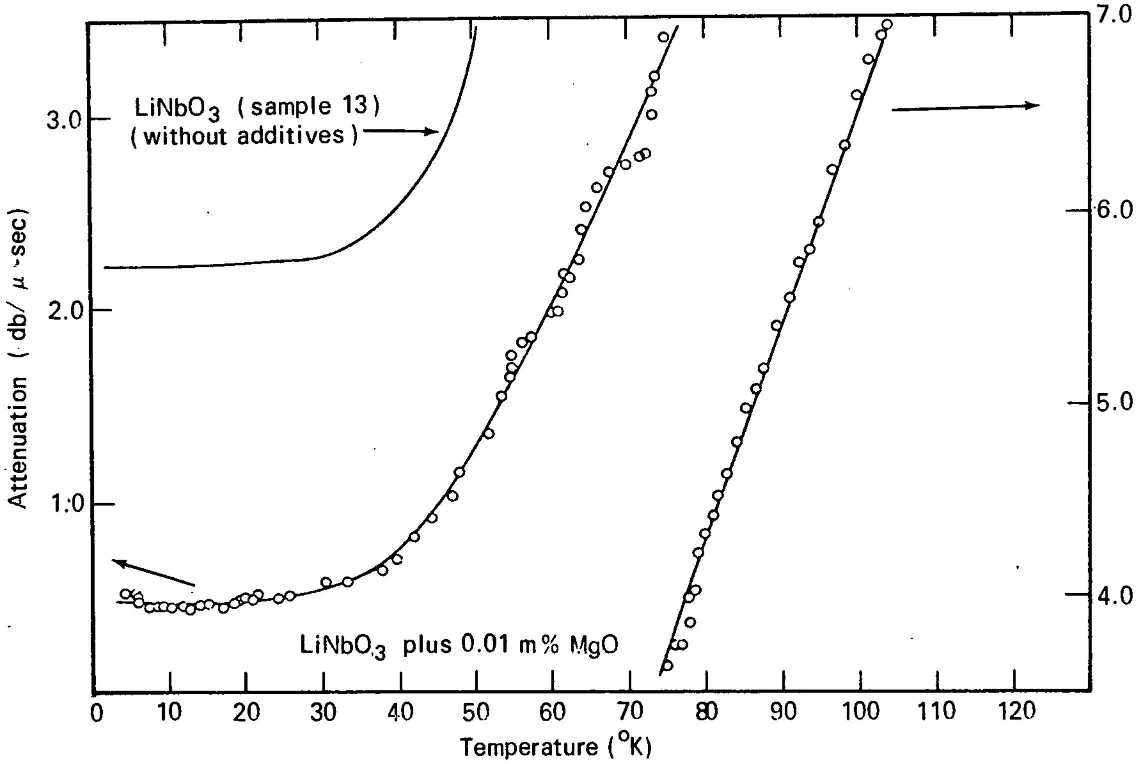
NASA TECH BRIEF

Magnesium Oxide Doping Reduces Acoustic Wave Attentuation in Lithium Metatantalate and Lithium Metaniobate Crystals



Longitudinal acoustic-wave attenuation in two samples of c-axis oriented $LiNbO_3$ as a function of temperature at X-band frequencies. The upper solid curve is due to $LiNbO_3$ without added impurities, and the other curves drawn through the open circles are due to $LiNbO_3$ doped with 0.01 mole % MgO. Two separate ordinates are used for the data on the doped crystals.

Lithium metatantalate ($LiTaO_3$) and lithium metaniobate ($LiNbO_3$) are potentially useful new piezoelectric materials which have recently been synthesized. They exhibit extremely low attenuation of microwave acoustic waves which makes them very attractive for use in delay lines and acoustic signal processing devices operating at microwave frequencies. Also, these materials have optical properties which make them well suited for many electro-optic and photoelastic applications.

During the growth of single crystal materiais, crystal imperfections may develop which will lead to

(continued overleaf)

a temperature-independent attenuation of acoustic waves. These imperfections may take the form of impurities, strains, or lattice site vacancies. Thus when measurements are made at a low temperature, the amount of attenuation measured serves to gage the quality of the crystal structure. In order to study this mechanism, single crystals of $LiNbO_3$ and $LiTaO_3$ were grown from melts having different stoichiometries, and different amounts of MgO were added to the melt. The results of these experiments showed that the addition of MgO served to lower the temperature-independent portion of the attenuation.

In addition to the temperature-independent attenuation, the attenuation observed in single crystal materials at room temperature included a temperature-dependent portion caused by the interaction of the sound waves with thermal phonons. Tentative results indicated that this temperature-dependent portion of the attenuation in $LiNbO_3$ and $LiTaO_3$ was also reduced by MgO doping.

The figure shows attenuation of longitudinal acoustic waves measured in $LiNbO_3$ as a function of temperature. The upper curve represents the lowest attenuation data obtained from measuring several samples without MgO. The lower curve shows the results obtained with a doped sample. The difference between these two curves is typical of the differences between doped and undoped samples. The attenuation at very low temperatures is decreased, but the general shape of the attenuation vs temperature characteristic is not altered. This would suggest that the addition of MgO to the melt has resulted in a more perfect crystal, because crystal perfection determines the attenuation at very low temperatures. In general, crystal imperfections are the only mechanism which can scatter the acoustic beam at low temperatures, since interactions with thermal phonons only become important at higher temperatures. This can be seen by the rise in the attenuation data above 40°K. These interactions with thermal phonons are not appreciably affected by MgO additions, indicating that the addition of MgO does not make gross changes in the phonon modes of the crystal.

Although chemical analysis has shown that Mg ions enter the grown crystal, it is not yet clear whether the improvement in acoustic quality is due to charge compensation or other mechanisms. No matter what mechanism is involved, MgO-doping results in a more perfect crystal.

Note:

The following documentation may be obtained from:

Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.65)

Reference:
NASA-CR-86145 (N69-24766), Investigation of Single Crystal Microwave Acoustical Delay Line Materials

Patent status:

No patent action is contemplated by NASA.

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