Refractive Indices of $\text{Sr}_{0.61}\text{Ba}_{0.39}\text{Nb}_2\text{O}_6$
Single Crystals

By

D. Kip$^2$), S. Aulkemeyer, K. Buse, F. Mersch, R. Pankrath, and E. Krätzig

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Photorefractive $\text{Sr}_{x}\text{Ba}_{1-x}\text{Nb}_2\text{O}_6$ crystals are promising for many applications [1], e.g. for volume holographic storage [1] and self-pumped phase conjugation [3]. The transition temperature from the ferro- into the paraelectric phase depends on the mole fraction $x$ [4], which enables tailoring of the photorefractive properties. However, crystals grown from the congruently melting composition with $x = 0.61$ show the best quality and visible striations can be completely avoided. Investigation of $\text{Sr}_{0.61}\text{Ba}_{0.39}\text{Nb}_2\text{O}_6$ crystals and development of devices made from $\text{Sr}_{0.61}\text{Ba}_{0.39}\text{Nb}_2\text{O}_6$ often require precise knowledge of the refractive indices [5, 6]. In 1968 Venturini et al. [7] measured the refractive indices of $\text{Sr}_x\text{Ba}_{1-x}\text{Nb}_2\text{O}_6$ crystals with the compositions $x = 0.25$, 0.50, and 0.75. Values for crystals of the congruently melting composition $\text{Sr}_{0.61}\text{Ba}_{0.39}\text{Nb}_2\text{O}_6$ can only be obtained by interpolation of these data. In this contribution measurements of the refractive indices of single domain $\text{Sr}_{0.61}\text{Ba}_{0.39}\text{Nb}_2\text{O}_6$ crystals are presented.

$\text{Sr}_{0.61}\text{Ba}_{0.39}\text{Nb}_2\text{O}_6$ has a tungsten-bronze structure and is ferroelectric (point group 4mm) at room temperature. A nominally pure crystal is grown in the crystal-growth laboratory of the Physics Department of the University of Osnabrück using the Czochralski technique. Growth temperature and pulling rate are 1480 °C and 0.7 mm/h. A triangular prism is cut from the crystal. The c-axis is oriented perpendicular to the two parallel surfaces using a {100} growth face as a reference. All sides were polished to optical quality. Heating the crystal to 110 °C and cooling down to room temperature with an applied electric field of 600 kV m$^{-1}$ yields a single domain sample. By the minimum deviation method the refractive indices are determined with an absolute accuracy better than ±0.002. We chose different lines of an Ar$^+$ laser and a HeNe laser for illumination of the prism. All measurements are carried out at room temperature ($T = 22$ °C) and the light intensity is kept low (of the order of Wm$^{-2}$) to avoid heating of the sample.

Fig. 1 shows the dispersion of extraordinary $n_e$ and ordinary $n_o$ refractive indices. The curves are fits of the Sellmeier equation [8]

$$n^2(\lambda) - 1 = A + \frac{B\lambda^2}{\lambda^2 - C}$$

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1) D-49069 Osnabrück, Germany.
2) e-mail: dkip@physik.uni-osnabrueck.de.
I I I Fig. 1. Refractive indices $n_e$ and $n_o$ of Sr$_{0.61}$Ba$_{0.39}$Nb$_2$O$_6$ crystals for extraordinarily and ordinarily polarized light vs. light wavelength $\lambda$ at room temperature ($T = 22^\circ C$). The symbols are measured values and the solid lines fits to the Sellmeier equation (1) with the parameters of Table 1.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>$A$</th>
<th>$B$</th>
<th>$C$ (10$^{-14}$ m$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n_e$</td>
<td>1.667</td>
<td>2.188</td>
<td>5.690</td>
</tr>
<tr>
<td>$n_o$</td>
<td>1.711</td>
<td>2.248</td>
<td>5.982</td>
</tr>
</tbody>
</table>

Table 2

Extraordinary ($n_e$) and ordinary ($n_o$) refractive indices and birefringence ($n_e - n_o$) for some frequently used laser wavelengths $\lambda$ at room temperature ($T = 22^\circ C$)

<table>
<thead>
<tr>
<th>$\lambda$ (nm)</th>
<th>$n_e$</th>
<th>$n_o$</th>
<th>$n_e - n_o$</th>
</tr>
</thead>
<tbody>
<tr>
<td>488.0</td>
<td>2.354</td>
<td>2.390</td>
<td>-0.036</td>
</tr>
<tr>
<td>514.5</td>
<td>2.335</td>
<td>2.370</td>
<td>-0.035</td>
</tr>
<tr>
<td>532.0</td>
<td>2.325</td>
<td>2.358</td>
<td>-0.033</td>
</tr>
<tr>
<td>632.8</td>
<td>2.284</td>
<td>2.314</td>
<td>-0.030</td>
</tr>
</tbody>
</table>

Fig. 2. Birefringence ($n_e - n_o$) vs. light wavelength $\lambda$ at room temperature ($T = 22^\circ C$). The symbols are measured values and the solid line is calculated from the Sellmeier equation (1) with the parameters of Table 1.
to the experimental values with the parameters $A$, $B$, and $C$ given in Table 1. Table 2 summarizes the refractive indices for some frequently used laser wavelengths. The birefringence values are also presented in Table 2, and Fig. 2 shows the spectral dependence of the birefringence. The Sellmeier equation (1) describes the experimental values very well and for this reason intermediate values may be interpolated with high reliability.

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References