Fig. 2 shows the Rutherford backscattering-channeling spectra of samples at different fluences. For the sample implanted with 100 keV H-ion at the fluence of 1.0×10^{17} ions/cm^2, there is an obvious damage peak created in the crystal, about 0.23 dpa of damage level according to the simulation result from SRIM2008[4]. However, for the sample implanted with 100 keV He-ion, at the same fluence, the damage peak almost approaches the amorphization, and the corresponding damage level is about 2.2 dpa. It is obvious that He-ion implantation created greater damage level, comparing with the H-ion implantation.

Therefore, in the case of 100 keV H-ion or He-ion implanted $LiTaO_3$ single crystal, H-ion implantation creates a lower damage level than the He-ion implantation does, but the yield of oxygen vacancy produced by H-ion implantation is far higher than that produced by He-ion implantation.

References

[1] P. Günter, J. P. Huignard, Photorefractive Materials and Their Applications: Materials, Springer Verlag, (2007).
[2] K. M. Wang, F. Chen, et al., Opt. Commun., 196(2001)215.
[3] L. A. Kappers, K. L. Sweeney, et al., Phys. Rev., B31(1985)6792.
[4] J. F. Ziegler, SRIM, Available from: < http://www.srim.org/ >.

3 - 13 Energy Loss Effects on Absorption Edge of $LiTaO_3$ Irradiated by Energetic Heavy Ions

Pang Lilong, Wang Zhiguang, Sun Jianrong, Yao Cunfeng, Wei Kongfang, Shen Tielong, Cui Minghua
Zhu Yabin, Sheng Yanbin, Li Yuanfei, Chang Hailong, Wang Ji and Zhu Huiping

$LiTaO_3$ exhibits prospects for optical waveguide fabrication by ion irradiation/implantation[1-3]. This work is focused on the energy loss effects of MeV~GeV ions irradiation on the $LiTaO_3$.

The z-cut $LiTaO_3$ single crystals, with the size of $10\times10\times1$ mm^3, were irradiated by 6 MeV Xe-ion at the fluences in the range of $1.0\times10^{12}\sim1.0\times10^{15}$ ions/cm^2, or 30, 375, 1980 MeV Kr-ion at the fluences in the range of $1.0\times10^{11}\sim1.0\times10^{13}$ ions/cm^2, respectively. Then the samples were analyzed by using UV spectroscopy. We have used the SRIM 2008 code [16] to simulate the energy loss of incident ions in the samples. Here we give a parameter η, integral energy loss which is described as following formula.

$$\eta = \int_0^{R_p} S_{\text{energy loss}}\, \mathrm{d}x_{\text{depth}}$$

Where, R_P is ion range; $S_{\text{energy loss}}$ is nuclear energy loss or electronic energy loss.

In Table 1, the corresponding integral nuclear energy loss η_n and integral electronic energy loss η_e are given, respectively.

Table 1 The integral nuclear (η_n) and electronic (η_e) energy loss of energetic Xe or Kr ions in $LiTaO_3$

Incident ions	6 MeV Xe-ion	30 MeV Kr-ion	375 MeV Kr-ion	1.98 GeV Kr-ion
η_n(MeV/ion)	6.37	6.36	8.27	10.2
η_e(MeV/ion)	4.16	27.8	370	1968

From Fig. 1, it can be seen that all the absorption edges of irradiated samples appear red-shift, and the red-shift increases with increasing fluence. Fig. 2 shows the absorption edge of irradiated $LiTaO_3$, corresponding to the optical absorption near 2.4 in Fig. 1, as the functions of fluence. In the case of 6 MeV Xe-ion irradiated samples, the red-shift of absorption edge shows a weak dependence of fluence. Energetic Kr-ion irradiation, however, creates a significant red-shift of absorption edge.

Fig. 3 shows the absorption edge as a function of η_e when the fluence is 1.0×10^{11}, 1.0×10^{12}, 1.0×10^{13} ions/cm^2, respectively. It can be seen that at a fix fluence, the absorption edge increases with increasing η_e. Note that all of the η_n in Table 1 are almost in the same order of magnitude. It seems that electronic energy loss plays an important role to contribute to the red-shift of absorptio edge of $LiTaO_3$. Nuclear energy loss is very limited to dominate the red-shift of absorption edge of $LiTaO_3$.

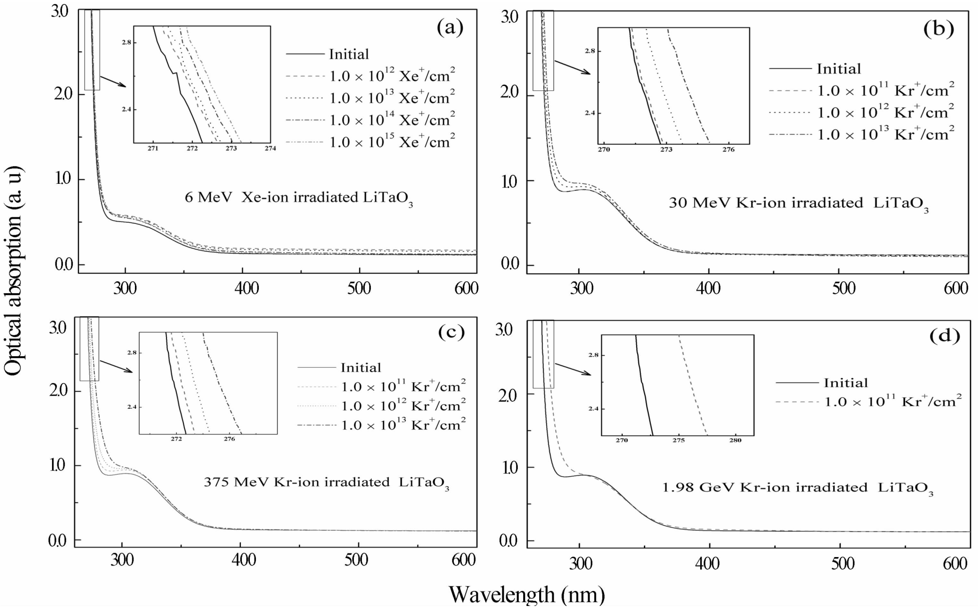

Fig. 1 The UV spectra of $LiTaO_3$ under energetic ion irradiation. The ion irradiation conditions are given in the figure.

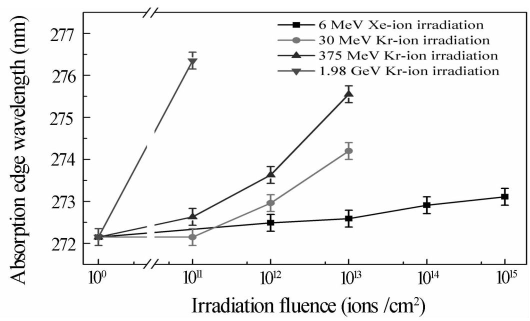

Fig. 2 The absorption edge varying with ion fluence. The ion conditions are given in figure.

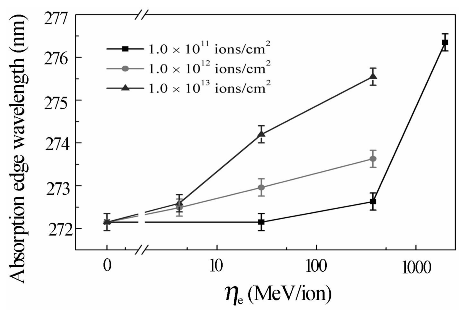

Fig. 3 The absorption edge varying with the integral electronic energy loss η_e.

The study shows that the mechanisms of red-shift of absorption edge are different according to the energy of incident ions. In 6 MeV Xe-ion irradiated samples, nuclear energy loss dominates the red-shift of absorption edge of $LiTaO_3$, but it is very limited. For the irradiation by Kr-ion with energy exceeding 30 MeV, however, the electronic energy loss, which makes much more contribution than the nuclear energy loss, is mainly responsible for the significant red-shift of absorption edge.

References

[1] V. V. Atuchin, Nucl. Instr. and Meth., B168(2000)498.
[2] G. Fu, X. F. Qin, Journal of the Korean Physical Society, 56(2010)1364.
[3] P. Liu, Q. Huang, et al., Appl Phys., B108(2012)675.