Growth of X-112° and 36°Y-X $LiTaO_3$ single crystal by Czochralski method

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1. Introduction

Lithium tantalate ($LiTaO_3$) single crystals grown by X-axis and 36°Y-axis were one of the most useful materials for surface acoustic wave(SAW) devices. Recently, X-axis $LiTaO_3$ crystal has produced by many company for commercial substrate used by TV IF filter[1] and 36°Y-axis $LiTaO_3$ crystal has used for mobile communication components(pager, cellular phone, PCS, etc.).

The thermal condition, rotation rate and growth rate have been established for the growth of $LiTaO_3$ crystal with 3 inch diameter. X-axis and 36°Y-axis $LiTaO_3$ crystals could be successfully grown by the Czochlaski method using Ir crucible. The purpose of the present work is to establish commercially a suitable thermal condition in the growth furnace, growth rate and crystal rotation rate for the growth of 3 inch $LiTaO_3$ crystal, and is to discuss with the relation between the grown axis and crystal growth condition.

2. Experimental

$LiTaO_3$ crystals are grown by the Czochralski method using an induction heating furnace. The Ir crucible (130 mm in diameter and 120 mm in height) is imbeded in bubble alumina thermal insulation contained in alumina ceramic

crucible. The growth furnace is designed for suitable thermal condition to prevent cracking, using an Ir afterheater.

Starting materials are prepared by mixing Li_2CO_3 and Ta_2O_5 in 0.95 mole ratio (Li/Ta), followed by calcining. The melt charge consisted of about 90 % by volume of the Ir crucible is used. Crystals are grown in N_2 atmosphere. Crystal rotation rate ranged from 9 to 12 rpm and linear growth rate ranged from 5 to 6 mm/h are used. All crystals are grown using an automatic diameter control(ADC) system by weighing the grown crystal, and the Curie temperature (T_c) is measured by differential thermal analysis(DTA).

3. Results and Discussion

The suitable growth condition of X-axis and 36°Y-axis $LiTaO_3$ crystals shows in Table I, and compare with X-axis and 36°Y-axis $LiTaO_3$ crystals.

Fig 1 shows a photograph typical X-axis and 36°Y-axis $LiTaO_3$ crystals with 3 inch diameter grown under the suitable condition. Most of the crystals can be obtained without crack. As shown in Fig 1 the large $LiTaO_3$ crystal was grown with very high cone angle, that is, almost top, shoulderness, to produce it commercially. Sometimes the many localized cracks were observed 1) along the (1 1 2) cleavage plane due to the unsuitable thermal conditions, and 2) along the (0 1 2) cleavage plane near the growth ridges on the side of the crystals due to formed abnormal growth ridges with X-axis $LiTaO_3$ crystal[2,3]. But in case of 36°Y-axis $LiTaO_3$ crystal the crack was mainly formed along (0 1 2) cleavage plane due to by abnormal growth ridges.

Table 2 shows the Curie temperature of X-axis $LiTaO_3$ crystals dependent on the growth charge. ΔT_c (T_c(top)-T_c(tail)) is shown with together. The ΔT_c found that a slight variation is shown due to the homogeneity of composition along the growth axis.

Reference

[1] T.Fukuda, S.Matsumura, H.Hirano and T.Ito, J. Crystal Growth **46** (1979) 179

[2] Ho. Hao-Yang, J. Crystal Growth **50** (1980) 757

[3] S.Matsumura, J. Crystal Growth **51** (1981) 41

Table 1. The Growth Condition of X-axis and 36°Y-axis $LiTaO_3$ Crystals

	X-axis $LiTaO_3$ crystal	36°Y-axis $LiTaO_3$ crystal
Crystal Rotation (rpm)	12.5	10,5
Crystal Growth Rate (mm/h)	5.8	5.3
Shoulder & ADC-Standby Growth Rate (sp/h)	0.35	0.30

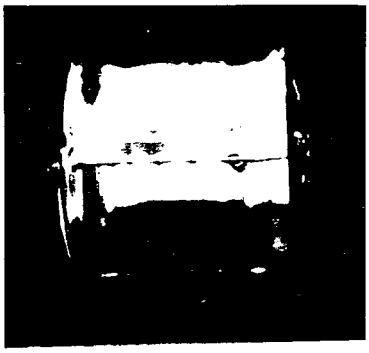
Table 2. The Curie Temperatures of X-axis $LiTaO_3$ crystals

	X-axis $LiTaO_3$ crystal		
	T_c(Top)	T_c(Tail)	ΔT_c
Initial Charge	603.8	604.0	-0.2
1st Recharge	602.8	602.5	0.3
2nd Recharge	604.3	604.5	-0.2

Fig. 1. The Photograph of X-axis and 36°Y-axis $LiTaO_3$ crystals

(a) X-axis grown crystal (from top)

(b) X-axis grown crystal



(c) 36°Y-axis grown crystal (from top)