Lattice-preferred-orientation of hcp metals studied by high-pressure deformation

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Plastic deformation of hexagonal-close-packed (hcp) iron is one of the candidate processes to form the anisotropy in the Earth's inner core. Knowledge of deformation-induced lattice preferred orientation (LPO) of hcp-iron is important for understanding of nature of the inner core. In this study, we have carried out shear deformation experiments on hcp-iron and its analogue materials, hcp-Co and hcp-Zn, and determined their deformation induced LPO.

Shear deformation experiments were carried out using a deformation-DIA apparatus at high-pressure and high-temperature. Experimental conditions were 14–18 GPa and 723 K for Fe, 3 GPa and 673 K for Co, and 2 GPa and 573 K for Zn. Development of LPO in the deforming sample was observed in-situ based on two-dimensional X-ray diffraction using monochromatized synchrotron X-ray. In shear deformation of Fe, <0001> and <11$\bar{2}$0> axes gradually aligned to be sub-parallel to shear plane normal and shear direction, respectively, from the initial random orientation. In the deformation experiments of Co and Zn, the <0001> was aligned to parallel to shear plane normal. The above results suggest basal slip <11$\bar{2}$0>{0001} is the dominant slip system in these hcp metals under the studied deformation conditions.

Earth's inner core has an axisymmetric anisotropy with P-wave traveling ~3% faster along polar paths than along equatorial directions. Theoretical studies consistently shows that P-wave velocity of hcp-iron is fastest along <0001> direction at least at low-temperatures. Our experimental results could be suggesting that most part of the inner core deforms with shear plane sub-parallel to equatorial plane.