

## Shrinkage and regrowth of magnetic domains in Sr<sub>2</sub>IrO<sub>4</sub>

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We investigated how the long-range antiferromagnetic (AFM) state of Sr<sub>2</sub>IrO<sub>4</sub> organizes itself in space and time following its electronic demagnetization driven by an ultrafast laser. We showed by ultrafast pump-probe resonant coherent X-ray imaging that domains shrink and regrow in the same location every time. Below its ordering phase transition at T=230 K, Sr<sub>2</sub>IrO<sub>4</sub> is AFM, reported to have a tetragonal structure. The AFM structure breaks the 4-fold symmetry leading to 90° magnetic twin domains with a slight orthorhombic distortion. We carried out ultrafast magnetic Bragg Coherent Diffraction Imaging (BCDI) experiments at the MID instrument of the European X-ray Free Electron Laser (XFEL) facility. The 106 magnetic reflection of a high-quality single crystal sample of Sr<sub>2</sub>IrO<sub>4</sub> was aligned at 100 K and 11.215 keV, just below the Ir L<sub>3</sub> absorption edge, using XFEL self-seeding. Real space images, obtained by inversion of the BCDI diffraction patterns, revealed an array of antiphase domains, about 1 micron in size, which shrank and grew again in response to a 50 fs laser pulse of 15 mJ/cm<sup>2</sup>. The non-random domain nucleation observed suggests some strain-related pinning may be present. Static domain structures in the critical scattering associated with phase transitions have been reported previously.