# Nanomagnetism of $Cr_2O_3$ investigated using parabolic diamond pillars

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**Abstract:** Thin-film antiferromagnets are key contenders in the development of spintronic devices. We investigate one such material, $Cr_2O_3$ using nitrogen vacancy scanning magnetometry and present quantitative magnetic field maps showing the structure and nucleation of domain walls over the paramagnet to antiferromagnet transition, allowing us to extract critical material properties.

Antiferromagnetic (AF) thin-films have emerged as a promising platform for realizing smaller and faster spintronic devices, and in particular, magnetoelectric antiferromagnets are promising materials for such applications as their order parameter can be switched electrically [1]. However, compared to bulk materials, thin-films exhibit significant domain wall pinning due to granularity, which can only be explained by surface effects. Investigation of these granular contributions, such as the intergranular exchange coupling and other crucial material properties can best be achieved by high resolution and high sensitivity measurements. These requirements can be met by nitrogen vacancy (NV) magnetometry, which is well suited for nanoscale measurements of the weak stray fields emerging from the non-zero surface magnetization of magnetoelectric antiferromagnets [2].

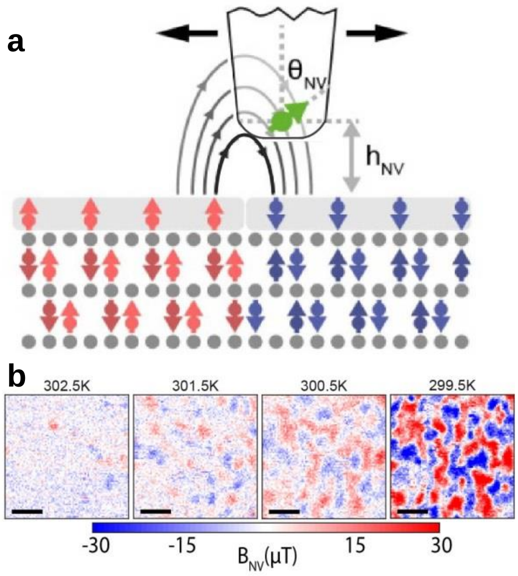


Figure 1. **a**) The parabolic diamond scanning probes containing an NV are sensitive to the stray magnetic fields from uncompensated spins at the $Cr_2O_3$ surface, with the spin structure shown by red and blue arrows. **b)** Quantitative magnetic field maps show the progression from paramagnetic (left) to antiferromagnetic (right) as the sample is cooled (scale bar is 500 nm).

Here we present the results of a quantitative study of the AF ordering of 200 nm, granular thin films of $Cr_2O_3$, carried out using NV magnetometry with all-diamond parabolic reflector scanning probes and zero offset Hall magnetometry (ZOHM). $Cr_2O_3$ is of particular interest due to its room-temperature ordering. We observe the formation of such domain structures across the phase transition between paramagnetic and antiferromagnetic phases (see Figure 1), allowing us to measure key material properties such as the boundary magnetization. We furthermore extract information regarding the intergranular exchange coupling as well as the distribution of critical temperatures [3]. We also shortly present the improved optical properties of the parabolic scanning probes, which allow us to realize a sensitivity of < 1uT/√Hz and spatial resolution of under 40 nm.

**References**


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