Recent progress on the generation of ultrabroadband coherent infrared pulses

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1. Introduction

Our group has been developing ultrabroadband coherent infrared spectroscopy system for studying solid state physics. Using hollow fiber compressed sub-20 fs optical pulses and air as nonlinear media, so far we realized the time domain measurement of infrared pulses in the range of 1−150 THz [1]. Also we applied the system to the time-resolved measurements of semiconductors such as silicon and indium antimonide [2,3]. However, we could not obtain an enough signal to noise ratio for components with frequencies above 100 THz. In the present paper, controlling the polarization of two-color pulses for plasma excitation[4,5], we have enhanced the intensity of coherent infrared pulses by at least a few times at the frequency of 150 THz (2 μm).

2. Experiments

In experiments, we employed a titanium sapphire laser amplification system with a pulse width of 35 fs as a light source. We focused hollow fiber compressed sub-20 fs pulses together with their second harmonics (SH) in air. We placed a β-BBO crystal with a thickness of 100 μm for SH generation after the parabolic mirror with an effective focal length of 76 mm and inserted a true zero-order half wave plate (HWP) with a design wavelength of 775 nm and a thickness of 43 μm between the β-BBO crystal and the plasma. This wave plate works as a half wave plate for optical pulses at 775 nm and as a full wave plate at 388 nm. Hence we can make the polarizations of fundamental and SH pulses parallel each other with it.

3. Results and discussion

Figure 1 shows the intensity spectra of the coherent pulses with and without the HWP. The intensity was much enhanced by controlling the polarization. In a low frequency range below 50 THz, the enhancement of the intensity was not so significant, however, the magnification factor was higher in a high frequency range than in a low frequency range: at 150 THz (2 μm) a few times at least. When we also inserted an α-BBO crystal, which has been used for controlling the phase difference of two-color pulses [4,5], we could not recognize any enhancement. While in a quartz crystal, the difference between the group delay dispersion (GDD) is small (2.2 fs^2 (5.1~5.3 fs^2) for fundamental (SH) pulses), the difference is much larger in α-BBO with a thickness of 100 μm (5.1~7.9 fs^2 (16~23 fs^2) for fundamental (SH) pulses). Hence it will be certain that the effect of pulse stretching is dominant for sub-20 fs pulses.

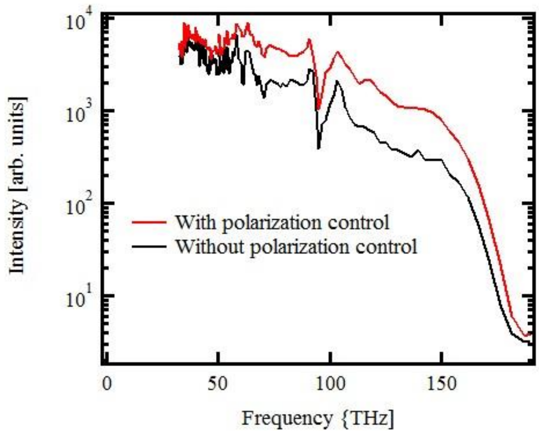

Fig. 1 Intensity spectra of ultrabroadband coherent infrared pulses with (red curve) without polarization control using a true zero order half wave plate.

3. Conclusions

In conclusion, we have enhanced the intensity of ultrabroadband coherent infrared pulses by adjusting polarization of two-color input pulses using a true zero order half wave plate. The magnification factor realized with the wave plate is much larger than that reported in the terahertz range. This makes us expect that the present observation in the mid and near infrared involves novel physics.

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