atomic order parameter. However, the ordering kinetics of Ni_3Fe formed by annealing have been well established by Iida [18]. He has shown that short range order is completed after about 10 h annealing, while long range order requires about 60 h. Our results show that n changes markedly after short anneals, but annealing times of over about twenty hours have little or no effect. This indicates primarily a short range order dependence: as to be expected if the regions of spin correlation are as described earlier.

If the degree of spin order is assumed to increase with that of atomic order (as indicated by Curie temperature and magnetization results) then the present work appears to be in complete contrast with theoretical predictions. It is interesting to note, however, that the experimental results obtained by Graham [4, 6] using Fe and Fe–Si gave a fourth power law at low temperatures rising to a ninth power at higher temperatures. Spin order decreases with rise in temperature, thus Graham's results imply that n decreases with the formation of spin order, in agreement with our experiments.

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Thermal expansion anisotropy of a $LiY_{0.5}Er_{0.5}F_4$ single crystal

Interest has recently been renewed in the use of certain mixed fluoride single crystals as laser host lattices by the recognition that, when doped with holmium (Ho^{3+}), stimulated emission can be obtained at a wavelength of 2.06 µm. This radiation is somewhat safer to the eye than that emitted at 1.06 µm in corresponding neodymium (Nd^{3+}) based systems.

Compounds on the pseudo-bonary section $LiY_{1-x}Er_xF_4$ ($0 \leqslant x \leqslant 1$) of the ternary system $LiF–YF_3–ErF_3$, have proved to be particularly efficient hosts for the Ho^{3+} ion, especially when sensitized with Tm^{3+} [1]. The end component, $LiYF_4$, of the series possesses the body-centred tetragonal structure (a = 5.175 Å, c = 10.74 Å) of the Scheelite group [2], and recent work in the authors' laboratories has shown that the tetragonal symmetry is retained across the entire section [3]. Crystals with a low symmetry such as this often exhibit defects such as dislocation low-angle boundaries, twins and/or cracks, when produced as single crystals by melt growth processes such as the Czochralski or Stockbarger techniques [4, 5]; defects of this type are obviously detrimental in optical applications.

One of the major causes of these particular defects in low symmetry crystals is the stress arising from anisotropic thermal contraction in the crystal while cooling to room temperature subsequent to growth. For some of these materials, a knowledge of the thermal expansion characteristics is known to be very important in determining the optimum crystal growth direction for minimizing the stresses arising from thermal anisotropy [6, 7]. The present note reports the thermal expansion data obtained for a typical tetragonal fluoride which is of interest as a laser material.

Dilatometric measurements have been performed on a cubic specimen (cube edge ~ 4 mm) cut from a crystal grown by the Stockbarger

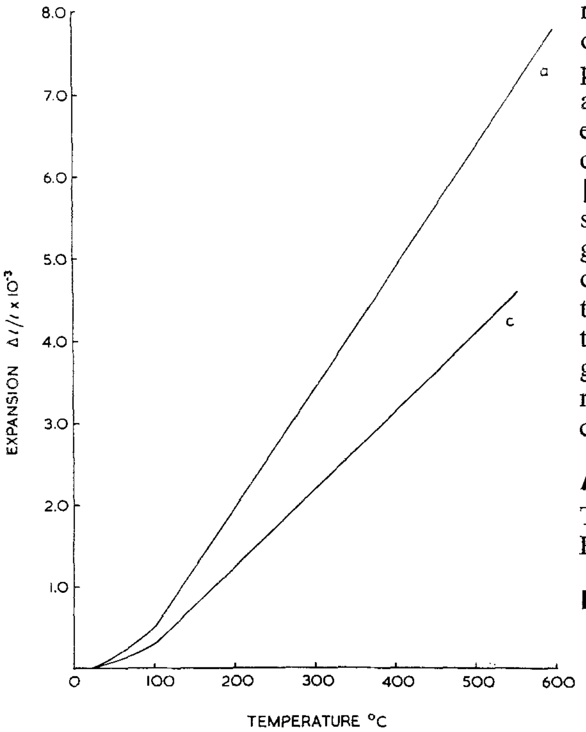

Figure 1 Expansion characteristics of the *a*- and *c*-axes of a $LiY_{0.5}Er_{0.5}F_4$ single crystal. The data for the two measured *a*-axes were coincident and for the sake of clarity only one has been shown.

technique [8] using a melt with the composition $LiY_{0\cdot5}\ Er_{0\cdot5}\ F_4$ which typifies the series of compounds described above. The faces of the cube were cut perpendicular to the principal axes of the tetragonal structure. The expansion characteristics along these axes were determined at a linear heating rate of 2° min^{-1} under a vacuum of 10^{-6} Torr, using an automatic dilatometer, employing a linear variable displacement transducer and silica push rod system. A detailed description of the equipment and technique has been given in an earlier paper [6].

The data obtained are plotted in Fig. 1 from which it is apparent that a marked anisotropy exists between the *a* and *c* directions; the mean expansion coefficients for these axes are 14.75 $\times\ 10^{-6}$ and 9.5 $\times\ 10^{-6}$ respectively for the temperature range 100 to 500°C.

Thermal anisotropy generally exerts its maximum influence in the radial plane of the crystal during Czochralski and Stockbarger growth procedures, where it accentuates the hoop stresses arising from the temperature differential which exists between the centre and outer surface of the crystal [5]. In some cases, for instance $YAlO_3$ [7], anisotropic contraction provides the major source of stress in the crystal and promotes the generation of both dislocation low-angle boundaries and twins. The thermal expansion data for the fluoride examined here suggest that effects of this type could be minimized by using *c*-axis growth to provide isotropic contraction in the radial plane and the consequent production of crystals with a low level of strain.

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