



## Discovery of the Shape Controllable Cavity Surrounded by Facets in Ceramics

Hiroyuki Serizawa

Japan Atomic Energy Agency, 2-4 Shirane Shirakata, Tokai-mura, Naka-gun, Ibaraki 319-1195,  
Japan

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My investigation on cavities in ceramics was triggered by the unexpected discovery of a polyhedral cavity in a  $\text{UO}_2$  matrix. The SEM image that attracted my attention was a cavity observed in the fracture surface of a single crystal of  $\text{UO}_2$  that was heat-treated in helium at 90 MPa, followed by annealing at 1573 K for 1 h. It was clear that the cavity was a negative crystal that was formed by the precipitation of helium during heat treatment after Hot Isostatic Pressing (HIP) injection. In a series of experiments, I noticed that the shape of the negative crystal changes depending on the heat-treatment history. As can be seen in Fig. 1, a truncated octahedron-type, an octa-triacontahedron-type, and a pentacontahedron-type negative crystal were observed. Our study implies that the shape of the negative crystal should change depending on the helium inner pressure enclosed in the negative crystal. In general, it is difficult to control arbitrarily the shapes of these polyhedral negative crystals embedded in a solid medium; however, the shape can easily be controlled using the helium injection method. Our research team named the shape controlled negative crystal as image crystal. At this time, we discovered that three types of image crystals formed in  $\text{UO}_2$ . We conducted further research on the formation of image crystals in  $\text{CeO}_2$ . However, because of manufacturing difficulties, single-crystal  $\text{CeO}_2$  is not available. Consequently, we used a  $\text{CeO}_2$  thin film formed by epitaxial growth. Helium was injected as 130-keV  $\text{He}^{4+}$  ions from a 400-keV ion implanter. The helium-ion-doped film was heat treated at 1673 K for 2 h. The sample was cut into rectangular slices for transmission electron microscopy. We confirmed that nanosized image crystals had been formed in the matrix.

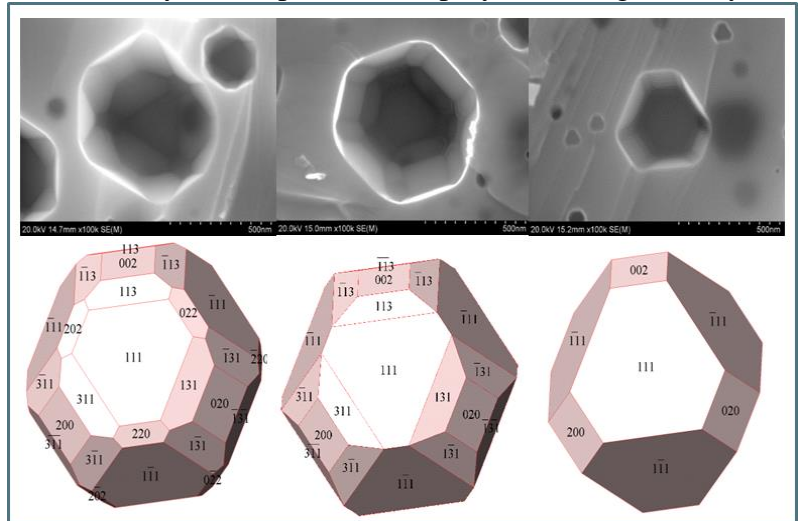


Figure.1 Negative crystal (wall faceted cavity) observed in  $\text{UO}_2$

**Keywords:** negative crystal; image crystal; facet; cavity; helium; polyhedron