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Nanotextured dynamics of a light-induced phase transition in VO2[1]

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Programming properties of quantum materials at will is a central goal of modern condensed matter physics. Light stands out as a particularly powerful tool for inducing properties on-demand [1]. Light-induced states, however, can exhibit complex phase separation at the nanoscale. In this talk I will discuss our inquiry into transient nanotextured heterogeneity in vanadium dioxide (VO2) thin films during a light-induced insulator-to-metal transition (IMT) [2]. Room temperature, steady-state, phonon enhanced nano-optical contrast reveals preexisting "hidden" disorder in VO2. The observed contrast is associated with inequivalent twin domain structures. Upon thermal or optical initiation of the IMT coexisting metallic and insulating regions are observed. Correlations between the transient and steady-state nano-optical textures reveal that heterogeneous nucleation is partially anchored to twin domain interfaces and grain boundaries. Ultrafast nanoscopic dynamics enable quantification of the growth rate and bound the nucleation rate. Finally, we deterministically anchor photo-induced nucleation to predefined nanoscopic regions by locally enhancing the electric field of pump radiation using nano-antennas and monitor the on-demand emergent metallicity in space and time. [1] A.J. Sternbach et al., *Science*, **371**, 617 (2021). [2] A.J. Sternbach et al., *Nano Letters,* DOI: 10.1021/acs.nanolett.1c02638 (2021).

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