



World's First Growth of Rutile-type GeO_2 Bulk Crystal by FZ method

31st October 2025

Patentix Inc.

Patentix Inc. has achieved the world's first growth of a Rutile-type Germanium Dioxide (r-GeO_2) bulk crystal using the Floating Zone (FZ) Method.

Background

Rutile-type Germanium Dioxide (r-GeO_2) is attracting attention as a next-generation semiconductor material crucial for realizing high-voltage, high-power, and high-efficiency power semiconductor devices. This is because r-GeO_2 possesses a bandgap of 4.68 eV, which is even larger than that of wide bandgap semiconductors like Silicon Carbide (SiC) and Gallium Nitride (GaN), and is theoretically predicted to allow control of both p-type and n-type conductivity.

To maximize the potential of r-GeO_2 , the realization of high-quality bulk substrates with minimal crystal defects is required. We (Patentix Inc.) have previously reported the synthesis of bulk crystals using the Flux Method, achieving a maximum size of approximately $15 \times 2.5 \times 2.5$ mm [1]. To realize power semiconductor devices using r-GeO_2 , higher quality and larger bulk crystals are necessary.

Results

Using the r-GeO_2 bulk crystal synthesized by the conventional Flux Method as a seed crystal, we succeeded in the world's first crystal growth of r-GeO_2 by the FZ Method. The black portion on the left side of the crystal shown in Figure 1 is the crystal grown by the FZ Method, achieving a size of approximately 5 mm. The grown crystal appears black due to incorporated additives, but facet planes (crystal planes) were observed on its side surfaces, suggesting high crystallinity. Evaluating the side facet plane by X-ray diffraction (XRD) confirmed that the facet planes correspond to the r-GeO_2 (110) plane (Figure 2). Furthermore, powdering the black grown portion and evaluating it by XRD confirmed the crystal peaks of r-GeO_2 . However, crystal peaks of trigonal-type GeO_2 were also confirmed, indicating that the grown crystal includes an impure phase different from the rutile type (Figure 3)

Future Work

We have achieved the world's first r-GeO_2 crystal growth using a seed crystal by the FZ Method. We will continue research and development aiming for further enlargement and higher quality of the crystal—especially the realization of bulk single crystals consisting only of Rutile-type GeO_2 —with the goal of realizing half-inch r-GeO_2 bulk substrates. Looking ahead, by utilizing half-inch r-GeO_2 bulk substrates and the Minimal Fab system [2], we aim to realize ultra-high-performance power devices that were impossible with conventional semiconductor materials



- [1] K. Kawanishi *et al.*, “Evaluation of physical properties of r-GeO₂ bulk crystals,” The 86th JSAP Autumn Meeting, (2025) 7a-N322-11.
- [2] Shiro Hara, *et al.*, “Concept of Minimal Fab and Development of Minimal Equipments,” Journal of the Japan Society for Precision Engineering Vol. 77, No. 3 (2011): pp. 249-253.

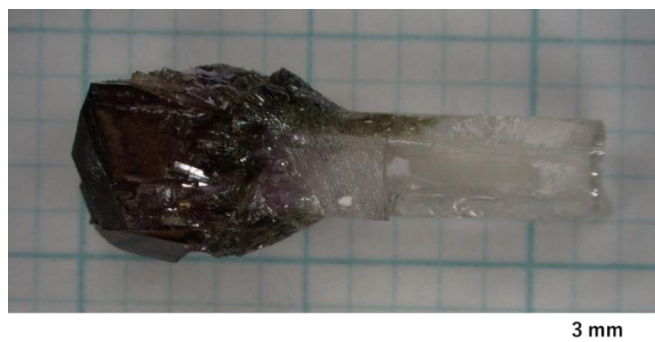


Figure 1: A photograph of the r-GeO₂ bulk crystal grown by the FZ Method. The black part on the left side is the crystal grown by the FZ Method; the white part on the right side is the seed crystal synthesized by the Flux Method.

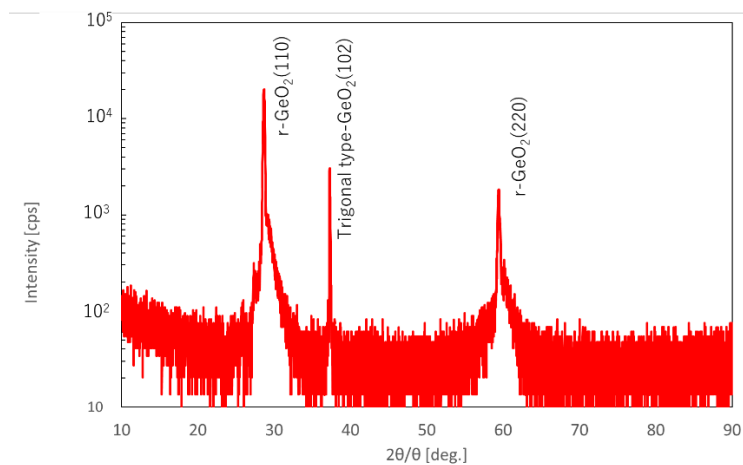


Figure 2: X-ray 2θ/θ diffraction profile of the facet plane.

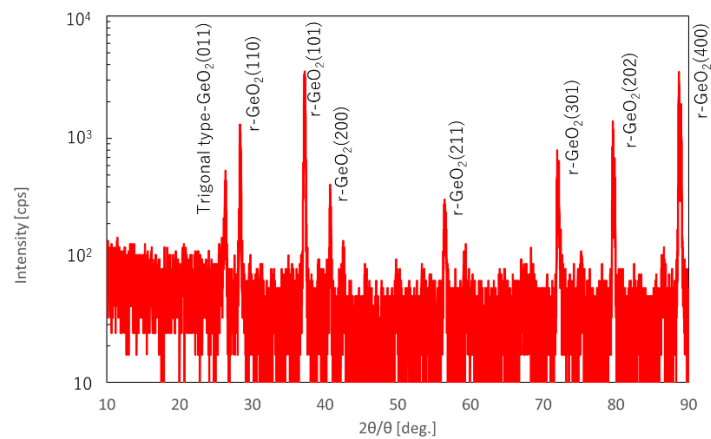


Figure 3: X-ray 2θ/θ diffraction profile of the powdered crystal.