The defect structure of the $LiNbO_3$ single crystals grown by the Czochralski method.

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1. Introduction

This study is aimed to grow the bulk $LiNbO_3$ single crystals of 2″ in diameter with the high quality for the optical applications. Undoped and 5mol%MgO-doped $LiNbO_3$ single crystals with the congruently melting composition were grown using a self-designed RF-CZ grower(see Figure 1).

The established optimum growth conditions are as follows :

- Congruently melting composition : 48.6 mol%Li_2O
- Growth direction : c-axis
- Pulling rate : 2 mm/hr (Growth rate : ≈ 3 mm/hr)
- Rotation rate : 20 rpm
- Atmosphere : in air
- Size of Pt-crucible : 60×60 mm
- Weight of the initial charge : 400 g
- Diameter of the $LiNbO_3$ crystals grown : 35~40 mm
- Length of the $LiNbO_3$ crystals grown : 60~80 mm

2. Experimental Results

2.1. Diameter control by the compensated power control method

The specially-designed quartz tube, which was positioned above the Pt-crucible, made the easy observation of the meniscus during the growth process possible and improved the thermal uniformity in the radial direction. Diameter of the $LiNbO_3$ single crystal was successfully controlled by the compensation of the input power with the thickness of the meniscus under the temperature gradient measured. The accuracy of the diameter control by this method is about ±10%(see Figure 2).

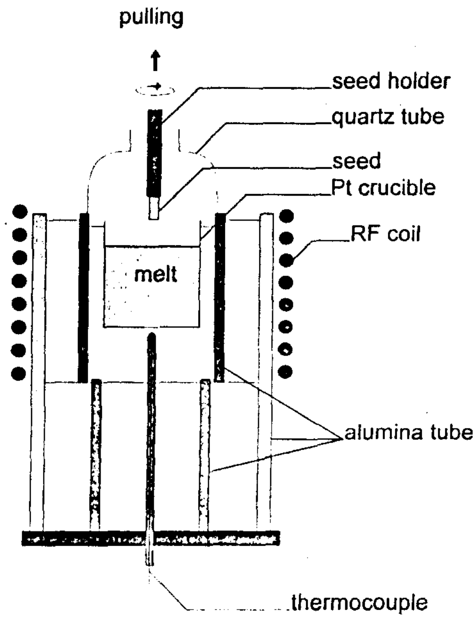

Fig. 1 A schematic diagram of the RF-CZ grower.

Fig. 2 $LiNbO_3$ single crystal grown by RF-CZ grower.

2.2. Domain structure

The domain structure of undoped and 5mol%MgO-doped $LiNbO_3$ single crystal are compared with each other.

Undoped $LiNbO_3$ crystals exhibited almostly single domain structure from the seed to the tail, with only one thin domain layer in outer circular edge(Figure 3). However, MgO-doped $LiNbO_3$ crystals revealed that the domain structure changes from the regular-circular rings(like the radial waves) to the random splits along the fraction solidified, g(see Figure 4).

Fig. 3 Domain formation near the growing shoulder of undoped $LiNbO_3$.

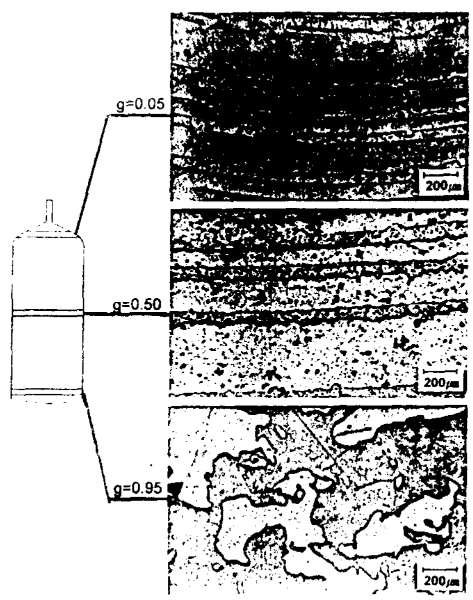

Fig. 4 Change of the domain structure along the fraction solidified, g.

Mg^{2+} ions doped in $LiNbO_3$ crystal lattice is thought to have an effect on forming the domain structure. A back-scattered SEM image supports to this explanation, however more quantitive analysis are needed using more delicate chemical analysis technique such as WDS(see Figure 5).

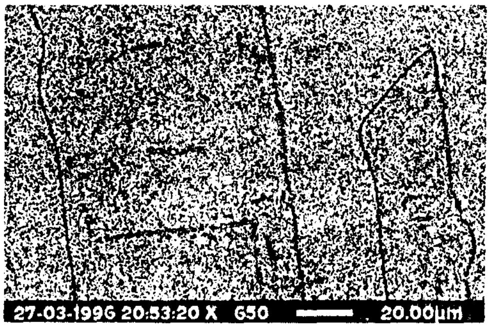

Fig. 5 Back-scattered SEM image showing a compositional contrast of the domain wall.

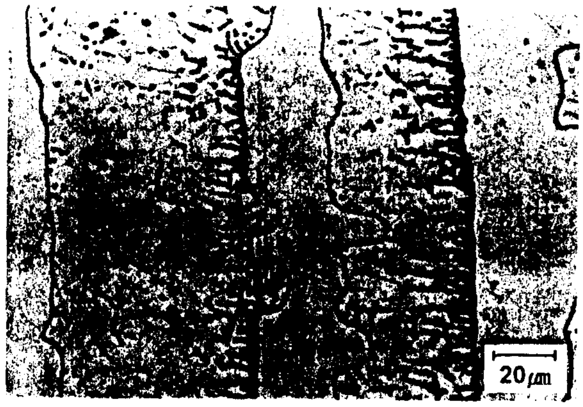

Fig. 6 Dislocation structure near the domain boundaries.

2.3. Dislocation structure

Dislocation etch pits and hillocks were observed mainly in negative domain regions and accumulated in near the domain boundary where the negative domains transforms to positive(see Figure 6). The phenomena became more clear after sannealing heat treatment.