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Effect of Lattice Structure on Energetic Electron Transport in Solids Irradiated by Ultraintense Laser Pulses[1]

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The generation and transport of energetic (MeV) electrons in solids irradiated by ultraintense laser pulses is of fundamental importance to many topics in intense laser-solid interactions, including ion acceleration, warm dense matter studies and the fast ignition approach to inertial confinement fusion. An investigation into the effect of lattice structure on the transport of energetic electrons in solids irradiated by ultraintense laser pulses will be presented. The study involved the use of various forms (allotropes) of carbon. We observe smooth electron transport in diamond, whereas beam filamentation, arising from resistive instabilities, is observed with less ordered forms of carbon. The highly ordered lattice structure of diamond is shown to result in a transient state of warm dense carbon with metallic-like conductivity at temperatures of the order of 1-100 eV, leading to suppression of electron beam filamentation. First-principles models of the electrical conductivity of the various carbon allotropes under these highly non-equilibrium conditions were used in 3D simulations with the ZEPHYROS particle-based hybrid code. The experimental observations and the simulation results are in very good agreement. The lattice structure is shown to be important in defining the conductivity of the transient warm dense matter state induced by rapid heating of the solid and this defines the fast electron beam transport pattern. P. McKenna et al., Phys. Rev. Lett. 106, 185004 (2011)

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