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**Optical Characterization of Structural Evolution of Ultra-thinVO2 Films across Metal-Insulator Transition** L. GUO, Penn State University — We use ultrafast x-ray diffraction, time resolved pulsed THz spectroscopy and infrared transient absorption techniques to study the structural and electronic evolution of photo-induced ultrathin $VO_2$ film epitaxied on Titanium Dioxide ($TiO_2$) substrate. We have demonstrated the lattice structural state of $VO_2$ film can be tunable by the amount of excitation fluence. The structural evolution in nanosecond scale can be understood by thermal transport model simulation done by comsol. At high excitation fluence (as high as $29mj/cm^2$), a new transient state is observed based on the x-ray diffraction result. The transient structure is unambiguously identified to benon-thermally induced and decoupled from metal-insulator electronic phase transition. It recovers to the tetragonal phase within one nanosecond, and further to the monoclinic phase in tens of nanoseconds. Moreover, the lattice vary properties are highly dependent on the orientation of substrate. The lattice expands along surface normal axis in $VO_2/TiO_2$ (100) films while contracts in $VO_2/TiO_2$ (001) films when going through the phase transition region.

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