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Mechanism of Resonant Mid-Infrared Laser Ablation of Polystyrene[1] RICHARD HAGLUND, Vanderbilt University, STEPHEN JOHNSON, University of Kentucky, DANIEL BUBB, Rutgers University-Camden — We investigated the mechanism of resonant-infrared laser ablation of polymers using polystyrene as a model material. The ablation laser was a picosecond mid-infrared free-electron laser tuned to mid-IR laser wavelengths that are resonant with specific vibrational modes of the polystyrene target. Time-resolved plume imaging combined with etch-depth measurements and finite-element calculations indicate that a blowoff model fits the experimentally measured etch depths and plume images, provided one accounts for moderate shielding of the surface by the ablation plume. The finite-element model includes the temperature-dependent absorption coefficient and specific heat that dramatically change the material properties above the glass-transition temperature. Ablation begins after a thin surface layer of the material is superheated to temperatures exceeding 1000 C and undergoes spinodal decomposition. The majority of the ablated material is then expelled by way of recoil-induced ejection as the pressure of the expanding vapor plume compresses a laser-melted area at the target surface.

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