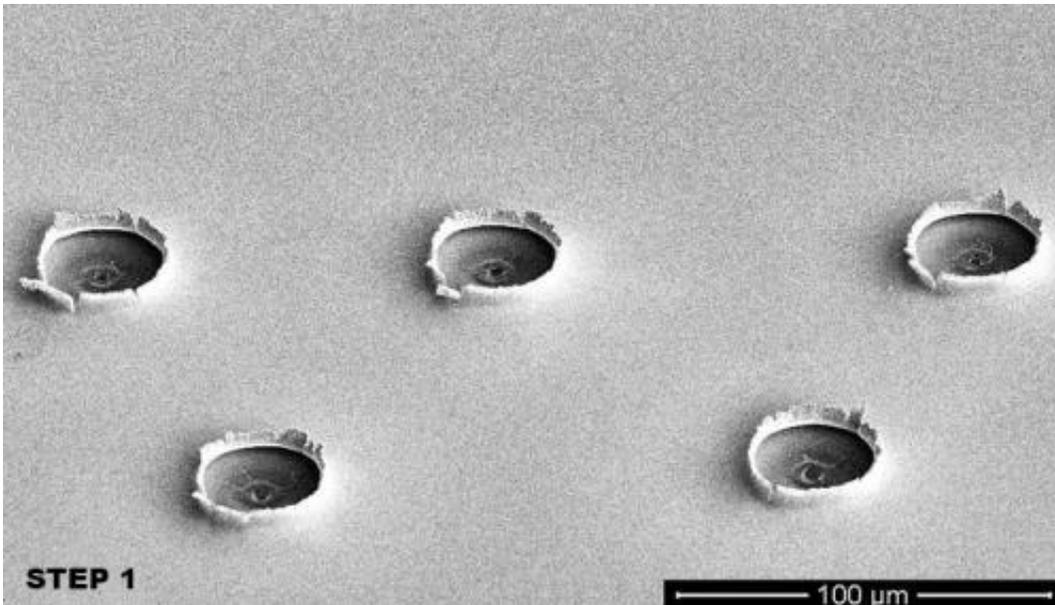


# Putting iron to the stress test

April 29 2014, by Anne M Stark

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A scanning electron microscopy image of the free surface of an iron sample after five separate laser-driven "shots." The iron was in the form of a thin film (in this case 1.2 micrometers thick), and was supported on glass. The "craters" are due to the arrival at the free surface of compression waves and other phenomena generated by an intense laser pulse incident on the opposite surface (i.e. the iron/glass interface). Credit: Nick Teslich.

(Phys.org) —Using an ultrafast laser system, a group in Physical and Life Sciences at Lawrence Livermore National Laboratory have subjected iron to extremely rapid dynamic compression and have shown that the transition from one crystal structure to another can take place in less than 100 trillionths of a second after the compression begins.

If a material is squeezed hard enough, the way in which its atoms are arranged is often severely altered. In solids, pressure or stress may drive what are known as polymorphic transitions in which the [crystal structure](#) of the material changes from one form to another.

One of the best known of all such transitions is in iron and occurs at a typical stress of around 13 GPa (about 130 000 atmospheres). This transition has been very well studied over at least half a century since it was first inferred from shock wave measurements. However, the detailed nature of how it occurs is still not well understood. For example, how does it depend on the rate at which the stress is applied? How quickly can it take place and what are the characteristics of the material before and during the transition?

The team shows, qualitatively consistent with other recent reports, the stress at which the transition occurs is substantially higher (up to twice) than reported for typical shock wave experiments where the compression occurs more slowly. Furthermore, they showed that the "deviatoric stress"—a measure of the strength of the iron—is comparatively very large (up to 3 GPa) shortly before the transition begins. Team members analyzed their experimental data with a state-of-the-art theoretical method recently developed at LLNL.

"We hope this work will substantially improve our understanding of how polymorphic phase transitions take place under [dynamic compression](#) and inspire further interesting experiments and theoretical treatments," research member Jonathan Crowhurst said. "In particular, the time scale of the experiment is short enough to permit close comparison with the results of [molecular dynamics simulations](#), which are emerging as the theoretical tool of choice for modeling this class of phenomena." Co-author Michael Armstrong also points out that "these far from equilibrium [compression](#) studies can also inform kinetic models of phase transitions in the limit of very high strain rates."

The work was published in the March issue of *Journal of Applied Physics*.

Provided by Lawrence Livermore National Laboratory

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