

Grain-boundary initiated inhomogeneous melting of thin metal films

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The role of domain boundaries in the electrical and mechanical properties of crystals is known from electrical conductivity measurements and theoretical modelling. The models can be tested with ultrafast lasers at high power levels sufficient to melt a thin film in a single shot. So we performed ultrafast time-resolved diffraction experiments at the X-ray Free-electron Laser (XFEL) facility in Pohang, Korea [1]. We studied 300 nm polycrystalline thin films of gold evaporated onto silicon nitride windows, melted by a Ti-sapphire laser pulse. By analyzing the evolution of the X-ray diffraction lineshape, we established separate roles for the electron and phonon contributions in the melting dynamics, consistent with the prevailing 2-temperature model. We deduced that the laser energy is primarily transmitted into the crystal at the grain boundaries, converting to heat which diffuses into the grains and melts them. The appearance of liquid was tracked by pair-distribution function analysis and found to have a slight time dependence following melting [2]. We concluded that the melting process is highly heterogeneous, commencing at the domain boundaries [1]. The localized electrical and mechanical properties are intimately connected with the short time-scales accessible in XFEL-based diffraction experiments.

[1] Tadesse A. Assefa, Yue Cao, Soham Banerjee, Sungwon Kim, Dongjin Kim, Sunam Kim, Jae Hyuk Lee, Sang-Youn Park, Intae Eom, Jaeku Park, Daewoog Nam, Sangsoo Kim, Sae Hwan Chun, Hyojung Hyun, Kyung Sook Kim, Pavol Juhas, Emil S. Bozin, Ming Lu, Changyong Song, Hyunjung Kim, Simon J. L. Billinge and Ian K. Robinson, *Science Advances* 6 eaax2445 (2020)

[2] Ian K. Robinson, Jack P. Griffiths, Robert Koch, Tadesse A. Assefa, Ana F. Suzana, Yue Cao, Sungwon Kim, Dongjin Kim, Heemin Lee, Sunam Kim, Jae Hyuk Lee, Sang-Youn Park, Intae Eom, Jaeku Park, Daewoog Nam, Sangsoo Kim, Sae Hwan Chun, Hyojung Hyun, Kyung sook Kim, Ming Lu, Changyong Song, Hyunjung Kim, Simon J. L. Billinge and Emil S. Bozin, *IUCrJ* 10 656–661 (2023)