THz Spectrum of KDP Crystal

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***Abstract*—THz time domain spectrum of KH_2PO_4 crystal has been measured in the range from 0.2THz to 1.6 THz. Ultraviolet-visible -infrared spectra have been measured in the range from 190 nm to 1600nm at the room temperature.**

The energy band gap Eg of KH_2PO_4 Crystal is 5.90eV. There is a wide band of the phonon absorption in the KDP crystal. The frequency ω_{LO} of the longitudinal optical phonon model LO is about 1.29×10^{15}Hz. Frequency ω_{TO} of the transverse optical phonon model TO is about 6.28×10^{12}Hz.

I. INTRODUCTION

Potassium dihydrogen phosphate KH_2PO_4 (KDP) Crystal was developed as a good nonlinear optical crystal. It is excellent electro-optic crystals with high electro-optic coefficient, widely used as electro-optical modulators. The KDP is commonly used for frequency conversion and electro-optical switching[1]. It is usually used for doubling, tripling and quadrupling of a Nd:YAG laser at the room temperature. U. K. Sapaev et al. investigated the frequency doubling of spatially and temporally limited laser light in a collinear, type-II phase matched configuration[2]. G. Focht et al. efficiently extracted an ultraviolet femtosecond pulse train of milliwatt average power and 100 MHz repetition rate from a colliding pulse mode-locked dye laser by intracavity frequency doubling in KDP. The ultraviolet and visible outputs, which are comparable in power and pulse duration, are perfect synchronized with each other[3].

The KDP is tetragonal crystal system (pattern: 35-807), D_{2d} point group, and I42d space group with the lattice constants a=b=0.7453nm, c=0.6975nm. The density is ρ=2.3325g/cm^3. The high-quality KDP is easy to grow with simple crystal form and good optical homogeneity. It can be used to implement phase matching with large transmission bandwidth. The crystal is also well-known hydrogen-bonded ferroelectric[4]. In addition, the ferroelectric phase transition temperature Tc=123K. Geometrical quantum effects appear to play a central role[5].

II. EXPERIMENT

The KDP is a water-soluble crystal. The sample was cut along the (001) plane and twin polished. The thickness of sample was 1.447 mm.

The ultraviolet-visible-infrared spectra have been measured by ShiMaDZu Corporation's spectrum analyzer at the room temperature, and the wave length is from 190 to 1600nm.

The THz time domain spectrum is measured by THz time-domain spectroscopy system in a frequency range from 0.2THz to 1.6 THz.

There is a measured gap in the spectrum from 150 THz to 1.6 THz.

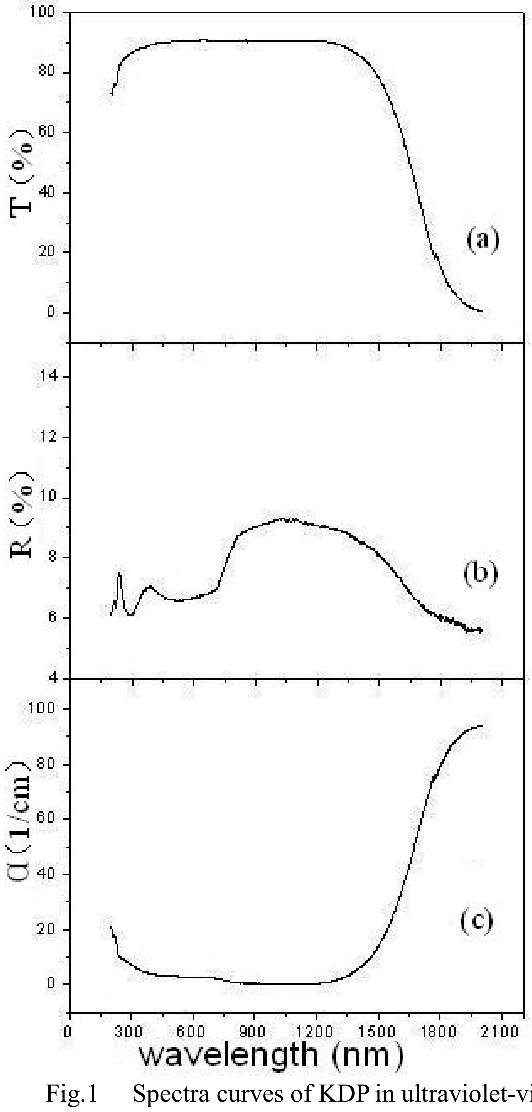

Fig.1 Spectra curves of KDP in ultraviolet-visible-infrared band. (a): Transmittance T(λ) , (b): Reflectance R(λ) , (c): Absorption coefficient $\alpha(\lambda)$.

III. RESULTS AND ANALYSIS

The ultraviolet-visible-infrared spectra of reflectance T(λ) and transmission R(λ) of KDP sample were measured as shown in Fig. 1 (a) and (b). The calculated absorption coefficient $\alpha(\lambda)$ curve was shown in Fig.1(c). The transmission T(λ) increased

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sharply from 190 to 472nm. The T(λ) was 90% in the region of wavelength from 472nm to 1262nm. And the T(λ) decreased sharply from 1262nm to 1600nm. The reflectance R(λ) curve is shown in Fig.1(b). The R(λ) is smaller than 10% in the region from 190nm to 1600nm. The absorption coefficient α(λ) curve is shown in Fig.1(c). We can found the intrinsic absorption edge of the KDP is at 210nm from the Fig. 1(a) and (c), and the energy band gap Eg of KDP is 5.90eV. We can also found the lattice absorption (or phonon absorption) edge of the KDP is at about 1460nm when α(λ) is $40cm^{-1}$. It is to say that the wavelength of longitudinal optical model LO is about 1460nm, and the frequency ω_{LO} is 1290THz.

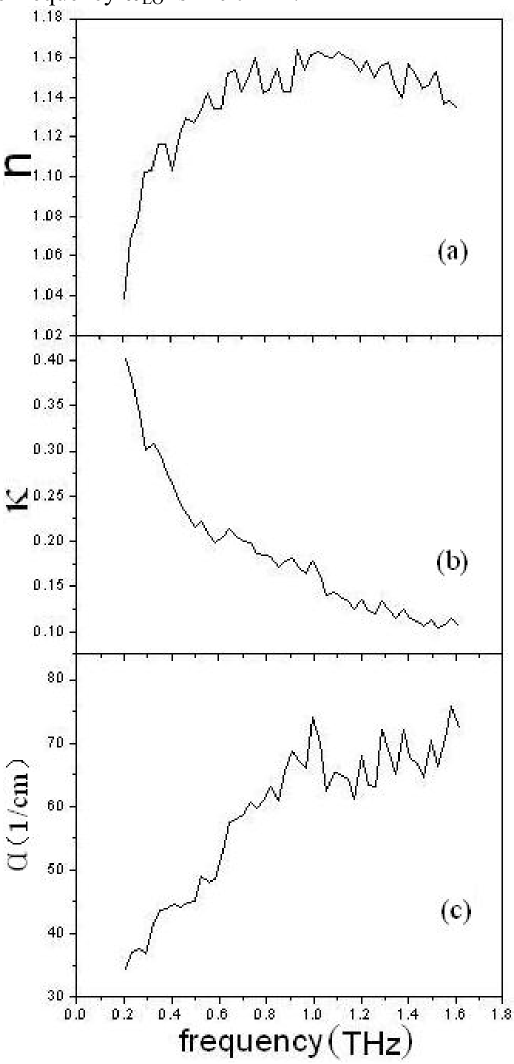

Fig. 2 Spectra curves of KDP in THz band.
(a): Refractive index curve n(ν), (b): extinction coefficient κ(ν), (c): Absorption coefficient α (ν)

THz time-domain spectrum of the KDP crystal had been measured at room temperature. Absorption coefficient α(ν) of was obtained from the Fourier transform and data calculated. The refractive index n(ν) was calculated from the relations between optical constants. The refractive index n(ν) of the KDP increases from 1.04 to 1.16 when the frequency increasing from 0.2THz to 1.0THz as shown in Fig. 2 (a). The n(ν) almost no changes from 1.0 THz to 1.6 THz. The extinction index κ(ν) decreases with the frequency increasing as shown in Fig. 2 (b). The absorption coefficient α(ν) is larger than $30cm^{-1}$ as shown in Fig. 2 (c). The α(ν) increased with frequency increasing. The absorption is from the transverse optical phonon model TO. We select a point, the α(ν) is $60cm^{-1}$ at 1.0THz, as the frequency ω_{TO} of the transverse optical phonon, and it is about 6.28THz. Real part $\varepsilon_1(\nu)$ and imaginary part $\varepsilon_2(\nu)$ of dielectric function are shown Fig. 3. The real part of dielectric function $\varepsilon_1(\nu)$ also increased from 0.9185 to 1.325 with the frequency in the region 0.2 - 0.94 THz. The $\varepsilon_1(\nu)$ is near 1.3 in the regions 0.94-1.6 THz. The imaginary part of dielectric function $\varepsilon_2(\nu)$ decreased from 0.8322 (at 0.2THz) to 0.2430 (at 1.6 THz) with increasing frequency.

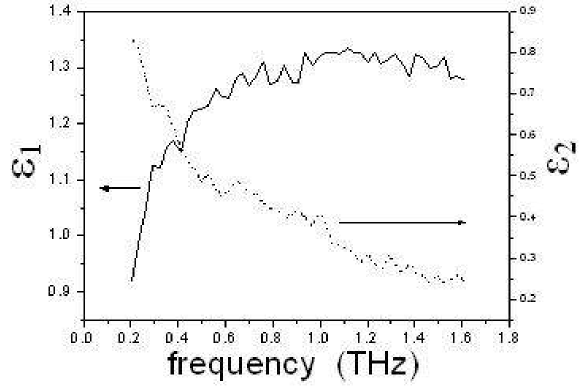

Fig .3 Real and imaginary part of dielectric function

IV. CONCLUSION

The energy band gap Eg of the potassium dihydrogen phosphate KH_2PO_4 (KDP) Crystal is 5.90eV.

There is a wide band of the phonon absorption in the KDP crystal. The frequency ω_{LO} of the longitudinal optical phonon model LO is about 1.29×10^{15}Hz. And the ω_{TO} of the transverse optical phonon model TO is about 6.28×10^{12}Hz.

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