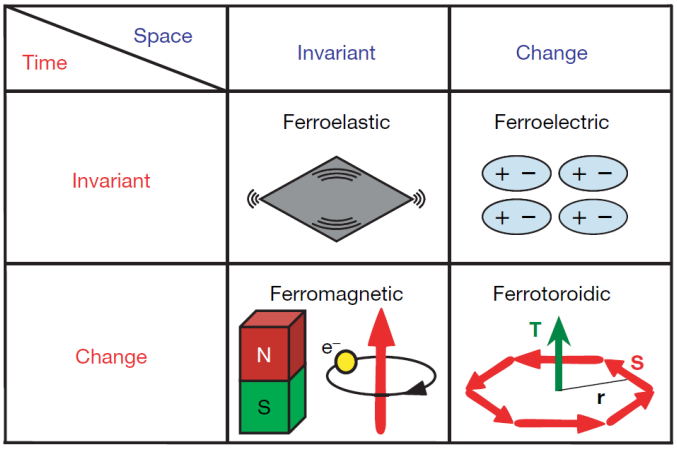
Ferroics: fundamental aspects and applications

Ferroics are generally described as materials presenting at least one intrinsic long range property such as magnetization, electric polarization or deformation. This class of materials includes semiconductors, metals, polymers, and insulators. Among them, ferroic oxides have the particularity of being strongly dependent on oxygen bonding and stoichiometry, playing a major role in the stabilization of (anti)ferroic ground states through different cationic-oxygen interactions within the material unit cells, and at the different interfaces, grain boundaries or surfaces. Oxygen is also at the origin of the ferroic properties of these materials, being able to control the bonding with the neighboring cations from purely ionic to covalent, or to drive the electronic conduction, *i.e.* through the creation of oxygen vacancies. Moreover, the properties of ferroic oxides are also characterized by the existence of spatially determined regions, called domains, where the ferroic order parameter is homogenous. The transitions mediating the change in the order parameter from one domain to another constitute the domain walls (DWs). DWs are rather inhomogeneous, have lower symmetry than domains, and introduce gradient property effects (charge trapping, chemical inhomogeneities, flexoelectricity, …). Thus, unexpected physical properties arising from the DWs can also be observed. It is in this rich landscape that multidisciplinary and multiscale know-how's and techniques are joined together, from material growth/thin film technology to nano/micro-characterization tools and calculations, all of them being needed to reach a full understanding and control of the synthesis – structure – properties relationship, finally leading to propose means to exploit them in applications, like sensors, memories, or spintronic devices. In addition, the coupling between their properties in multiferroics provides new avenues for understanding and engineering functionality in devices, as well as enhancing material properties.



Ferroic materials, from B. B. Van Aken *et al.*, Nature 449, 702 (2007)

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