Visualiza
tion of polar domains in a ferroelectric organic conductor
by nonlinear optical interferometry

To explore the possibility of finding innovative new ferroelectrics, researchers have begun to focus on an unconventional class of polar materials, in which electric polarization arises from a non-centrosymmetric distribution of valence electrons with respect to the underlying lattice of the ion cores.

Yamamoto et al. have performed direct observation of polar domains in the organic conductor α-(BEDT-TTF)$_2$I$_3$ [BEDT-TTF: bis(ethylene-dithio)tetrathiafulvalene], which is recognized as a potential candidate for such an electron-associated ferroelectric compound. This organic conductor exhibits strong optical second-harmonic (SH) generation, which is considered to be an unambiguous indication of spontaneous polarization, in the charge-ordered phase at low temperatures. Yamamoto et al. performed two-dimensional scanning measurements of optical interference between excitation light and SH light to observe the phase difference of SH waves emanating from different polar domains, using a tandem arrangement of a multi-domain sample and a single-domain nonlinear optical crystal, as illustrated in Fig. 1.

Figure 2a shows a transmission image of a thin crystal of α-(BEDT-TTF)$_2$I$_3$ and Fig. 2b shows the SH image obtained from the region indicated in Fig. 2a. The SH image contains bright and dark regions due to optical interference. The clear contrast reveals the ferroelectric domain structure. Although no poling treatments were performed on the sample, very large domains, several hundred microns in size, were found to develop spontaneously. This indicates a strong tendency toward single domain growth in this ferroelectric compound.

This ability to distinguish different polarizations demonstrated by the study can offer us visual access to the macroscopic properties of unconventional ferroelectric matter. It should be stressed that the presence of such large domains is highly advantageous for experimental evaluation of the electric polarization and associated physical parameters. As a result of these characteristics, this organic compound is expected to play an essential role in the fundamental understanding of the nature of unconventional ferroelectrics polarized by electrons.