Spectroscopic Measurement of Terahertz-wave based on Wavelength Conversion

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We propose a spectroscopic measurement in the terahertz region based on parametric wavelength conversion between terahertz wave and infrared using a nonlinear crystal. Wavelength conversion techniques with frequency stabilized infrared beams allow the spectra in the terahertz region to be determined their frequency as traceable to the national standard in the Infrared region. In this study, as a reference infrared beam, we used high-brightness 1.5 µm beam generated by injection-seeded PPLN optical parametric generator and KTA optical parametric amplifier pumped by Nd:YAG MOPA system for terahertz wave spectroscopic measurement. When detecting the terahertz-wave, mixing the terahertz-wave with the intense pumping (reference) beam at the input region of the nonlinear $MgO:LiNbO_3$ crystal, up-converted signal photons are created in difference-frequency mixing. Then, by injecting the terahertz-wave satisfying noncollinear phase matching condition, the up-converted signal was seeded and parametrically amplified by the nonlinear $MgO:LiNbO_3$ optical parametric amplifier [1].

In our experimental apparatus, shown in Figure 1, the frequency stabilized pumping beam is generated using a PPLN-OPG seeded by a stabilized 1.539 µm laser beam (continuous wave, power: 4 mW) as traceable to the national standard. The generated pulses are amplified by a KTA-OPA amplifier pumped by a SLM Nd:YAG laser based MOPA system (duration: ~ 1 ns, energy: > 3 mJ/pulse). Figure 2 shows the 1064 nm pumping energy dependence of output energy of frequency stabilized 1.5 µm beam when the amplified seeding peak energy of 40 µJ/pulse. As the pumping 1064 nm energy increases, as the output energy of stabilized 1.5 µm also increases monotonically. When the pumping 1064 nm energy is 1.7 mJ/pulse, the maximum output 1.5 µm energy is about 0.35 mJ/pulse. The frequency of up-converted beam for the terahertz-wave spectroscopic measurement is detected using "spectral drill" cavity [2]. We used a $MgO:LiNbO_3$ crystal with a high-resistivity Silicon prism as an efficient input coupler for the terahertz-waves. The angle between the frequency stabilized pumping beam and the signal beam satisfies the non-collinear phase-matching conditions in the crystal. These are very promising for extending applied research into the terahertz region, and we expect that these will open up new research fields such as wireless information communications in the terahertz region.

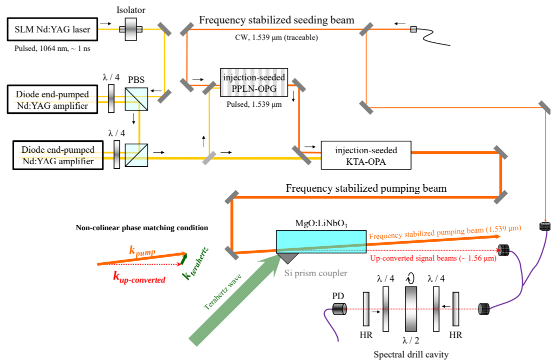

Figure 1. Experimental apparatus.

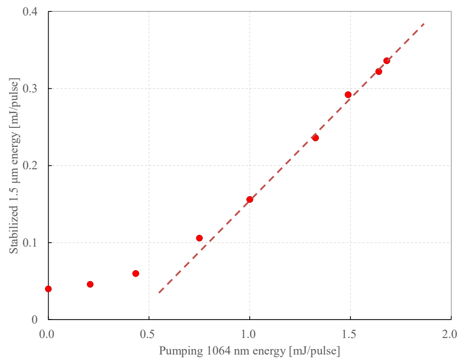

Figure 2. Pumping 1064 nm energy dependence of output frequency stabilized 1.5 µm peak power.

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References

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