# Materials Science :


*"What is not fully understood is not possessed."*
*by Johann Wolfgang von Goethe*

To control the properties/functions of a material, visualization of key structural characteristics is crucial. In 2013, outstanding research unveiled structures related to phase changes (by Yamada *et al.*), superconductivity (by Fujihisa *et al.*), antiferroelectricity (by Vakhrushev *et al.*), chirality (by Ohsumi *et al.*), proton conductivity (by Kitagawa *et al.*), and drug delivery (by Sakurai *et al.*).

Controlling the phase of matter is essential approach to create novel properties/functions in materials science. Phase change (PC) materials are widely used as optical storage media, and have been intensively studied for larger capacities and higher recording rates. Based on the in situ micro-diffraction technique, Yamada *et al.* successfully revealed the rapid crystallization of $Ge_{10}Sb_{90}$ nanodots with a 50-nm diameter, which have potential for next-generation optical storage media. The appearance of a superconducting phase in an element has yet to be demonstrated. Fujihisa *et al.* investigated X-ray diffraction under a high pressure of 241 GPa for phase VII calcium, which shows the highest $T_c$ among all the elements (29 K at 216 GPa), and found a complex host-guest structure with two kinds of guest Ca chains.

# Structure

Symmetry breaking is one way to create functions. An intriguing antiferroelectric transition of $PbZrO_3$ has been suggested to occur by an antiparallel shift of lead ions with the tilt of an oxygen octahedron, but its mechanism remains controversial. Vakhrushev *et al.* found that the phase transition originates from flexoelectric coupling between the transverse acoustic (TA) and transverse optical (TO) modes by means of high-resolution inelastic scattering measurements. Chirality, which is a typical example of symmetry breaking, plays an important role in biological activity, optical properties etc. However, identification and control of chiral-domains in crystals are quite difficult. Ohsumi *et al.* successfully visualized the three-dimensional distribution of the chiral domain in a racemic mixed crystal of $CsCuCl_3$ by scanning scattering measurements using circularly polarized X-rays.

In many fields, self-assembly is common for sophisticated structure/function control. Metal-organic frameworks (MOFs), whose structure can be precisely controlled by chemical design, have offered a wide range of applications, such as gas-sorption, catalytic reaction and proton conductivity. Kitagawa *et al.* found an unusually high proton-conductivity on the surface of a highly oriented MOF nanosheet, whose structure can be characterized only by high brilliance synchrotron X-ray diffraction. To develop a drug delivery system (DDS), the design of complexes for drug and delivery carriers and characterization of these complexes are quite important. Sakurai *et al.* fabricated self-assembled DDS nanoparticles, and successfully constructed a structural model based on the results of anomalous small-angle scattering (ASAXS) and light scattering.

All the highlighted research papers in "Materials Science I: Structure" in 2013 deal with key structural characterizations for novel properties and functions. This trend suggests the importance of synergic development of synthesis/growth of matter and characterization using synchrotron radiation to create new functions.

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