**Probing local order in multiferroic thin films by (scanning) transmission electron microscopy**

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Multiferroic materials that exhibit simultaneous and strongly coupled magnetic and ferroelectric order above room temperature offer exciting potential for room-temperature device integration. Thus, magnetoelectric multiferroic films are ideal candidates for applications in next-generation memory devices which utilize low consuming electric fields to control magnetic order. However, due to competing requirements for displacive ferroelectricity and magnetism, only a hand-full of single-phase materials displaying multiferroic properties above room temperature are known. Most multiferroics are not suitable for practical applications either because they exhibit antiferromagnetic or weak ferromagnetic alignments, small spontaneous polarization, week coupling between the order parameters, or because their properties only emerge at extremely low temperatures. Therefore, much effort is devoted to search new single-phase multiferroic materials that exhibit high ordering temperatures. On top, the multiferroic domain structures and structural defects present in these materials are considered to be an important factor affecting the efficiency and performance of future multiferroic devices. For that reason, a major challenge is their investigation at the atomic scale. Recent advances in aberration-corrected (scanning) transmission electron microscopy (S/TEM) as well as in microelectromechanical (MEMS) technology for miniaturized TEM specimen holders have opened up a wide range of new opportunities for in-situ studies. Thus, probing ferroelectric domain dynamics at atomic resolution by means of in-situ heating/electrical biasing TEM is now feasible thanks to the better spatial and temporal resolution of in-situ TEM.

In this talk, I will show recent progress in the field of investigation of ferroic order in thin films by state-of-the-art aberration-corrected S/TEM. To that end, different examples of BiFeO3 based multiferroic systems will be addressed. Additionally, the improper ferroelectric phase transition in the hexagonal YMnO3 perovskite will be presented.