Femtosecond Sources for Optical Arbitrary Waveform Generation

E. Ippen, D. Chao, A. Benedick, M. Sander, J. Morse,
G. Chang, G. Petrich, L. Kolodziejski and F. Kärtner
Department of Electrical Engineering and Computer Science and Research Laboratory of Electronics,
Massachusetts Institute of Technology, Cambridge, MA, 02139-4307, USA
E-mail: ippen@mit.edu

Abstract: Advances in high repetition-rate femtosecond laser technology for optical arbitrary waveform generation will be described. Combs spanning two octaves, from 500nm to 2µm, based on GHz modelocked Ti:sapphire and erbium-fiber lasers, have been carrier-envelope stabilized and frequency referenced.

Advances in the generation of ultrashort laser pulses are making it possible to control and manipulate, for the first time, not just the intensity shape of an optical pulse but the amplitude and phase of the electric field waveform within the pulse envelope. It is now well understood that with an octave-spanning spectrum the phase of the carrier wave field can be locked to that of the pulse train envelope and that then each optical frequency in the modelocked comb is tied to an exact multiple of the repetition rate.[1,2] This frequency-divide/multiply relationship between the optical and RF domains is enabling dramatic advances in precision timing and frequency metrology.

In the frequency domain, one has a comb of equally spaced frequencies phase-locked to each other. By further phase locking one of these comb modes to a precisely known and ultrastable optical frequency standard, one extends this accuracy across the entire octave-spanning comb. If one could modulate, individually and separately, each one of these comb frequencies in amplitude and phase, arbitrarily at speeds up to the rep rate, one would have complete and arbitrary control over the optical waveform. This is what is referred to as optical arbitrary waveform generation (OAWG). Optical pulse shaping by manipulation in the spectral domain [3] is already used for a variety of applications but has for the most part been restricted to modulations of clusters of modes and at rates slow compared to the rep rate. Line-by-line modulation [4] has also recently been reported albeit not at the pulse-to-pulse repetition rate.

A major challenge in realizing true OAWG is that of achieving octave spanning spectra with comb lines that are separated sufficiently in frequency to permit them to be resolved spatially by some form (ideally integrated) of grating. This requires a pulse repetition rate of at least 10 GHz. Then, each comb line can be modulated, both in amplitude and in phase, at frequencies up to the rep rate. This talk will describe successes toward this goal made with both Ti:sapphire and fiber laser technology that now provide carrier-envelope-stabilized and frequency referenced GHz combs extending from 500nm to 2µm in wavelength;.

References

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