Oxide Crystal growth from Cold Crucible; Ce doped $Gd_3(Al,Ga)_5O_{12}$ and β-Ga_2O_3 as examples.

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Most of the oxide single crystals used in industrial products such as $LiTaO_3$, $LiNbO_3$, sapphire, $Y_3Al_5O_{12}$, and $Gd_3(Al,Ga)_5O_{12}$ (GAGG) are produced by the Czochralski (CZ) method, in which the crucible is regarded as essential to hold the melt. Especially in the case of oxides, crucibles are often used as a heat source. However, the use of precious metal crucibles has many drawbacks, such as (1) limitation of melting points and growth atmospheres, (2) generation of impurities and other defects, and (3) high cost of crucibles (precious metals are used for the growth of high melting point materials), and crucibles have long been a problem. The Floating Zone method, Laser Heated Pedestal Growth method, Verneuil method, and Skull Melting method are known as methods for producing bulk single crystals of oxides without using precious metal crucibles for melt growth. Recently, it has been reported that single crystal growth is also possible by the sintering method.

The skull-melt method [1-4] is the general name for a crystal growth method that uses skull melting to form the melt. The melt of the raw material is heated by induction heating (non-contact heating), and is held in a solid with the same chemical composition (the container: Cold Crucible (CC)). This method has the advantage that there is no contamination of the melt by the crucible material and no restriction on the melting point or atmosphere.

The method of growing single crystals by holding the melt in a CC and attaching seed crystals to the melt using CZ method (skull-melting method + CZ method) is very attractive. However, this method is not always easy to apply, and requires strict control of the temperature distribution between the melt and the crystal surface. Although it is accompanied by several important problems, this crystal growth process is very interesting. The fabrication of corundum and ruby single crystals was the first important research result using this fusion technique [3,4].

We have been studying the fusion of the CZ method and the skull-melt method, named the Oxide Crystal growth from Cold Crucible (OCCC) method, for several years. We have succeeded in growing single crystals of Ce:GAGG single crystalline scintillator (Fig.1) [5] and β-Ga_2O_3 single crystal, which release oxygen and volatilize at high temperatures under low oxygen partial pressure, by melt growth in air.

Fig. 1. Single crystals of OCCC grown Ce:GAGG.

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