Crystal growth and photorefraction of uranium-doped lithium niobate series crystals

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Lithium niobate crystal (LN), also called the "silicon of photonics," is a famous versatile crystal with superior and diverse optical-electrical properties [1-4]. As an important photorefractive (PR) material, LN plays a significant role in holographic storage. But its PR properties still cannot meet the commercial requirements. Doping different ions is an effective way to adjust the PR properties of LN. In recent years, more attention has been paid in doping ions with valence equal to or higher than +5 which tend to occupy the Nb-site in LN and are more beneficial to improve the photorefraction of LN [5-8].

In recent years, uranium-doped lithium niobate series crystals with 1 inch in diameter and 11 cm in length had been grown successfully by the modified vertical Bridgman method. Though UO_2 was chosen as the raw material, U^{4+}, U^{5+} and U^{6+} ions eventually existed in LN: U [9]. Comparing with pure congruent LN crystal, the absorption edge of LN: U significantly red shifted about 184–218 nm as the concentration enhanced. A strong wide absorption in the region of 300–600 nm and an absorption peak centered at 740 nm were observed, which was beneficial to realize the multi-wavelength holography. PR properties of LN: U in the visible band (488nm, 532nm and 671nm) were systematically investigated for the first time. The optimal concentration of UO_2 was 0.6mol%, due to it made LN possess good comprehensive photorefraction of the saturation diffraction efficiency, response speed and sensitivity reached 1.98 s and 2.24 cm/J at 488nm, respectively. Based on it, magnesium and uranium co-doped lithium niobate crystals (LN: U,Mg) were investigated furthermore. The OH^- absorption spectra of LN: U,Mg crystals showed that 7mol% Mg^{2+} reached the real doping threshold concentration in LN: U. The absorption edge of LN: U,Mg had a significant violet shift relative to LN: U, while LN: U,$Mg_{7.0}$ had a red shift relative to LN: U,$Mg_{5.0}$. The photorefractive properties of LN: U,Mg crystals were studied and could also realize holography at 488nm, 532nm and 671nm. The response time of LN: U,Mg at 532nm was shortened to about 2s, which was similar to LN: U, and was twice faster than LN: Fe,Mg. Besides, it was found that the optical damage resistance of LN: U,$Mg_{7.0}$ crystal was $2.36\times10^5 W/cm^2$, which has increased by 1 order of magnitude compared with LN: Mo,Hf crystal. In addition, the occupation of doping ions and photorefractive centers are discussed in these crystals. Uranium-doped lithium niobate series crystals are candidates for holographic data storage at multiple visible wavelengths.

References

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