Sensitive scanning probe microscopy performed in an ultra-low vibration closed-cycle cryostat down to 1.5 K

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We report on state-of-the-art scanning probe microscopy measurements performed in a pulse tube based top-loading closed-cycle cryostat with base temperatures down to 1.5K and a 9T magnet [1]. We introduced measures to reduce the level of mechanical and acoustic noise coupling into the system to enable scanning probe experiments. To demonstrate the extremely low vibration amplitudes in our system, we successfully imaged the 0.39 nm lattice steps on single crystalline $SrTiO_3$, as well as magnetic vortices in a high-Tc superconductor ($Bi_2Sr_2CaCu_2O_{8+x}$). Fine control over sample temperature and applied magnetic field further allowed us to probe the helimagnetic and the skyrmion-lattice phases in $Fe_{0.5}Co_{0.5}Si$ with unprecedented signal-to-noise ratio of 20:1 (see Fig. 1). Finally, Piezo-response Force Microscopy (PFM) was demonstrated on a thin film of BFO in a read and write experiment at low temperatures, as well as on $TmFe_2O_4$ at 100 K as a function of magnetic field (+/-9 T).

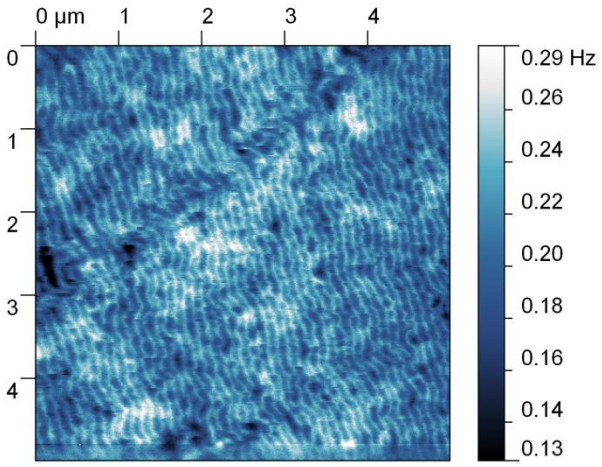

Figure 1. Large range MFM scan at low temperature of $Fe_{0.5}Co_{0.5}Si$. The helimagnetic structure is clearly visible as a stripe pattern with a periodicity of approx. 100 nm. This is in good agreement with the expected value (raw, unfiltered data).

References

[1] F.P. Quacquarelli, J. Puebla, T. Scheler, D. Andres, C. Bödefeld, B. Sipos, C. Dal Savio, A. Bauer, C. Pfleiderer, A. Erb, and K. Karrai, arXiv:1404.2046v1 (2014).