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Single-pulse fabrication of deep vertical nano-holes with a micro-joule femtosecond laser. LLOYD M. DAVIS, YELENA V. WHITE, XIAOXUAN LI, ZBIGNIEW SIKORSKI, WILLIAM H. HOFMEISTER, University of Tennessee Space Institute — When a single energetic 200-femtosecond laser pulse is tightly focused onto the surface of a dielectric material, Zener (tunnelling) ionization and Zener-seeded saturation avalanche ionization cause a plasma to be formed at the surface. The tail of the pulse reflects from the plasma so that the resultant damage is typically shallow. However, we have found that when the laser pulse is focused with negative spherical aberration, holes exceeding 11 microns in depth and with diameters at the surface of only 200—500 nm may be created. A simple acetate sample replication technique is used to estimate the dimensions of the holes. The validity of the replication technique for characterizing such high-aspect-ratio features is confirmed by focused ion-beam sectioning of holes followed by visualization with a scanning electron microscope. We discuss physical processes that may be responsible for the creation of such deep nano-holes, including the role of self-focusing of the laser beam, and the possibility of acceleration of electrons along the direction of the laser beam into the hole. Applications, including direct laser writing of vertical channels for nanofluidic devices, are discussed. Related research on femtosecond laser machining of diamond is also presented.

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