

High Intensity Pulse Interaction with Dielectric Optical Filters Simulated using FDTD

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Ultrashort optical pulses that are generated by modern table-top laser systems are of sufficiently high intensity to induce nonlinear optical effects in many of the materials used in optical components. We will discuss the interaction of such pulses with several types of dielectric optical filters: (a) dielectric stacks composed of a sequence of two dielectric layers with quarter-wave optical thickness and (b) rugate filters, i.e. filters with a refractive index profile that is sinusoidally modulated on the length scale of an optical wavelength.

Our simulations were performed using the finite difference time domain (FDTD) technique to numerically integrate the Maxwell curl equations for both the electric and magnetic fields. This technique enables the simulation of the reflection of ultrashort pulses from dielectric filters and also allows the incorporation of dispersion and optical nonlinearity through an auxiliary differential equation.

We present FDTD simulations of optical pulse propagation through dielectric filters for pulses with pulsewidths in the range 5–100 fs with peak intensities up to < 10 TW/cm². At low intensities the reflective properties of the dielectric optical filters determined using FDTD simulations are directly comparable to the results calculated using the characteristic matrix method. At high intensities, optical nonlinearity in the dielectric layers is responsible for a decrease in the reflectance of the filter and causes stretching and distortion of the reflected pulses.