geometries. We also studied the CDW properties in ring-shaped crystals. In this case, the "mixed state" of CDW analogous to that in type-II superconductors is expected which may show quite different electric response from ordinary CDW state. We also comment on some crystal properties of these "topological crystals".

Keywords: superconductivity, charge density waves, topology

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Relaxation of geometrical frustration in $NbSe_3$ topological crystals

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Geometrical frustration in a curved crystal is examined through syncrotron X-ray diffraction experiments. Also its effects on the material's charge-density-wave (CDW) ordering are discussed. We performed diffraction measurements on individual $NbSe_3$ topological crystals, which are μm-scale crystals characterized by their multiconnected topologies. Our samples inclede rings, a Mobius strip and 2π-twisted strips. Their volume-avaraged strain turned out unexpectedly low for such highly deformed crystals, while strain distribution is as broad as >0.01. These features are common to all samples, regardless of their apparent size nor deformation. On the contrary, CDW transition temperatures in crystals with a twist exhibit substantial reduction of a few K, while those without twists showed much less reduction. Also, we have an indication of dimensional crossover in the behavior of pre transition fructuations between twisted and untwisted samples. We analyzed elastic free energy of topological crystals. A structural model, in whichthe crystal lattice forms a spiral, best accounts for the measured distribution of lattice strain. According to our model, geometrical frustration due to curvature brings fragmentation of coherent region of atomic arrangements. As a result, enhanced low-dimensionality modifies transition temperatures and pre-transition fluctuations of CDW, in accordance with the transport study.

Keywords: charge density waves, diffraction synchrotron radiation microcrystals, crystal morphology

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Polyhedral topological-crystals in TaS_3

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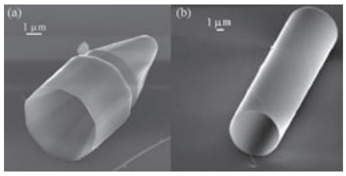
We produced micrometer-scale polyhedral ring-crystals of TaS_3, which are synthesized by chemical vapor transportation method. Topological crystals of MX_3 ($NbSe_3$, TaS_3 et al), known as ring and Moebius shaped, is already known since 2000 but angularity of ring-crystal is freshly discovered in TaS_3. The crystals are investigated by electron backscatter diffraction pattern technique and it is revealed that the orientation change abruptly along the circumference. The difference between usual and polyhedral ring-crystals is the arrangement of edge dislocations. Dislocations cause attraction and repulsion by the distance between them. The corner of polyhedral crystal is made by the concentrated dislocations because of attractive interaction between dislocations. Figure (a) shows polyhedral ring-crystals as a result of attractive interaction and (b) shows ring crystals as a result of repulsive interaction. In fabricated various crystals, we insist that these structures are classified by the radius and the thickness.



Keywords: topology, polyhedra, incommensurate structures

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New class of topological crystals: Hopf link of crystals

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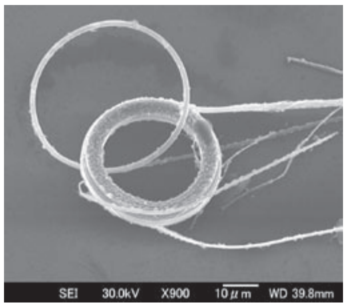
Exotic topological crystals, such as ring-shaped crystals, Mobius strips of crystals, and figure-8 (2π-twisted strip) crystals, have been successfully created in $NbSe_3$ despite their inherent crystal rigidity by Hokkaido University group [1]. Recently, we discovered new topological crystals of $TaSe_3$, which are two ring-shaped crystals linked to each other exactly at once [2]. Since the rings are topologically linked, they cannot be removed without cutting of chemical bonding. The topology of the crystal form is called a "Hopf link", which is the simplest link involving just two component unknots linked together exactly once. Crystallography including the topological crystals has provided rich interesting problems involving their growth mechanism, frustration of defect creations and bending and twisting, topological classification of crystals using concept of manifold embedding and analogous between crystals and general theory of relativity.



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Keywords: topological crystals, Hopf link, catenane