Straining to see the $M_2$ phase in ultrathin epitaxial vanadium dioxide

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It has been more than a decade since Muroaka et. al. showed that the transition temperature of the metal insulator transition ($T_{MIT}$) of VO$_2$ in epitaxial thin films can be tuned by $\pm 50$ K by applying compressive and tensile strain along the rutile c-axis,[1] but we still can’t explain why. Since this discovery, uniaxial strain studies of VO$_2$ nanobeams have demonstrated that compressive strain does indeed lower $T_{MIT}$, thus stabilizing the metallic rutile phase. The tensile strain case is different. Even minor tensile strain induces an additional insulating monoclinic phase, i.e. the $M_2$.[2] Whether the $M_2$ phase can be stabilized in thin films remains contentious owing to the constraints of sample and/or interface quality. Understanding how and why tensile biaxial strain induces the $M_2$ phase should provide insight into the mechanism dictating the $T_{MIT}$ of VO$_2$ of thin films.

In this talk, I will present our group’s studies of ultrathin epitaxial films of VO$_2$ grown on TiO$_2$ to determine the presence and origin of the $M_2$ phase. From measurements at dedicated synchrotron facilities in the US and UK, we provide evidence of a tensile-strained stabilized $M_2$ phase. Our results reveal that the MIT is not exclusively determined by the spacing of the V-V dimers along rutile c-axis and that strain-induced variations in electron correlation effects are more likely responsible for stabilizing the $M_2$ phase. We acknowledge support from the National Science Foundation under grant number DMR-1409912.

Refs: