# Ferromagnetism in Tetragonal-Distorted Chromium

Wuwei Feng, Dang Duc Dung and Sunglae Cho
Department of Physics, University of Ulsan, Ulsan 680-749, Republic of Korea

The *3d* transition metals are of great importance in the study on magnetism and magnetic materials. Thin film growth of these materials on semiconductor substrates have proven to be very important both for the potential application in spintronics and for the fundamental research due to the fact that thin films with reduced dimensions or altered structures grown on different substrates may exhibit greatly changed magnetic properties compared to bulk materials. Significant progresses have been made during the last decades. For example, the bcc Co that does not occur in nature and the fcc Mn that exists only at high temperature were obtained by the epitaxial growth on GaAs substrate. To modify the lattice constant of a low-dimensional structure, the most common approach is to epitaxially stabilize a thin film using a suitable substrate. Unfortunately, the allowable modification of the lattice parameter is limited by the epitaxial strain relaxation and is rarely sufficient to form new magnetic phases. One interesting exception is that the antiferromagnet of bcc α-Mn could demonstrate ferromagnetic (FM) ordering when stabilized on GaAs substrate.

Chromium is a *3d* transition metal showing the unique spin density wave antiferromagnetism with a small magnetic moment in the bulk that was normally observed. However, the very large moment (~5 $\mu_B$) in its atomic form suggests that peculiar magnetic effects might be observed in the low-dimensional Cr layers. The ferromagnetism of Cr has been predicted in the metallic overlayers and interfaces [5] and in the hexagonal close packed (hcp) structure. Especially the chromium was predicted to undergo a first-order transition from nonmagnetic to magnetic behavior at expanded atomic volumes. Several groups attempted to prepare metastable Cr films on various substrates, including Ru (0001), Au (100), Cu (100), Ag (100), Pt (111), Co (0001) and GaAs (100). However, scarce information about the magnetic properties was reported in addition to the observation of a weak FM ordering in hcp chromium in Cr/Ru (0001) superlattices.

Here we report on the first experimental observation of ferromagnetic ordering in the tetragonal-distorted α-Cr phase based on the magnetic-field dependent anomalous Hall effect and corroborated by the magnetization hysteresis. This observation was ascribed to the expansion of out-of-plane lattice parameter of α-Cr phase due to the low-dimensional connection to the matrix of δ-Cr crystal lattice which suffered large compressive lattice-mismatch strain from the substrate under two-dimensional growth. In addition, our study demonstrated the specific Cr phase evolution dependent on the growth temperature. The low composition of α-phase in the Cr film resulted in the weak ferromagnetic moment for the Cr film on a macroscopic scale.