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Extraordinary magnetic properties of ordered and disordered Co_2CrAl alloy films

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A significant number of intermetallic semi- and true-Heusler alloys (HAs) have been predicted theoretically to be half-metals, and their films might be used as spin injectors in spintronic devices. In this study, Co_2CrAl HA films with different structural orders were fabricated, and the magnetic properties were investigated and analyzed in connection with the electronic energy structures of the films. Co_2CrAl alloy films of about 100 nm in thickness with different degrees of structural order were prepared by flash evaporation onto a glass in a high vacuum. The evaporation onto substrates at different temperatures T_s ($293 < T_s < 723$ K) and various post-annealings at $293 < T_a < 770$ K were performed to manipulate the structural order in Co_2CrAl films. The magnetic properties of films were investigated by using a SQUID magnetometer. It was found that the ordered Co_2CrAl films were ferromagnetically ordered with a Curie temperature close to that of the bulk sample. The structural disorder causes a reduction of the saturation magnetization and a decrease in the Curie temperature. The field- cooled magnetization of ordered film is of a typical ferromagnetic material, while interestingly the measured temperature dependence of zero-field-cooled magnetization exhibits a giant negative magnetization at low temperatures. The magnetization direction is flipped abruptly at a certain temperature upon heating. The flipping temperature strongly depends on the field strength. These results are further analyzed in connection with the theoretical calculations of electronic energy structures.