Pulse characterization based on two-dimensional spectral shearing interferometry for Cr:ZnS oscillator pulses

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1. Introduction

Recently, mode-locked Cr:ZnS and Cr:ZnSe lasers attract attention in the field of ultrafast optical science due to their outstanding laser properties in the mid-infrared (mid-IR) [1]. Their emitted ultrashort mid-IR pulses find potential applications in many industrial and scientific fields such as vibrational spectroscopy and strong-field phenomena. Therefore, a reliable and sensitive pulse characterization technique is essential for the further development of the laser system and its applications. Here, we report on the design and development of a two-dimensional spectral shearing interferometry (2DSI) setup to characterize the pulses of our homemade Cr:ZnS laser system which emits pulses centered at 2.3 µm [2,3]. To the best of our knowledge, this is the first direct spectral phase measurement for Cr:ZnS oscillator pulses.

2. Experimental Setup

The 2DSI setup, whose schematics is illustrated in Fig. 1, is one of the spectral shearing techniques that enable the direct retrieval of the pulses' spectral phase [4,5]. Firstly, the pulse to be measured (red path) gets created by using the surface reflection of a Germanium window (Ge, t = 5 mm). The other part disperses through it and then consecutively through an additional 10 mm of Ge. The relatively large group velocity dispersion (GVD, 2503 fs²/mm) of Ge at 2.3 µm, is used to broaden the pulse. Thereafter, it travels along the yellow-orange path into an interferometer whereupon the relative delay of the pulse pair (orange and yellow path) is adjustable through the interferometer arm controlled by stage-τ_{Shear}. It is used to tune the shear frequency. Stage-τ_{CW} is for the other arm. It has a resolution of 0.1 µm. Through step-wise increment of it, a spectral phase-dependent SFG-signal modulation is achieved due to the chirped pulse pair's quasi-CW behavior. The stage-τ_{SFG} enables an adjustment of the SFG up-conversion frequencies through changing the relative position of the pulse to be measured with the other two. The SFG-signal is created by focusing the pulse to be measured (red path) with the other two onto a 0.3 mm thick $AgGaS_2$ (AGS) crystal ($d_{eff} \approx 10$ pm/V) by using a parabolic mirror (f = 76.2 mm). After coupling the signal into a fiber the SFG-signal gets measured by a fiber spectrometer.

3. Results

By measuring the SFG-signals spectrum for the different stage-τ_{CW} positions, a 2D map as it is seen in the right bottom of Fig. 1 can be obtained. The fringes in the 2D map are distorted dependent on the spectral phase. An implemented phase retrieval algorithm retrieves the spectral phase of the pulse from a 2D map. Figure 2(a) shows the spectrum of a 2 nJ Cr:ZnS oscillator pulse with its retrieved spectral phase taken at a shear frequency of 1.8 THz. Figure 2(b) shows the corresponding temporal profile with an FWHM of 51 fs. The transform-limited pulse width was calculated to be 39 fs and could be achieved through dispersion compensation.

4. Conclusions

We successfully designed a 2DSI setup specified for the phase measurement of mid-IR Cr:ZnS pulses and measure the spectral phase of a 2 nJ pulse with a width of 51 fs. Further improvement plans will focus on the sensitivity and the retrieved phase resolution. We believe that this system will become a useful tool for applications in mid-IR ultrafast optics.

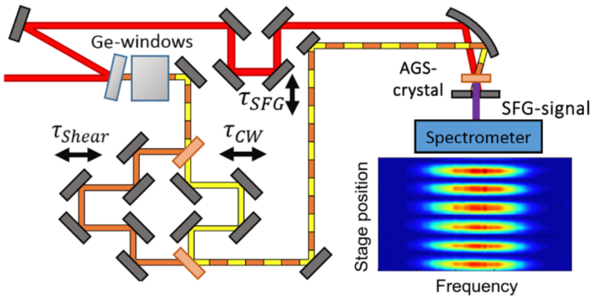

Fig. 1. The schematic of our 2DSI setup and a measured 2D map.

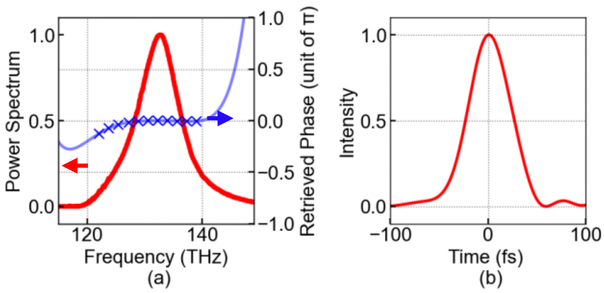

Fig. 2. (a) The pulse's power spectrum (left) with its retrieved spectral phase points and a 6th order polynomial fit (right). (b) The retrieved temporal intensity profile with an FWHM of 51 fs.

References

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