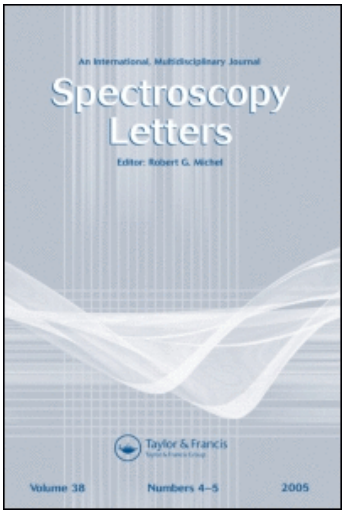
This article was downloaded by:
On: *30 January 2011*
Access details: *Access Details: Free Access*
Publisher *Taylor & Francis*
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Spectroscopy Letters
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597299

A STUDY ON THE RAMAN SPECTRUM OF THE $LiNbO_3$-DOPED Mg CRYSTAL AT LOW TEMPERATURE

Chan Jin[a]; Chaozhong Zhao[a]
[a] Department of Applied Chemistry, Harbin Institute of Technology, Harbin, China

Online publication date: 31 July 2001

To cite this Article Jin, Chan and Zhao, Chaozhong(2001) 'A STUDY ON THE RAMAN SPECTRUM OF THE $LiNbO_3$-DOPED Mg CRYSTAL AT LOW TEMPERATURE', Spectroscopy Letters, 34: 4, 437 — 442
To link to this Article: DOI: 10.1081/SL-100105090
URL: http://dx.doi.org/10.1081/SL-100105090

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.informaworld.com/terms-and-conditions-of-access.pdf

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

SPECTROSCOPY LETTERS, 34(4), 437–442 (2001)

A STUDY ON THE RAMAN SPECTRUM OF THE $LiNbO_3$-DOPED Mg CRYSTAL AT LOW TEMPERATURE

Chan Jin and Chaozhong Zhao

Department of Applied Chemistry, Harbin Institute of Technology, Harbin, 150001, China

Downloaded At: 03:11 30 January 2011

ABSTRACT

The Raman Spectra of $LiNbO_3$:MgO (6.7 mol%) at both low temperature and room temperature were studied. The results showed that the crystal structure has changed little after doping Mg^{++}. At room temperature the lattice distorted a little, which caused the appearance of coupling phenomenon of some individual scattering peaks. As the temperature decreased, the coupling reduced gradually.

Key Words: $LiNbO_3$:MgO Crystal; Raman spectrum; Low temperature; Laser

INTRODUCTION

The $LiNbO_3$ crystal is now widely used in laser techniques for its superior electro-optic and nonliner characteristics. Nevertheless, the applications are somewhat limited due to its poor ability of resisting laser damage. Recently, some researchers attempt to enhance this ability by doping Mg^{++} in $LiNbO_3$ crystals. In 1980, Zhong Giguo et al. found that

Copyright © 2001 by Marcel Dekker, Inc. www.dekker.com

doping 4.6 mol% of MgO in $LiNbO_3$ made an improvement of laser damage resistance by two orders of magnitude.This was a significant advancement in the study of $LiNbO_3$ applications. Hence, a further study of the characteristics of the $LiNbO_3$:MgO crystal is necessary. In this paper, we studied the Raman spectra of the $LiNbO_3$:MgO crystal (doping with 6.7 mol% Mg^{++}) at both low temperature and room temperature. We also compared these spectra with that of the pure $LiNbO_3$ crystal, and no clear distinction had been found. No obvious frequency shift of the scattering peak appeared. There was coupling between the two low frequency modes at room temperature. This phenomenon disappeared at low temperature, and meanwhile, the peak width became narrower. This meant that the symmetry of the crystal was not changed when the Li+ was substituted equivalently by Mg^{++} and the strong Raman spectra of the A_1-mode and E-mode were determined mainly by the characteristic vibration of the oxygen octahedron (NbO_3).

Downloaded At: 03:11 30 January 2011

Crystal Structure and Vibration Modes

At room temperature , $LiNbO_3$ is an ferroelectric crystal with space group $R_{3c}(C_{3V}^6)$, and point group (C_3v) in which each crystal cell contains two molecules. In other words, it contains ten total atoms. From the analysis of the lattice vibration on the basis of the symmetry group, it is well known that the vibration modes are as follow :

$$4A_1 + 9E + 5A_2 \tag{1}$$

where A_1 and E are Raman and infrared active modes respectively, while A_2 are not Raman active modes.

The Characteristics of the Raman Spectrum at Room Temperature

The experimental apparatus used for this work is a Raman spectrometer, Model SPEX 1403, configured with a microcomputer system. Specimens of size of $10 \times 10 \times 2\,mm^3$ were prepared from a $LiNbO_3$:MgO (6.7 mol%) crystal provided by the crystal laboratory of the Harbin Institute of Technology.

Figure 1 shows the Raman spectra of the A_1 mode (a) and E mode (b) at room temperature, respectively. From Figure 1(a) we can see two scattering peaks of low frequency A_1 modes overlap each other, so that they are indistinguishable. From the profile of the peak, we can assume that it has resulted from two peaks in superimposition. The non-harmonic interaction

between the modes was enhanced by lattice distortion due to the large amount of Mg^{++} doping in the crystal lattice of $LiNbO_3$, therefore the coupling of the two low frequency A_1 modes was enhanced, which resulted in superimposition of the scattering peaks. The other two scattering peaks of the A_1 mode remained unchanged.

From Figures 1(a) and 1(b) we can see eight scattering peaks of the E mode. As compared with the result of the group theory analysis, the peak of the $\Delta\gamma \sim 630\,cm^{-1}$ did not exist[1]. Table 1 gives the Raman frequency shifts of the modes.

Because the $277\,cm^{-1}$ vibration of A_1 (TO) model cannot be discriminated when doping 6.7 mol% Mg^{++}, it is difficult to determine whether it is due to a frequency close to $258\,cm^{-1}$ or due to other affecting factors rather than the change of frequency. This problem cannot be solved by

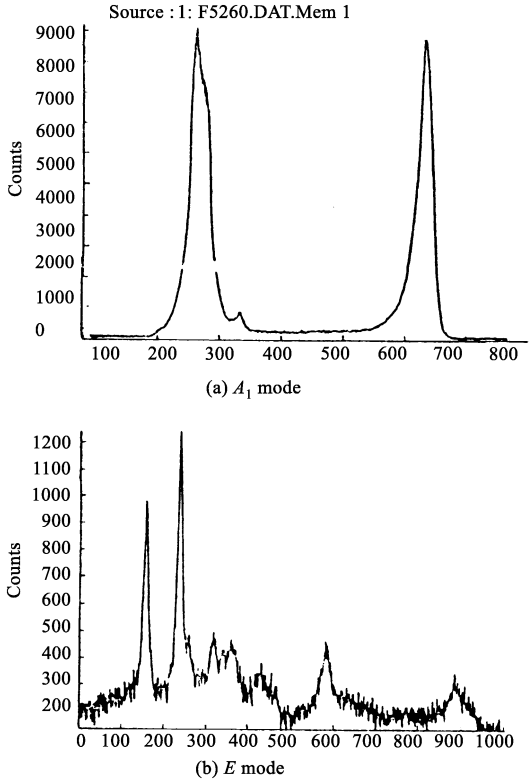


Figure 1. The Raman spectra of the A_1 mode and E mode at room temperature.

Downloaded At: 03:11 30 January 2011

Table 1. Raman Frequencies of Vibration Modes of the $LiNbO_3$:MgO (6.7 mol%) at Room Temperature (in cm^{-1})

Mode	Band Location (in cm^{-1})							
A_1			251	334		614		
E	155	236	265	325	371	431	582	890

measuring a Raman spectrum at room temperature, so we should study the Raman spectrum at low temperature.

The Raman Spectrum of the $LiNbO_3$:MgO(6.7 mol%) Crystal at Low Temperature

We first obtained the Raman spectra of the $LiNbO_3$:MgO crystal at low temperature. Figures 2 and 3 show the measurement results of A_1(TO) mode under coordinate X(ZZ)Y and E (TO) mode under X(ZY)Z respectively during the process of the temperature drop. The degree of superimposition of the scattering peaks of two low frequency A_1 (TO) reduces with the decrease of temperature, until 260 K; the A_2 peak reappears sharply, as shown in Figure 2. Further decrease of temperature separates the two peaks far apart from each other, this means that the nonharmonic interaction between the two modes are weakened. Actually there is no frequency shift. In Figure 3, it is obvious that the intensity of the scattering peak of the E mode is increased during the process of the temperature drop.

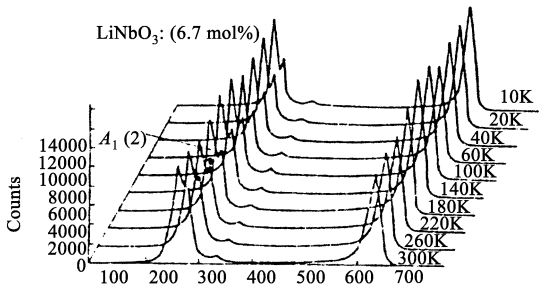
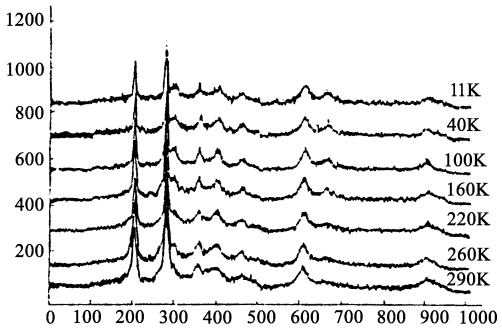


Figure 2. The measurement results of A_1(TO) mode under co-ordinate X(ZZ)Y during the process of temperature drop.

Downloaded At: 03:11 30 January 2011



Figrue 3. The measurement results of E(TO) mode under co-ordinate X(ZY)Z during the process of temperature drop.

Downloaded At: 03:11 30 January 2011

Table 2. Raman Frequencies of Vibration Modes of the $LiNbO_3$:MgO (6.7 mol%) at 11 K(cm^{-1})

Mode	Band Location (in cm^{-1})								
A_1				277 285	339			620	
E	157	240	269	328	374	435	589	638	897

SUMMARY

We have revealed that there is no distinct effect of doping on the vibrational modes in Raman spectra at both low temperature and room temperature. Table 2 gives the Raman frequency shifts of the modes at 11 K. Comparing Tables 1 and 2, it is known that at room temperature and low temperature, the peak of Raman spectra of the $LiNbO_3$:MgO crystal was not shifted and distorted , it shows that the crystal structure of $LiNbO_3$:MgO was not changed after substituting Li^+ by Mg^{++}. The stronger Raman spectra of the A_1(TO) and E(TO) vibrational modes were contributed to mainly by the characteristic radicals of the oxygen octahedron. The coupling of individual peaks of vibration was observed due to the crystal lattice distortion at room temperature. This coupling was also weakened at low temperature.

REFERENCES

1. Schauffle, R.F.; Weber, H.J. Phys. Rev. **1966**, *152*, 705.
2. Boudon, A.; Sapriel, J. Phys. Rev. **1980**, *166*, B21.
3. Xu Liangying; Zhu Yanan. Leser **1978**, *5*, 127.
4. Zhong Giguo; Jiu Jian; Wu Zhangkang. Measurement of Photorefraction of the $LiNbO_3$ Doped Mg Crystal. Journal of NanKai University, 1980; *1–2*, 59.
5. Li Minghua; Zhao Yequan. Study on the Photorefraction Effect of Ce:Mn:Ln Crystal. Chinese Science Bulletin **1993**, *38*, 563.

Received July 15, 2000
Accepted February 7, 2001

Downloaded At: 03:11 30 January 2011