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Investigation of the transport properties of Co2Ti(1−x)Cr(x)Al (x = 0, 0.25, 0.5, 0.75, 1) Heusler compounds

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The discovery of half-metallic property in the ferromagnetic compound Co₂MnZ (Z = Al, Sn) by Ishida et al. [1] and Kübler et al. [2] has prompted an extensive search for new Co₂YZ materials that exhibit the half-metallic ferromagnetic (HMF) property. Half-metallic ferromagnets are characterized by the presence of a gap at the Fermi energy (E_F) of the minority band of the electronic density of state (DOS) [1,2]. The presence of such a gap is expected to reveal exotic and unique transport properties [1,2]. Furthermore, half-metallic ferromagnetic materials are promising candidates for the development of spintronic storage devices with increased data processing speed and decreased electric power consumption.

In the present study, the transport properties of half-metallic ferromagnetic (HMF) Heusler compounds, Co₂Ti<sub>(1−x<
(x = 0, 0.25, 0.50, 0.75, 1), are investigated using temperature dependent of zero-field resistivity, ρ(T). The bulk Co₂Ti_(1−x)Cr_(x)Al (x = 0, 0.25, 0.50, 0.75, 1) samples were synthesized using the arc melting technique. It has been observed that the zero-field ρ(T) for Co₂Ti_(1−x)Cr_(x)Al for x = 0, x = 0.25, x = 0.50 and x = 0.75 decreases linearly with decreasing temperature, indicating metallic behaviour. Below 100 K, ρ(T) deviates from the high-temperature linear behaviour, indicating the different scattering mechanisms present at various temperatures. The linear behaviour (ρ ∝ T) at high temperature is attributed to the scattering of electrons from phonons (ρ_{e-ph}). The behaviour of ρ(T) below 100 K originates from electron-magnon scattering (ρ_{e-mag}) and electron-electron scattering (ρ_{e-e}). Due to the half-metallic nature of these compounds, the low-temperature behaviour is found to follow a T^{9/2} behaviour, indicating the presence of a gap in the density of states (DOS) at the Fermi level (E_F) for the minority states. Moreover, the residual resistivity (ρ₀) increases with increasing x from 0 to 0.5 followed by a decrease for x = 0.75, which is attributed to an increase in atomic disorder with increasing x. ρ(T) for Co₂CrAl decreases with increasing temperature, demonstrating semiconducting-like behaviour. The origin of the semiconducting-like behaviour arises from the presence atomic disorder which results in the localization of conduction electrons and the presence of a band gap in the DOS for the minority state. The presence of a band gap in the minority states was confirmed from the electronic band structure and electronic DOS calculations.

References
[1] S. Ishida, Y. Kubo, J. Ishida, and S. Asano. J. Phys. Soc. Jpn. 48 (1980) 814.
[2] J. Kübler, A. R. William, and C. B. Sommers, Phys. Rev. B 28 (1983) 1745.

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