Study on the electrical relationship at the interface between LN melt and LN crystal

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Background

The transport and partitioning of ionic solutes at the solid-liquid interface during growth of $LiNbO_3$ (LN) crystal under the electric field has been long investigated by μ-PD method, in which Seebeck effect-driven electric field, crystallization electromotive force (c-EMF) and applied electric field play important roles on the partitioning [1,2]. In previous work, it was found even if the intrinsic electric field was compensated by a much larger external current (-1.0mA, -127mA/cm^2), k_{E0} >1 still was obtained as shown in Figure 1. This study is conducted to investigate the electrical relationship between solid and liquid phase during the growth of MgO-doped LN via the μ-PD method under an external electric field.

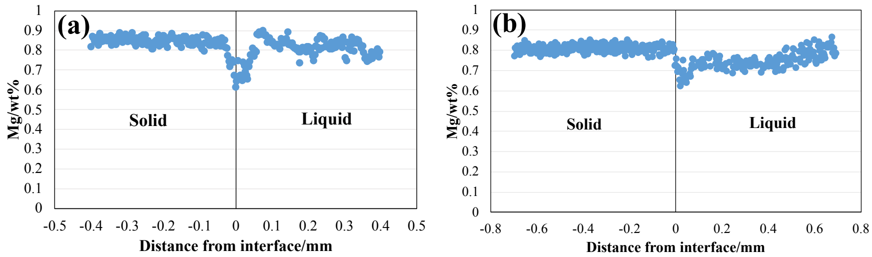

Fig. 1 Mg distribution at the interface of solid and liquid (a) without current, (b) with -1.0mA at the growth rate of 30mm/h.

Experimental

cs-MgO:LN (Li_2O:Nb_2O_5:MgO=45.3:50.0:4.7mol%) that is congruent and stoichiometric simultaneously, was employed for growth by μ-PD method. Fig.2 shows schematic of the measurement. A pair of Pt terminals were set in the liquid and solid phases to measure the current-voltage characteristic. The DC power was supplied to the voltage between T_1 and T_2, which was denoted as "positive" when the melt was positively charged.

Results

Fig. 3 shows the relationship between current and voltage at the interface between melt and LN crystal. The current-voltage characteristic shows a Schottky barrier curve, suggesting a metal-semiconductor junction existing at the interface. Mg segregation behavior at the interface under electric field can be explained by this I-V characteristic. When the electric field operates on Mg^{2+}, the modified velocity, V_E is expressed as $V_E=V-V^*$, where V^* is the field-driven velocity term and a positive sign indicates the direction from the interface to the melt. In the case for positive current, V_E decreased as V^* increased, thus k_{E0} increased to be more than 1. However, negative current still yielded k_{E0} >1 at the interface because the negative current didn't supply the compensating electric field large enough to convert k_{E0} >1 to k_{E0} <1 by yielding the large negative V^*.

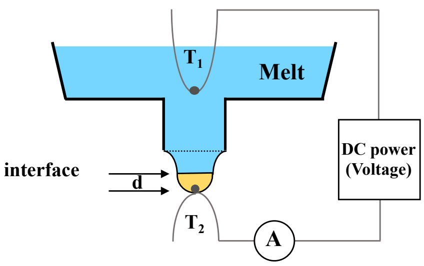

Fig. 2 Schematic illustration of I-V curve measurement by μ-PD method.

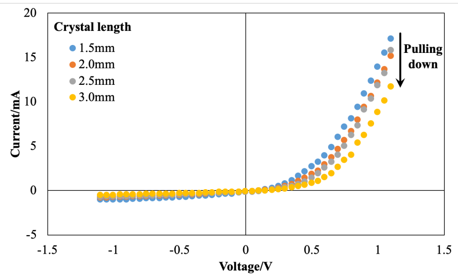

Fig. 3 Dependence of current on voltage with different distance (d) between the liquid-solid interface and T_2.

[1] Uda S, Kon J, et al., J. Crystal Growth, 1997, 179(3-4): 567-576.