quasicrystal is crystallographic, it is assumed that **w** transforms as a vector in the plane perpendicular to the direction in which the crystal is periodic, but differently if the point group is 5-, 8-, 10- or 12-gonal. From the Neumann principle follow restrictions on the form of the phonon, phason and phonon-phason coupling contributions to the elastic stiffness matrix that can be determined by combining the restrictions obtained for a set of elements generating the point group of interest. For the phonon part, the restrictions obtained for the generating elements do not depend on the system to which the point group belongs. This remains true for the phason and coupling parts in the case of crystallographic point groups but, in general, breaks down for the non-crystallographic ones. The form of the symmetric 12 x 12 matrix giving the phonon, phason and phonon-phason coupling contributions to the elastic stiffness is presented in graphic notation.

Keywords: quasicrystals, elastic properties, piezoelectricity

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Successive phase transition of a Cd-Yb 1/1 crystalline approximant under high pressure

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The phase study of a Cd-Yb 1/1 approximant crystal over a wide pressure and temperature range is crucial for the comparison study between periodic and quasi-periodic crystals. Our previous X-ray diffraction study revealed that the Cd4 tetrahedra, the most inner part of the atomic clusters, exhibit various structural ordering in the orientation sensitive to pressure and temperature [1]. Five ordered phases appear in a P-T span up to 5.2 GPa and down to 10K. In this study we surveyed higher pressure region up to 30 GPa at room temperature. Single crystal diffraction experiments at SPring-8 (BL22XU) using a helium pressure medium in a diamond anvil cell elucidated that the crystal undergoes successive structural phase transition with an alternation of the period. The bcc phase at ambient pressure transformed to a 3-fold ordered phase at about 12 GPa, and to 4-fold one at about 20 GPa. These phases are different from those found at the previous study. These transitions would be induced by charge order at the Yb ion site, while those at the lower pressure region at low temperatures are dominated by the orientational ordering of the Cd4 tetrahedra.
[1] T. Watanuki et al, Phys. Rev. Lett. 96 105702 (2006)

Keywords: quasicrystals, phase transitions in solids, high-pressure diffraction

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Aperiodic tiling structure with ten-fold symmetry in B-Ti-Ru rapidly solidified alloy

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We have been searching for decagonal quasicrystal (DQC) in B-Mg-Ru system, where stable or metastable DQC is predicted to exist by Michalcovic and Widom [1]. Four new approximant crystals have been discovered to form stably at a high temperature [2]. All the structure models can be described with tessellation of two subunits Boat and Hexagon. No QC has yet been discovered in B-Mg-Ru system. Rather higher temperature or rapid quenching would be needed. B-Mg-Ru alloy cannot be melted at normal pressures, so that Mg was replaced with the other elements. More than two approximants formed in the annealed alloys. The alloys prepared by arc melting were melt-quenched by copper single roll. A structure very similar to DQC was observed in some of the samples. The EDP shows ten fold symmetry and the scaling rule of the golden ratio. Diffraction spots are broad and the density of spots is less than that of well-ordered DQCs. The HAADF-STEM images indicated the local structure to be described as tessellation of the subunits Hexagon, Boat and Star oriented in ten-fold direction. Clusters with decagonal framework about 1.4nm in diameter are predominant. The tiling is not domain of crystals like multiple twins but an aperiodic structure. Analysis in five demensional space indicates that the structure has no long-range translational order such as quasipiriodicity, but has long-range ten-fold bond orientational order to show ten-fold symmetry as a whole.
[1] M. Mihalkovic and M. Widom, Phys. Rev. Lett., 93, 095507 (2004)
[2] Y. Miyazaki, J. T. Okada and K. Kimura, Phil. Mag., 87, 2701 (2007)

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HRTEM observation of displacement fields around dislocations in quasicrystals

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Originating in the quasiperiodic translational order, quasicrystals have a special type of elastic degrees of freedom, termed as phason degrees of freedom. Dislocations in quasicrystals are generally accompanied by the phason displacement fields in addition to the conventional displacement fields[1]. According to a generalized elastic theory of quasicrystals, several groups have attempted to deduce analytical expressions of displacement fields around various types of dislocations in quasicrystals. In contrast, there have been no experimental studies of displacement fields around the quasicrystalline dislocations. In this study, we have observed the displacement fields by high-resolution transmission microscopy (HRTEM) and compared them with the theoretical displacement fields to examine the validity of the generalized elastic theory of quasicrystals. The effects of phason elastic constants on the displacement fields have been discussed and evaluation of their values has been attempted.
[1] For a review, see K. Edagawa and S. Takeuchi, ‘Dislocation in Solids’ ed.By F. R. N. Nabarro and J. P. Hirth (Elservier B. V. 2007), Chap.76, pp367

Keywords: quasicrystals, dislocations, TEM