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Combinatorial thin film methodology for rapid investigation of composition-structure-property relationship in complex multifunctional materials

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We have developed thin film composition spread techniques to map compositional phase diagrams of multicomponent functional materials. Various combinatorial thin film deposition techniques including pulsed laser deposition, co-sputtering, and electron-beam deposition are used to fabricate binary and ternary composition spreads of metal oxide systems and metallic alloy systems. A variety of rapid characterization tools are employed to track physical properties of the materials as a function of sweeping composition changes. They include scanning SQUID microscopy, scanning microwave microscopy, and x-ray microdiffraction. High-throughput mapping of phase diagrams allow identification of new compounds as well as rapid delineation of composition-structure-property relationships. One of our emphases in these studies is to systematically look for structural phase transitions/boundaries in phase diagrams since these regions often display onset or peaking of ferroic properties such as ferroelectricity and magnetism. Mapping these active physical properties as a function of composition is an integral part of understanding the underlying physical mechanisms of the properties. To date, we have applied our methodology to investigation of a number of multifunctional materials including ferromagnetic shape memory alloys and magnetoelectric materials. We have demonstrated the utility of composition spreads as compact integrated devices where continuously changing physical parameters are used as a basis for functionally broadband detector arrays. The role of informatics in the high-throughput experimentation will also be discussed.