties were also investigated. It was found that the disordered alloy films are not ferromagnetically ordered. Annealing of the disordered films restores the ordered structure with an almost full recovery of the magnetic and transport properties of the ordered films. It was also found that the $Ni_2MnGa$ film deposited on a flexible mica substrate exhibit a clear martensitic transformation and a substantial magnetic anisotropy in the martensite phase. These results were further analyzed in connection with the theoretical electronic energy structures