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3 - 12 Damage Production in $LiTaO_3$ Crystal Induced by H- and He-ions Implantation

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Lithium tantalate ($LiTaO_3$) is an important multi-functional material because of its excellent piezoelectric, ferroelectric, acousto-optic and electro-optical effects[1]. Recently, this kind of crystal exhibits a promising prospect for optical waveguide fabrication by light ion implantation[2]. In this work, we will focus on the damage induced by H/He ions implantation in the $LiTaO_3$ single crystal.

Z-cut $LiTaO_3$ were implanted by 100 keV H-ion and He-ion at the fluences of 1.0×10^{16} and 1.0×10^{17} ions/cm^2, respectively. Fig. 1 shows the transmission spectra of the samples at different fluences. When the implantation reaches a certain fluence, the transmittance decreases in the visible region and the near-UV region. This indicates that great many point defects of oxygen vacancies are produced in the crystal, which results in a strong optical absorption near the 460 nm[3]. It also can be found that the optical absorption induced by H-ion implantation is more intense than that induced by He-implantation. This implies that H-ion implantation created more oxygen vacancies in the crystal.

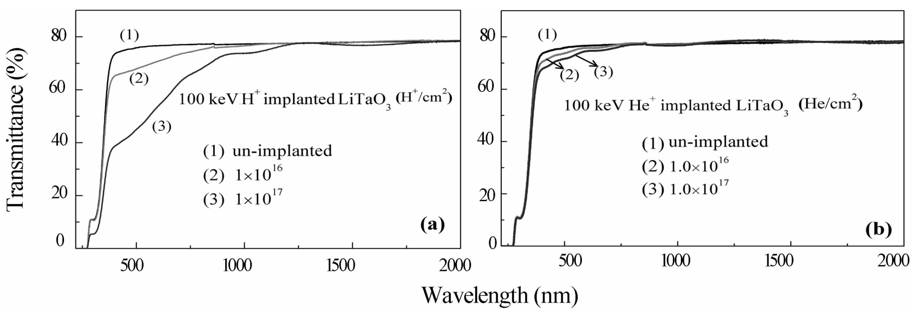

Fig. 1 The transmission spectra of samples at different fluences.

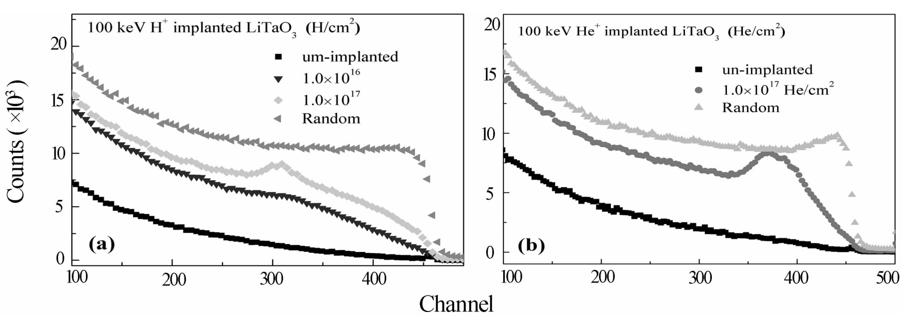

Fig. 2 The Rutherford backscattering-channeling spectra of samples at different fluences.

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.

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

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$LiTaO_3$ 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 $LiTaO_3$.