Effect of oxygen concentration during growth on crystalline quality of β-Ga_2O_3 crystals grown by crucible free growth techniques

Isao Takahashi[1,2]*, Vladimir Kochurikhin[1], Takahiko Horiai[1,2], Taketoshi Tomida[1], Takamasa Sugawara[2], Kei Kamada[1,2], Koichi Kakimoto[2] and Akira Yoshikawa[1,2]
*takahashi_isao@c-and-a.jp
1 C&A corporation, Japan
2 Tohoku university, Japan

β-Ga_2O_3 is a promising wide bandgap semiconductor to realize low-loss and high-voltage power devices due to its superior physical properties. In particular, β-Ga_2O_3 can be grown from the melt, hence high growth rate, low production cost and high quality are practically achievable like for Si crystals. Previous researches succeeded to obtain enough good quality β-Ga_2O_3 crystals grown by Czochralski(Cz)[1], edge-defined film-fed growth(EFG)[2] and vertical Bridgman[3] techniques. However, these techniques are required to use a precious metal crucible such as Ir or Pt-Rh which causes higher production cost and limitation of oxygen concentration in growth atmosphere.

We originally developed skull melting techniques for low conductivity oxide materials and named Oxide Crystal growth from Cold Crucible (OCCC) method as shown in Fig. 1. In this method, Ga_2O_3 feedstock is charged in a water cooled copper basket. The feedstock is directly heated by high frequency field and melts from the center part. At the periphery area of the basket, the feedstock does not melt and works as “self-crucible”. Finally, a seed is touched on top followed by ingot growth like at conventional Cz method. This method enables to grow β-Ga_2O_3 crystals in the atmosphere up to 100% oxygen.

The effect of oxygen concentration during growth on etch pit density was investigated in Fig. 2. The β-Ga_2O_3 ingots were grown under 40 to 100% oxygen concentration by Floating zone method. As a result, etch pit density decreases with increasing of oxygen concentration. In particular, more than 60% of the oxygen concentration is very effective to reduce etch pit density for less than 10^4 cm^{-2}. The other properties are discussed in the presentation.

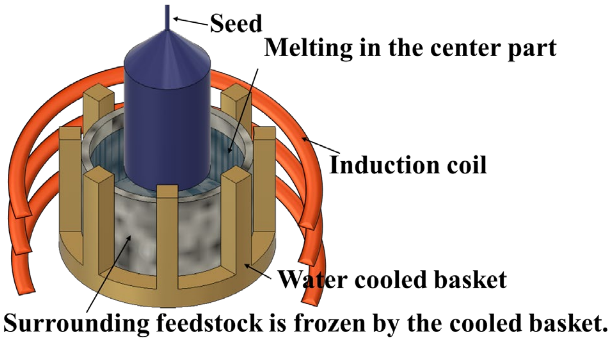

Fig. 1. Schematic diagram of OCCC method

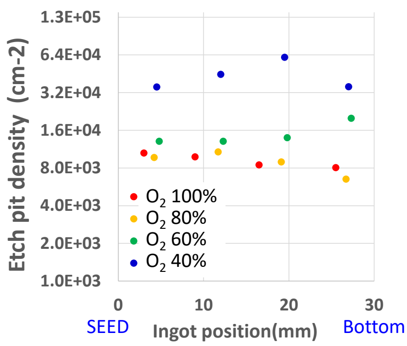

Fig. 2. Etch pit density of the crystals grown in various oxygen concentration

This paper is based on results obtained from a project, JPNP21005, subsidized by the New Energy and Industrial Technology Development Organization (NEDO).

References

[1]Galazka *et. al.*, “Scaling-Up of Bulk β-Ga2O3 Single Crystals by the Czochralski Method” ECS Journal of Solid State Science and Technology, **6** (2) Q3007-Q3011 (2017)

[2] Kuramata *et. al.*, “High-quality β-Ga2O3 single crystals grown by edge-defined film-fed growth”, Japanese Journal of Applied Physics **55** 12 (2016) 1202A2

[3]Hoshikawa et. al., “50 mm diameter Sn-doped (0 0 1) β-Ga2O3 crystal growth using the vertical Bridgeman technique in ambient air”, Journal of Crystal Growth 546 (2020) 125778