Extraordinary control of oxidation state and structure in high-entropy oxides

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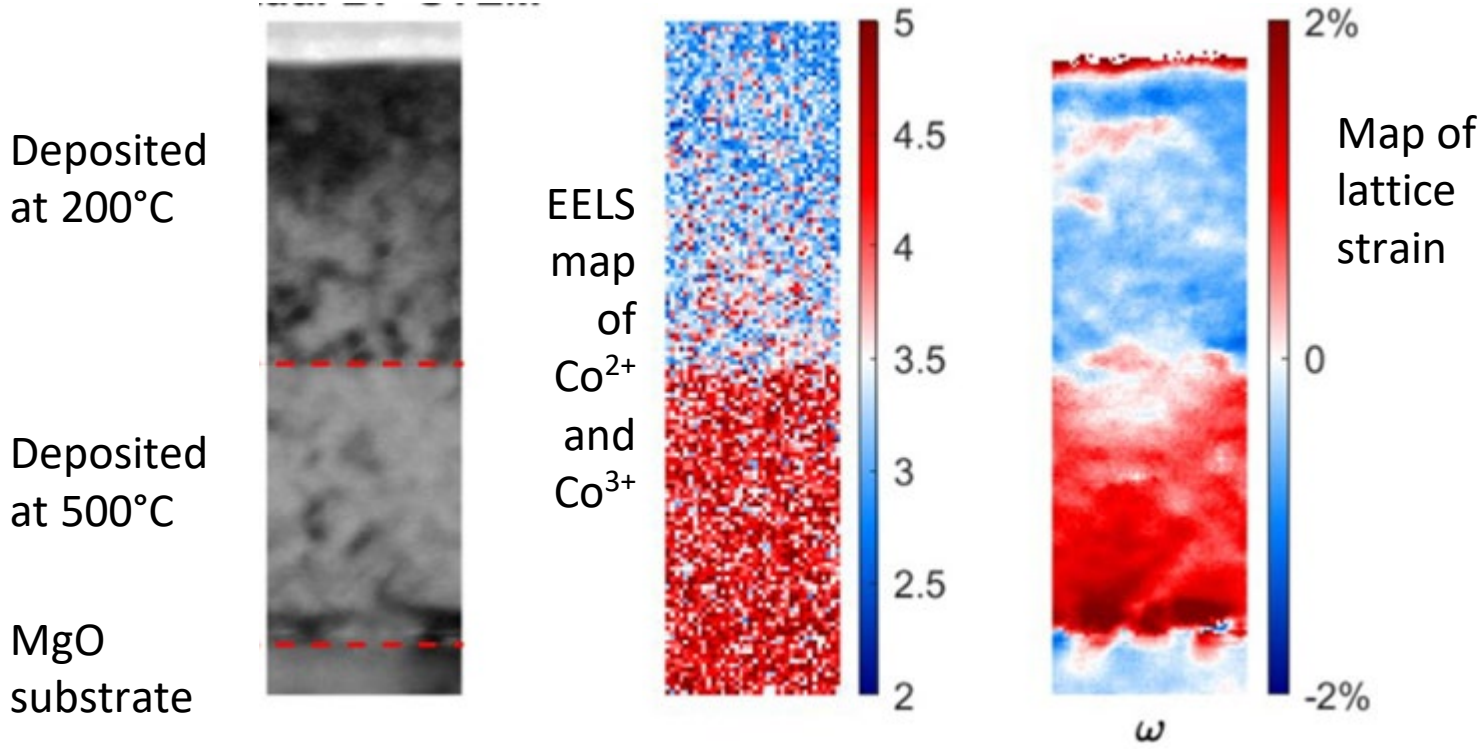
Entropy-stabilized oxides developed by MRSEC IRG members exhibit unusual structures and behaviors. The IRG team was able to stabilize a high-energy oxide film of composition “J14” as a thin film with cobalt in either the 3+ or 2+ state, depending only on the deposition temperature of the film, and extraordinary change in oxidation state for a system of nominally fixed composition. The film also undergoes a sharp change in out-of-plane lattice constant akin to a structural phase transition, all while maintaining an epitaxial relation to the substrate. Collaborative research validated and quantified this phenomenon and explored its impact on magnetic properties induced by the presence of cobalt.



Electron microscopy image (left) of a multilayer film, deposited first at 500°C and then at 200°. Center image shows a map of the cobalt electron energy loss spectrum, which reveals two different oxidation states with different electronic and magnetic properties. Right image shows the corresponding change in lattice constant perpendicular to the substrate.