

FLAME-FUSION GROWTH OF SrTiO_3

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Exact growth conditions for reproducible production of SrTiO_3 crystals of optical quality by the flame-fusion method have been defined. The overflow problem could be solved by precise adjustment of the SrCO_3 excess in the starting powder to the SrO evaporation. The thickness of the molten layer is nonuniform and varies from 0.4 mm in the center to 1.4 mm at the periphery. The crystals are characterized by their dislocation densities, lattice constant and EPR spectra.

1. Introduction

Strontium titanate at room temperature is cubic (perovskite, $\text{Pm}\bar{3}\text{m}$) and transforms below a range of 105 to 99 K to a nonferroelectric tetragonal phase ($\text{I4}/\text{mcm}$). This second-order phase transition [1] as well as interesting electrical and optical properties initiated systematic physical studies on SrTiO_3 . The optical similarity with diamond (index of refraction 2.4, optical dispersion 0.1) resulted in commercial flame-fusion growth of this synthetic gem "fabulite" by two companies [2].

The patents [3] and publications [4-6] do not contain all the necessary data on the experimental conditions for growth of large SrTiO_3 crystals. Therefore, a systematic investigation on the flame-fusion growth process of SrTiO_3 was undertaken in order to evaluate the conditions required in the growth of large crack-free crystals. Recently, the structural perfection of SrTiO_3 grown by various techniques has been related to the growth conditions and several characterization data on the flame-fusion-grown crystals described in this paper have been published [7,8].

2. Experimental

The versatile flame-fusion apparatus used for the present work will be described elsewhere [9]. Here,

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only specific details in connection with SrTiO_3 are discussed. The design of the three-tube burner is very similar to that of Linz et al. [5] although Nakazumi [6] applied a simple double-tube burner for SrTiO_3 . The crystal was growing in the center of an alumina tube of 4 cm internal diameter which was positioned in the afterheater. The latter was heated only after the growth run for in-situ annealing of the grown crystals.

The temperature profile of the flame with the conditions applied for growth of SrTiO_3 has been measured inside the apparatus by optical pyrometry. The temperatures of the five saw teeth (facing upward) of a vertical ZrO_2 ceramic plate ($20 \times 20 \times 2$ mm) were measured in the center of the tube as a function of the distance from the burner. The emissivity of the coarse ZrO_2 ceramic was determined as 0.75 (compared to 0.18-0.43 published for dense ZrO_2) and the temperatures corrected accordingly. The resulting temperature profile shown in fig. 1 indicates that the flame temperatures are significantly higher than the melting point of SrTiO_3 ($1920 \pm 15^\circ\text{C}$, as determined by DTA). These high flame temperatures might be the reason for the high melting points of SrTiO_3 reported earlier (2050°C [5], about 2050 to 2100°C [3], 2080 - 2130°C [4a]). Systematic flame and wall temperature profiles have been measured by Khambatta et al. [10] who tried to relate the data to their thermal model which we have not yet applied to SrTiO_3 .

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