Magnetic susceptibility studies of the \((\text{Cr}_{84}\text{Re}_{16})_{100-x}\text{V}_x\) alloy system

BS Jacobs,\(^1\) ARE Prinsloo,\(^1\) and CJ Sheppard\(^1\)

\(^1\)Cr Research Group, Department of Physics, University of Johannesburg, Auckland Park, Johannesburg 2006, South Africa

The temperature dependence of magnetic susceptibility, \(\chi(T)\) is a suitable measurement in determining the magnetic ordering temperature, obtaining information regarding density of states \([1]\), as well as to detect the presence of localised moments \([2]\). In accordance with previous studies on \(\text{Cr}_{100-u}\text{Re}_u\) alloys \([3]\), \(\chi(T)\) measurements of the \((\text{Cr}_{84}\text{Re}_{16})_{100-x}\text{V}_x\) alloy system exhibit anomalies at Néel temperature \(T_N\) associated with the onset of the antiferromagnetic (AF) spin-density-wave (SDW) state. These anomalies become more pronounced as \(x\) increases. \(T_N\) determined from \(\chi(T)\) measurements are in close agreement with \(T_N\) obtained from the measurement of temperature dependence of electrical resistivity, \(\rho(T)\). Prominent broad deep minima are observed in \(\chi(T)\) upon cooling below 100 K followed by low temperature upturns for samples with \(x = 10.9\) and \(x = 12.4\) which may be attributed to a Curie tail arising from oxide impurities \([4]\). A second anomaly, not associated with \(T_N\), but having the same trend, is observed at a temperature \(T_o < T_N\) for alloys with \(x = 0, 1.3, 2.4, 4.4, 5.7\) and 6.9. \(T_o\) observed in the \(x = 0\) alloy has value 309 ± 2 K which is very close to 308 K, the transition temperature of AF \(\text{Cr}_2\text{O}_3\) \([5]\). The presence of \(\text{Cr}_2\text{O}_3\) was confirmed using neutron diffraction study of the \(\text{Cr}_{84.7}\text{Re}_{15.3}\) alloy \([6]\). However, the value of \(T_o\) obtained from \(\chi(T)\) decreases with an increase in \(x\) indicating that the oxide is most likely a V doped oxide of Cr having the formula \((\text{Cr}_{100-\delta}\text{V}_\delta)_2\text{O}_3\). \(x\) dependence of \(T_N\) obtained from \(\rho(T)\) and \(\chi(T)\) measurements were fitted with a power law yielding \(x_c = 10.47 ± 0.03\), the critical concentration at which antiferromagnetism (AFM) disappears. It is therefore evident that the low temperature upturns for samples with \(x = 10.9\) and \(x = 12.4\) is associated with the \((\text{Cr}_{100-\delta}\text{V}_\delta)_2\text{O}_3\) oxide. Curie-Weiss (CW) behaviour in the \((\text{Cr}_{84}\text{Re}_{16})_{100-x}\text{V}_x\) alloy system was tested by plotting \(\chi^{-1}\) as a function of \(T\) and fitting the CW equation \([2]\) to the experimental data above \(T_N\). A positive gradient of the fit confirms CW behaviour \([7]\) which was observed in the \(x = 5.7, 10.4, 10.9\) and 12.4 alloys suggesting the existence of local moments at \(T > T_N\).

References: