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MIIPS® Application Notes

Dispersion Measurements on Dielectric Mirrors

Broadband mirrors are widely used in ultrafast laser setups because of their high reflectivity over a broad range of wavelength. However, most of such broadband mirrors, especially those with dielectric coatings, are not dispersion-free within the range of high reflectivity. What makes it even worse is that their dispersion depends on the laser beam incidence angle!

Figure 1(a) shows an experimental measurement of relative group delay imprinted on an ultrashort pulse after a single bounce off a broadband dielectric mirror set at 45° and 46° incidence angles [1]. The data reveals several distinct oscillations, where the group delay changes rapidly by as much as 150 fs. These features are known to be the result of Gires–Tournois interference between reflections coming from different layers of the mirror [2].

Such mirror alone would distort a 15-fs laser pulse into a complex waveform spanning over 300 fs, as shown in Fig. 1(b), and would have a dreadful effect on any nonlinear optics experiment. For instance, the resulting phase distortion generates multiple peaks in the second-harmonic generation (SHG) spectrum; see Fig. 1(c). The SHG peaks correlate well with the group delay oscillations in Fig. 1(a) if one accounts for double- and sum-frequency processes, and they notably drift when the incidence angle is changed even by one degree.

Fortunately, multiphoton intrapulse interference phase scan (MIIPS®) provides an adaptive solution for measurement and compensation of dispersion from any optics in the ultrafast laser setup. The inset in Fig. 1(b) shows that the distorted pulse was successfully compressed after the broadband mirror back to the transform-limited 15-fs Gaussian pulse by MIIPS®. In fact, MIIPS® measurements are so precise that one can distinguish the dispersion from the same mirror at two different incident angles, with 1 degree difference; see Fig. 1(a).

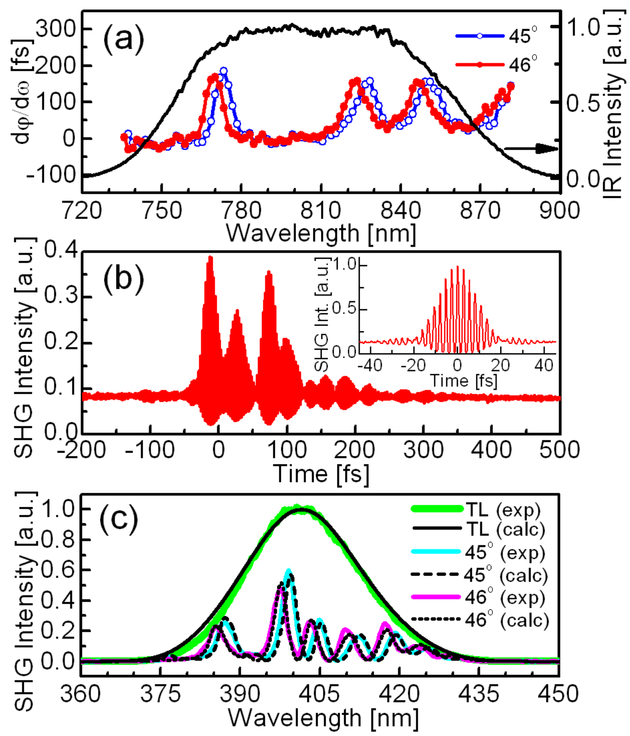

Fig. 1. Measurement and compensation of phase distortions introduced by a broadband dielectric mirror: (a) Group delay spectra measured for initially transform-limited pulses after a single bounce off a New Focus NIR5102 mirror set at 45° and 46° incidence angles. The black solid line maps the laser spectrum; (b) Shaper-assisted interferometric cross-correlation of the pulse (with a transform-limited one) after a single bounce off the mirror for 45° incidence. Inset: Interferometric autocorrelation of the pulse after MIIPS® compensation of phase distortions introduced by the broadband mirror; (c) Experimental and simulated SHG spectra produced by distorted pulses for the two incidence angles. The experimental SHG spectrum for a transform-limited pulse is obtained after MIIPS-S compensation of phase distortions for the 45°-incident beam. The figure is adapted from ref. [1].

Biophotonic Solutions, Inc. (BSI) has launch MIIPS® Certified Ultrafast Optics program. The dispersion of each optics from this program is measured individually in the spectral range of interest. BSI has also launched MIIPS® Certified Service program that enables ultrafast optics manufacturers to measure the dispersion from their optics experimentally.

References

[1] D. Pestov *et al.*, "Single-beam shaper based pulse characterization and compression using MIIPS sonogram," *Opt. Lett.* **35**, 1422 (2010).
[2] N. Matuschek *et al.*, "Theory of double-chirped mirrors," *IEEE J. Sel. Top. Quantum Electron.* **4**, 197 (1998).