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Evolution of Defect States from Different Starting States in $La_{1-x}Sr_xFeO_3$ Thin Films

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Understanding how materials behave in extreme conditions including under irradiation in important for understanding how robust the structures are and how under what conditions decomposition and amorphization occurs. Prior studies suggest that certain structures, such as film/substrate interfaces, may be more robust to amorphization. Spurgeon et al. [1] showed that when epitaxially grown crystal $La_2Ti_2O_7$ thin films grown on STO (110) were irradiated (ex-situ) by Zr ions at 1 MeV, disorder and amorphization progressed first in the film then the substrate, but the interface maintained crystallinity on the substrate side. The findings of this study raise the question of how different initial states of a thin film might affect the evolution of disorder and amorphization and whether different substrates have an effect.

To understand how different initial states affect the development of irradiation damage, we examine the material system $La_{1-x}Sr_xFeO_3$ (LFSO) grown on STO (001) and LSAT (001). Thin films of $LaFeO_3$ (LFO) and LSFO are epitaxially grown by PLD and MBE to produce single crystal LFO and LSFO films. In addition, some LFO films are made containing defect domains, which, under examination by scanning transmission electron microscopy (STEM) imaging, appear to be ruddlesden-popper phases. These defect domains are roughly columnar in shape and begin between 3-4 nm above the substrate. To probe the different stages of damage leading up to amorphization, films were masked and irradiated to progressively higher doses in quadrants to 0.1, 0.2, and 0.5 dpa with Au at 2 MeV at 3^o off the normal to reduce channeling effects. Samples were examined by STEM imaging and electron energy loss spectroscopy (EELS) prior to irradiation to determine film quality and after irradiation to evaluate the effects.

The schematic in Figure 1 describes the process of the study: different samples containing or representing different defect states are irradiated with ions and are analyzed at intermediate irradiation steps to examine the intermediate disorder states until full amorphization occurs. The far left of the schematic shows STEM HAADF (high angle annular dark field) micrographs for single crystal LFO (pristine single crystal film), $La_{0.75}Sr_{0.25}FeO_3$ (alloyed film), and LFO with defect domains (containing defect domains) prior to irradiation.

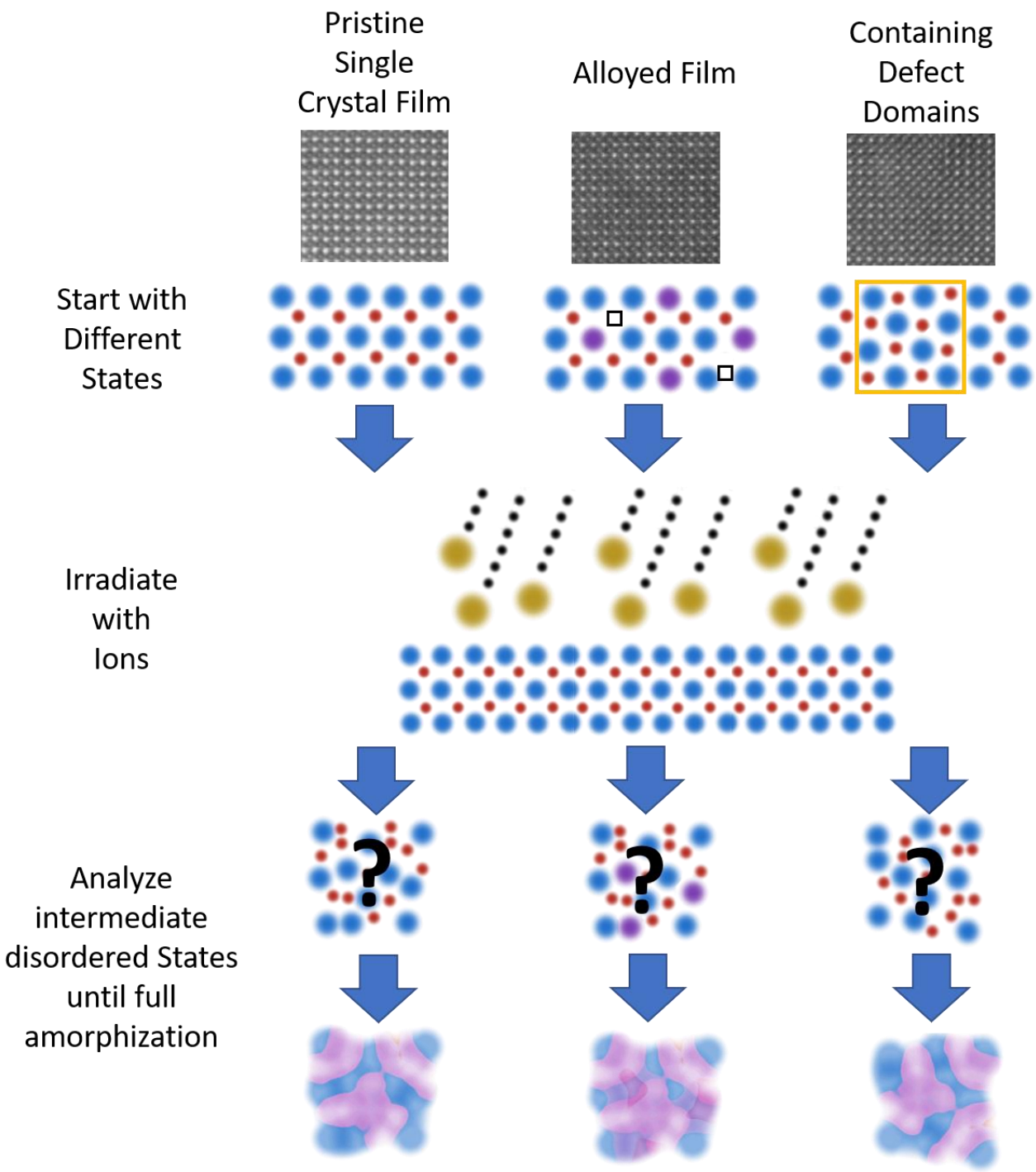

Figure 1. Schematic overview of the study showing the different initial states including samples of STEM HAADF micrographs of the pre-irradiated samples.

References

[1] S. R. Spurgeon, T. C. Kasper, V. Shutthanandan, J. Gigax, L. Shao, M. Sassi. "Asymmetric Lattice Disorder Induced at Oxide Interfaces". *Advanced Materials Interfaces.* 2020, 7, 1901944

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