Nanoscale Phase Separation in Two-dimensional Layers in the Limit of a Few Unit Cells Controlling Material Functionalities Unveiled by Scanning Submicron XRD

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The emergent functionalities in two-dimensional layers in the limit of a few unit cells is becoming a hot topic both for fundamental new low energy physics and for new exciting applications. Novel heterostructures at atomic limit show unconventional ferroelectrics, magnetic and superconducting properties which can be tuned by strain and photo-induced effects. Recent breakthroughs have led to intense research into these ferroelectrics and more generally ferroic materials. Understanding the ferroelectric properties of such engineered thin film systems requires taking into account the interfaces with electrodes, substrates, or atmosphere[1], the use of piezo-effets allows nanoscale domain writing[2,3] and strain engineering allows significantly change values of remnant polarization, coercive field, or the Curie temperature.[4,5] The scientific interest is now focusing to networks where superconducting, magnetic and ferro-electric nano-domains compete. New materials made of atomic layers intercalated by different atomic layers show nanoscale phase separation with co-existence of ferroelectric, magnetic and superconducting phases, where defects, and strain tune the material functionality. We have addressed our interest to develop a new method to get the spatial imaging of the fluctuating order in the k-space: scanning micro x-ray diffraction (SmXRD) [6-11] in these multi-phase materials. We have developed statistical methods of data analysis of SmXRD to get new information on the statistical physics of the complex nanoscale phase separation taking place in these novel functional materials[6-11]. Using SmXRD we have shown that statistical physics of the spatial distribution of the grains controls the material functionality, in the case of unconventional granular superconductors with the key role of percolation.

References

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