Ultrafast Melting in Metals Probed with Femtosecond Electron Diffraction

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Femtosecond (fs) lasers are an ideal tool to excite materials on timescales even shorter than vibrational periods, typically ~100 fs. The ability to resolve all of the resulting structural dynamics depends on having a technique with fs temporal resolution and capable of providing high structural resolution. Femtosecond electron diffraction satisfies both criteria and offers an unprecedented view of the fastest possible structural dynamics [1].

By using a fs laser, one is able to very quickly deposit energy into a material—in these experiments gold and nickel. This leads to superheating of the metal and thereby permits the study of the familiar phenomenon of melting, only in this case the process is strongly driven. Even under these conditions, however, the material properties mediate the material response. In our first work [1], aluminum melted in 3.5 picoseconds (ps); under equivalent conditions, gold melts in 12 ps and nickel more quickly than gold. The difference in timescales is a consequence of a material parameter—the electron-phonon coupling constant—that differs by an order of magnitude between the gold and nickel and determines how quickly the laser energy absorbed by the electrons is transferred to nuclear motion. The observed structural changes, however, are the same for the two metals and thus allow for a generalized description of the melting mechanism.

[1] Siwick B.J., et al., *Science*, 2003, **302**, 1382.

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