

heating) can reach 80 % and more while in the second case (RF heating) it is usually 30 to 40 %. Moreover, in the first case, the state of the liquid flow was easier to control, and, when grown with a flat interface, the crystal had a better diameter stability and its cross-section tended to be quite circular, but the surface finish was very poor (the analysis suggests that this is due to the interaction between volatile compounds from the graphite, the molybdenum and the crystal surface). As a rule, the YAG:Nd crystals grown with the resistance process are most suitable for pulsed devices while those grown using the RF process are mostly used for continuous devices.

**PS-15.02.19 DEFECTS IN YAG:Nd CRYSTALS CAUSED BY INTERFACE REVERSION.** By Xu Tianhua and Xu Guangyu, Southwest Institute of Technical Physics, PO Box 238, Chengdu 610041, P.R. China.

A region 1 to 2 cm long with macroscopic "filamentary" defects often appears in YAG:Nd crystals when their growth interface undergoes "spontaneous reversion". Microscopic examination has revealed that the region has the typical features of component supercooling: sharp images of cellular growth and interface breakdown appear after etching on the crystals sliced longitudinally; the "filaments" are usually tubular, and many "granules" of a secondary phase which are formed from the melt after climbing are imbedded in their inner walls. The defects due to the component supercooling resulted in two forms of dislocations: prismatic dislocation loops surrounding the filaments which do not extend downwards, and linear and helicoidal dislocations running roughly along the normal to the interface. After etching of the crystals sliced longitudinally, arrays of etch pits were observed on opposing faces with a good correspondence, as well as etch cannelures originating from the ends of the filaments due to the linear dislocations and arrays of etch pits due to the helicoidal dislocations. After etching of the crystals sliced transversally, some closely-packed bursts of dislocation etch-pits were observed surrounding the filaments. In the region where the filaments disappear, there are many scattered dislocation lines decorated with impurities.

The densities of the dislocation etch-pits before and after the region with filamentary defects usually differ from one another by 2 or 3 orders of magnitudes. The facts mentioned above show that the defects due to the component supercooling are the main cause for the generation of dislocations.

Finally, the causes of the defects due to component supercooling as well as their elimination are discussed according to the relationship between the control of the growth parameters, the stability of the liquid flow and that of the interface.

**PS-15.02.20 THE THERMAL FIELD IN THE GROWTH OF HIGH TEMPERATURE OXIDE CRYSTALS BY THE CZOCHRALSKI TECHNIQUE.** By Xu Tianhua, Peng Weiqing, Zheng Qimeng, Huang Changmin and Xu Guangyu, Southwest Institute of Technical Physics, PO Box 238, Chengdu 610041, P.R. China.

We consider that the thermal field is the most important factor that affects the pulling in a definite region growth system, and it is mainly characterized by the longitudinal and radial temperature gradients, the symmetry of the temperature gradients, and the smoothness of the variations of the longitudinal temperature gradient. The thermal field strongly affects the morphology and the intensity of the liquid flow, the shape of the interface, the external shape of the crystal, the stability of the crystal diameter, the crystal/charge ratio, the formation of defects, the

easiness of the operation, and so on.

The larger the temperature gradient, the stronger the natural convection, the more convex the interface, the better the stability of the diameter, and the more the external shape of the crystal tends towards a cylinder, but that will easily lead to cracks in the crystal when it is too large. When the radial symmetry of the temperature distribution is poor (the "cold point" deviates from the centre of the liquid interface), and the crystal is grown with a convex interface, there are a lot of scattered granules in the crystal caused by temperature fluctuations at given points on the growth interface. When the rotation rate is high, poor radial symmetry and a low temperature difference between the crystal and the crucible will result in the appearance of eddies on the surface of the liquid, the stability of the crystal diameter is very poor, and there are a lot of scattered granules in the crystal. When the smoothness of the variations in longitudinal temperature gradient is poor, the crystal has an extremely poor diameter stability which it is difficult to control. Besides, it leads easily to crystal brittleness and to a calabash-shaped growth.

The "window effect" vitally affects all the mentioned characterization parameters. For this reason, we have designed a special device called "Dynamic symmetric forced heat dissipator" in which the liquid flow is in a good state, the crystal/melt ratio is large (up to 60 to 70%), the stability of the diameter is satisfactory, there are no scattered granules, and the control of the growth is facilitated.

**PS-15.02.21 GROWTH OF SINGLE DOMAIN NEARLY PERFECT CRYSTALS OF LITHIUM NIOBATE.** By R.V. Anantha Murthy\*, K.S. Bartwal and Krishan Lal, National Physical Laboratory, New Delhi - 110 012, India.

High quality single crystals of lithium niobate have been grown by the Czochralski technique. A crystal growth system designed, developed and fabricated at NPL has been employed in these experiments. Crystals of diameter 20mm and length 30 mm are being grown. High purity (99.99%) powder was used as the charge. The perfection of the crystals was evaluated by high resolution X-ray diffractometry and topography. The half width of the diffraction curve was in the range 10 arc sec to 20 arc sec (Fig. 1). Also, the topographs reveal that dislocation densities are low. Ferroelectric domains could be observed in X-ray diffraction topographs of the crystals grown without poling. The domains were randomly oriented. Poling during growth experiment was accomplished with current densities in the range 1.5 mA/cm<sup>2</sup> to 2.5 mA/cm<sup>2</sup>. These crystals are of single domain and nearly perfect.

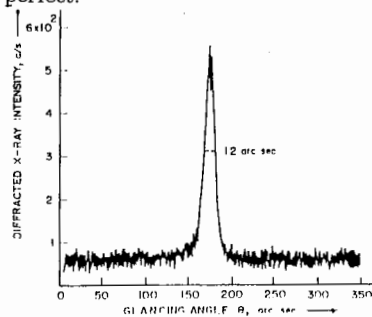


Fig. 1. A high resolution X-ray diffraction curve of a LiNbO<sub>3</sub> crystal, 11 $\bar{2}$ 0 Relp; MoK $\alpha$ ; (+, -, +).