interactions with the crucible) and the high quench rate necessary to achieve the fully amorphous state; melt spinning of $Nb_{0.55}Ir_{0.45}$ is difficult because of the high liquidus temperature of this alloy.

A comprehensive description of the I.I.R. method, its application and limitations, and further data obtained with it will be published subsequently [7]; in the meantime, experimental details can be obtained from the authors.

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Thermal expansion of gallium borate

Recently, Bither and Young [1] synthesized a number of borates under high pressure and high temperature conditions, and found that they belong to $R\bar{3}C$ space group and are isotypic with the calcite structure. A perusal of the literature shows that the thermal expansion of gallium borate which has the same structure as calcite, has not been so far studied. As the authors have determined the precision lattice parameters and the coefficients of thermal expansion of a number of carbonates [2–5], nitrates [6, 7] and borates [8, 9], it is thought worthwhile to include the borates synthesized by Bither in the general programme of X-ray investigation on calcite-type compounds.

The sample used in the present study was kindly supplied by Professor Bither, Central Research Department, E.I. du Pont de Nemours and Company, Experimental Station, Wilmington, Delaware, USA. It was found necessary to heat the sample to 600° C to obtain well-resolved sharp lines in the high-angle region. The sample for study was prepared by filling the powder in a thin walled quartz capillary. Using Cu*K* radiation, powder photographs at different temperatures were recorded in the temperature range 38 to 900° C. Temperature control was facilitated by the use of voltage stabilizer and a variac. The temperature could be held constant within about 2° C. Details of the experimental technique and the method of evaluating the precise lattice parameters and the coefficients ot thermal expansion has been described in an earlier paper [2].

Reflections from $(1.2.14)_{\alpha_1}$, $(1.2.14)_{\alpha_2}$, $(2.2.12)_{\alpha_1}$, $(2.2.12)_{\alpha_2}$, $(416)_{\alpha_1}$, $(416)_{\alpha_2}$, $(329)_{\alpha_1}$ and $(329)_{\alpha_2}$ in the Bragg angle region 65° to 80° were used to evaluate the lattice parameters at different temperatures. In evaluating the lattice parameters independent measurements and calculations were made on several films and the average of the deviations of the individual values from the mean was taken as the error in the lattice

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TABLE I Lattice parameters of $GaBO_3$ at various temperatures

Temperature (° C)	a (Å)	c (Å)
38	4.5676	14.173
128	4.5677	14.178
237	4.5694	14.190
357	4.5739	14.220
634	4.5747	14.240
804	4.5776	14.260
900	4.5784	14.273

parameters. This error was found to be about 0.0002 Å in the a parameter and 0.0016 Å in the c parameter. The coefficients of thermal expansion at various temperatures have been evaluated from the lattice parameter versus temperature data using a graphical method.

The lattice parameters determined at various temperatures are given in Table I. The lattice parameters versus temperature curve was found to be linear. The temperature variation of the lattice parameters a and c can be expressed by following equations.

$$a_T = (4.566\,51 + 1.344\,41 \times 10^{-5} T)\,\text{Å}$$

$$c_T = (14.165\,2 + 1.182\,7 \times 10^{-4} T)\,\text{Å}.$$

The coefficients of thermal expansion, both perpendicular ($\alpha_\perp$) and parallel ($\alpha_\parallel$) to principal axis, remain constant throughout the range of temperature studied. The mean coefficients of expansion over the temperature range studied are as follows:

$$\alpha_{\perp(38°\text{–}900°)C} = 2.74 \times 10^{-6}\,°\,C^{-1}$$

$$\alpha_{\parallel(38°\text{–}900°)C} = 8.19 \times 10^{-6}\,°\,C^{-1}.$$

In Table II, the room temperature lattice parameters obtained in the present study are compared with those obtained by Bither and Young [1]. There is good agreement in the a parameter whereas there is slight deviation in the c parameter.

The average coefficient of linear expansion of gallium borate is $4.56 \times 10^{-6}\,°\,C^{-1}$ this value is comparable with the linear coefficients $4.19 \times 10^{-6}\,°\,C^{-1}$ and $5.98 \times 10^{-6}\,°\,C^{-1}$ of $ScBO_3$ and $InBO_3$, respectively, calculated at 50° C [8, 9].

TABLE II Lattice parameters of $GaBO_3$ at room temperature

Reference	a (Å)	c (Å)
Bither [1]	4.568	14.182
Present study	4.5676 ± 0.0002	14.173 ± 0.0016

The thermal behaviour of gallium borate is similar to the rest of the calcite-type compounds ($\alpha_\parallel > \alpha_\perp$).

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