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Mechanism of Resonant Infrared Laser Ablation of Polystyrene. STEPHEN JOHNSON, RICHARD HAGLUND, Vanderbilt University, DANIEL BUBB, Rutgers University, Camden, KANNATESSEN APPAVOO, Berea College — Although the ablation of intact polymers by resonant infrared (IR) laser irradiation has been demonstrated, the mechanism has remained mysterious. This is partly because the IR excitation of complex polymer materials is poorly understood, and partly because most of the experiments have been conducted with a tunable infrared free-electron laser (FEL) with an unusual micropulse-macropulse temporal structure. We have fully characterized the resonant and non-resonant IR ablation of polystyrene (PS) at several IR wavelengths. The energy input at each wavelength was ascertained by convoluting the temperature-corrected lineshape functions of individual C-H and C-C bonds with the spectral profile of the picosecond FEL micropulses. Data from ablation rate, ablation depth, time-resolved photoacoustic and photothermal measurements and nanosecond pulsed-laser shadowgraphy were fed into a simple finite-element model of energy deposition and relaxation. The data and model are consistent with a steady-state ablation mechanism, modified by plume shielding late in the microseconds-long FEL macropulse. Thus the mechanism of the resonant IR laser ablation process is apparently connected primarily with the bond-selective absorption leading to relatively shallow absorption depths and a high local density of vibrational excitation.

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