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Ultra-Broadband Terahertz Phonon-Polariton Dispersion in Centrosymmetric Strontium Titanate

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1. Introduction

The polariton dispersion relation is the very important basic properties for such an application of the frequency-tunable terahertz laser radiation. Nevertheless, the study of the dispersion relation including the damping of polariton has been quite few. Up to the present the polariton dispersion relation was mainly studied by Raman scattering in the forward scattering geometry. However, there are two serious disadvantages. At first the uncertainty of wave vector of scattering light at small angle scattering causes the difficulty for the determination of a damping factor of polariton. Secondly, it is impossible to study Raman inactive polariton in centrosymmetric crystals. Therefore, terahertz time-domain spectroscopy (THz-TDS) is a powerful tool to study phonon-polariton dispersion relation.[1,2]

2. Experimental

The (100) plate of a $SrTiO_3$ single crystal from Furuuchi Chemical, whose size is 10 × 10 × 0.5 mm^3 with two optically polished surfaces, was used in this study. The dielectric constant was investigated by the broadband polarized THz-TDS from 0.2 to 6 THz using transmission and reflection measurements (TAS7500SU, Advantest Co.).[3,4] The IR region between 4 and 36 THz was measured by the FT-IR reflection method (Biorad 575C).

3. Results and discussion

Ultra broadband dielectric constant

The real and imaginary parts of a dielectric constant of a $SrTiO_3$ crystal were determined in the frequency range between 0.2 and 36 THz. The frequency dependence of a real part was shown in Fig. 1. The three TO modes with T_{1u} symmetry are clearly observed.

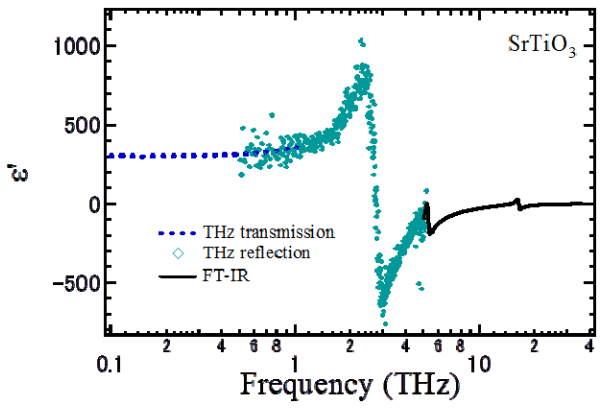

Fig. 1 Real part of a dielectric constant of $SrTiO_3$.

Polariton dispersion

Figure 2 shows the complex dispersion relation from 0.2 to 36 THz, which was determined from the complex refractive index which reflects the infrared active and Raman inactive T_{1u} symmetry phonon-polariton.

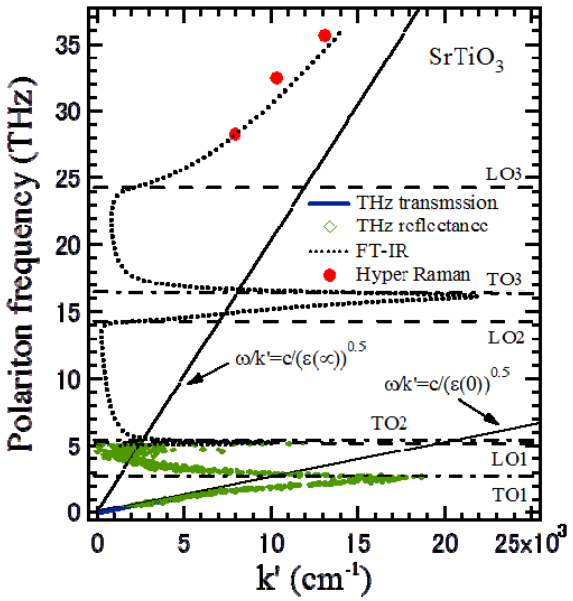

Fig. 2 Polariton dispersion relation of $SrTiO_3$.

3. Conclusions

The ultra-broadband dispersion relation of Raman inactive phonon-polaritons was studied in a centrosymmetric strontium titanate crystal. The resonance below the lowest TO mode frequency from the intrinsic anharmonicity of a ferroelectric soft phonon reported in $LiNbO_3$ and $LiTaO_3$ was not observed. The observed dispersion relation of T_{1u} symmetry polaritons higher than 25 THz is in agreement within the experimental uncertainty with the phonon-polariton frequencies determined using the forward hyper Raman scattering reported by K. Inoue.[5]

References

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