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Scattering Studies of $CdCr_2Se_4$ Films

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Beamlines: X22C, X23B

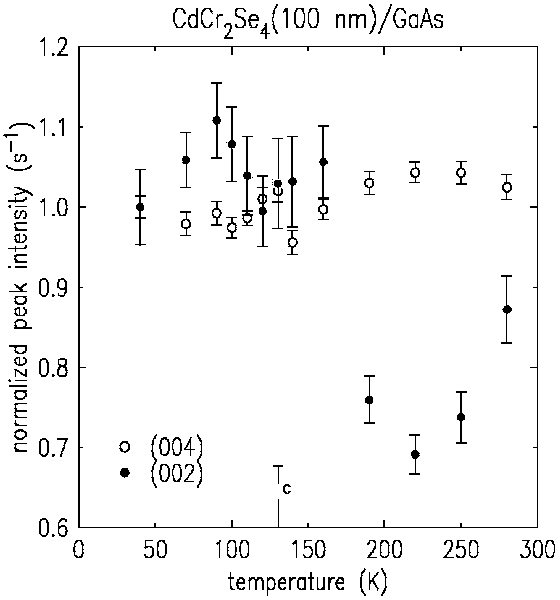
Chromium-based chalcogenide spinels have recently been the focus of attention due to colossal magnetoresistance exhibited near T_C, and semiconducting behavior both above and well below T_C.[1] The latter property has suggested the use of these materials as ferromagnetic semiconductors, which are of interest for future spintronic applications. $CdCr_2Se_4$ is an example of such a chromium-based chalcogenide spinel that has the additional attractive property that it can be doped to result in either n- or p-type behavior; and recently, epitaxial growth of $CdCr_2Se_4$—with the bulk T_C of 130 K—has been demonstrated on both GaAs and GaP substrates.[2]

Bulk $CdCr_2Se_4$ exhibits a cubic spinel structure with *Fd3m* symmetry, with the Cd/Cr ions sitting at tetrahedral/octahedral sites. Slight lattice distortions and site disorder, which may result in valence disorder, have been proposed, and are believed to play an important role with regard to the behavior exhibited by this material.[2] In films, the presence of a lattice mismatch between the film and substrate may alter the lattice distortion, while the growth technique could affect the amount of site disorder. Therefore in order to investigate these properties, we carried out scattering studies of two epitaxial films on beamlines X22C and X23B.

The 100 nm thick films were grown using molecular beam epitaxy on GaAs substrates with two different surface preparations: oxide desorbed and an epitaxially-prepared n^+-GaAs buffer. Both films are observed to be (001)-oriented, with room temperature lattice constants less than 0.1% smaller than the bulk value. Nominally forbidden peaks with an (002) wavevector were observed in both films, and an example of the peak intensity as a function of temperature is shown below. Note that while the (004) Bragg peak intensity remains nearly constant as a function of temperature, the forbidden (002) peak intensity clearly decreases at temperatures between 160 and 190 K. This change is not correlated to the magnetic ordering, though, which sets in at ~130 K. Resonant scattering was next utilized in an attempt to measure the amount of site disorder, but due to the different crystallographic symmetry exhibited by the films (as opposed to bulk), we were unable to obtain a quantitative result. Future experiments to determine the crystallographic symmetry would aid in this effort and thereby reveal any connection that may exist between the presence of site disorder and the intriguing properties exhibited by $CdCr_2Se_4$.

References

[1]A.P. Ramirez, R.J. Cava, and J. Krajewski, *Nature* **386**, 156 (1997).
[2]Y.D. Park, A.T. Hanbicki, J.E. Mattson, and B.T. Jonker, *Appl. Phys. Lett.* **81**, 1471 (2002).



The (004) Bragg and nominally forbidden (002) peak intensities—normalized to equal 1 at 40 K—as a function of temperature. T_C indicates the Curie temperature of the film.