Unsteady-state crystal growth in the presence of interface electric field

Tohoku Univ.[1] ○(D) Qilin Shi[1], Jun Nozawa[1], Satoshi Uda[1]

E-mail: shiqilin@imr.tohoku.ac.jp

Background

Doping a certain amount of MgO to the LN enables it to be stoichiometric and congruent simultaneously (denoted as cs-MgO:LN, Li_2O:Nb_2O_5:MgO=45.3:50.0:4.7mol%). According to our thermodynamic analysis on partitioning of ionic species, it is expected that no segregation of any ionic species takes place during steady-state growth of the cs-MgO:LN. Since the equilibrium partitioning coefficient, k_0, is unity for all constituent species including ionic species. Based on the understanding of partitioning of ionic species in cs-MgO:LN, we expect that for the unsteady-state growth, Mg concentration changes in the presence of interface electric field while there is no segregation with zero interface electric field. To prove the validity of our model, crystal growth was conducted by μ-PD method accompanying high temperature gradient at the solid-liquid interface during growth, which induces an intrinsic electric field (Seebeck effect), converting k_0 into the field-modified equilibrium partitioning coefficient, k_{E0}. An external current is injected into the solid-liquid interface to compensate the intrinsic electric field. The sudden change of growth velocity during steady-state affects k_{E0} and consequently changes Mg distribution.

Experimental

An abrupt change of growth velocity (from 5mm/h to 40mm/h) during the steady-state growth of cs-MgO:LN crystal was carried out by μ-PD method. The external current was applied to compensate the intrinsic electric field during crystal growth. Mg distribution in the crystal was measured by EPMA.

Results

Fig. 1 (a) shows the sudden decrease of Mg concentration due to the change of growth velocity in the presence of interface electric field from 5mm/h to 40mm/h. As the velocity abruptly increased, k_{E0} decreased while C_i increased, leading to decrease of C_s. However, when the intrinsic electric field was totally compensated by current injection, k_{E0} recovered to k_0 (=1) and C_s became constant regardless of abrupt velocity changes (Fig. 1(b)). During the steady-state crystal growth with abrupt change of velocities under the counterbalanced current, the effect of c-EMF became gone and the effect of supercooling was observed via potential difference curve (shown in Fig. 2) that the larger the abrupt velocity change, the more supercooling appeared.

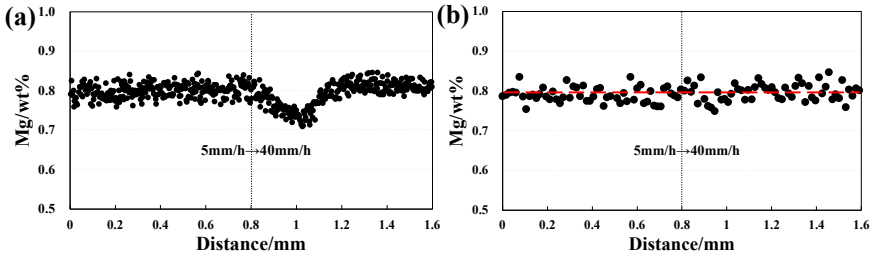

Fig.1 Mg distribution in the crystal under abrupt change of growth velocity from 5mm/h to 40mm/h (a) without current and (b) with −0.1mA.

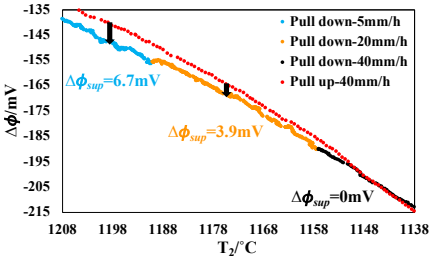

Fig.2 $\Delta\phi$ plotted a function of T_2 with velocity change (−0.1mA).