Growth of $KNbO_3$ thin films on MgO by pulsed laser deposition

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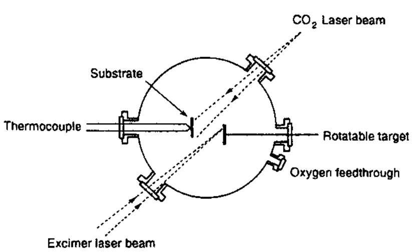
$KNbO_3$ crystals have numerous uses in electro-optical, nonlinear optical, and photorefractive device applications. However, their widespread availability is somewhat limited due to their cost and growth difficulties. For applications requiring waveguide geometries, further problems exist, as $KNbO_3$ is not particularly suited to general fabrication techniques such as diffusion or ion exchange. Ion beam implantation has produced optical waveguides,[1] and liquid phase epitaxy techniques[2] prove successful, but so far, the technique of Pulsed Laser Deposition (PLD) has not been applied to thin film $KNbO_3$ growth. We report here the results of waveguide growth using this technique.[3]

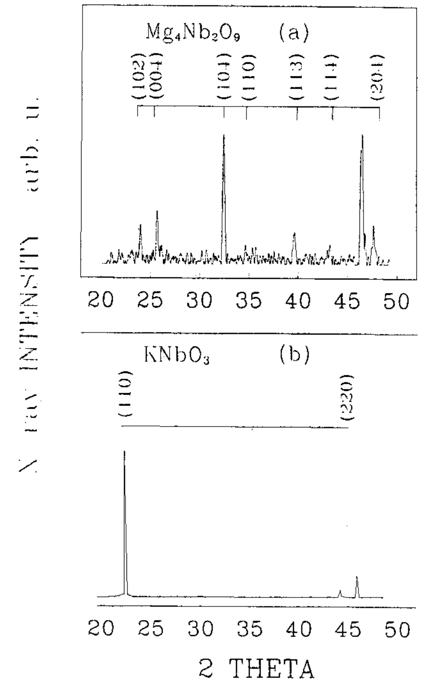
The arrangement used is shown in Fig. 1 and involves ablative deposition using a KrF excimer laser operating at λ = 248 nm. The films were grown in a partial pressure of 2×10^{-2} mbar of oxygen, which was necessary to produce the correct O_3 composition. The target materials tried ranged from single crystal $KNbO_3$ samples to varying composition ratio targets of $KNbO_3/K_2CO_3$ sintered ceramics. Typical ablation fluxes were $5J/cm^2$ for single crystals, and $2.5J/cm^2$ for ceramic targets. The substrate chosen was MgO, which has the required lower refractive index for waveguiding and has a lattice parameter that is ~5% larger than $KNbO_3$. At a distance of 60 mm the films grown on MgO substrates when heated to ~650°C yielded stoichiometric $KNbO_3$, using ceramic targets that were prepared with a K/Nb ratio of 2.85. When single crystal targets were used, the K concentration in the film was negligible.

Figure 2 shows a comparison of the X-ray diffraction results for films grown from (a) single crystal targets and (b) ceramic targets. The spectra indicate that with the correct growth conditions, oriented single crystal films can be grown. Rutherford Backscattering has also been used to check the composition of the films, and Fig. 3 shows the analysis of the films used for Fig. 2. Again it is seen that the correct stoichiometry is achievable in a thin layer, with an additional diffused region below.

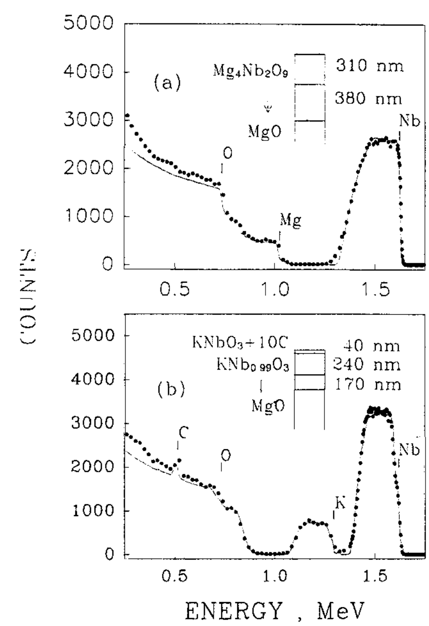
The films of $KNbO_3$ that show oriented stoichiometric growth are currently under investigation to determine their linear, nonlinear, and photorefractive properties.



CMK6 Fig. 1. Experimental arrangement used for Pulsed Laser Deposition and heating the MgO substrate with a CO_2 laser.



CMK6 Fig. 2. X-ray diffraction patterns of the films formed on (100) MgO single crystal substrates. (a) Film deposited at 765°C from a $KNbO_3$ single crystal target. (b) Film deposited at 650°C from a ceramic target with [K]/[Nb] = 2.85. The diffraction peaks identified have been marked for convenience.



CMK6 Fig. 3. Rutherford Backscattering spectra of the films grown on (100) oriented MgO single crystal substrates. The points are the experimental results and the lines represent the fit obtained assuming the compositions sketched in the figure. (a) Film deposited at 765°C from a $KNbO_3$ single crystal target. (b) Film deposited at 650°C from a ceramic target with [K]/[Nb] = 2.85.

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