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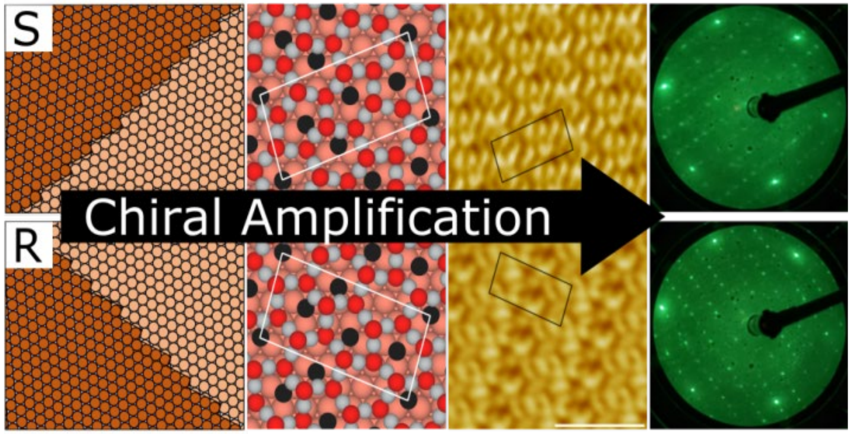
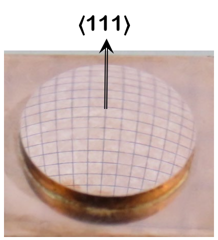
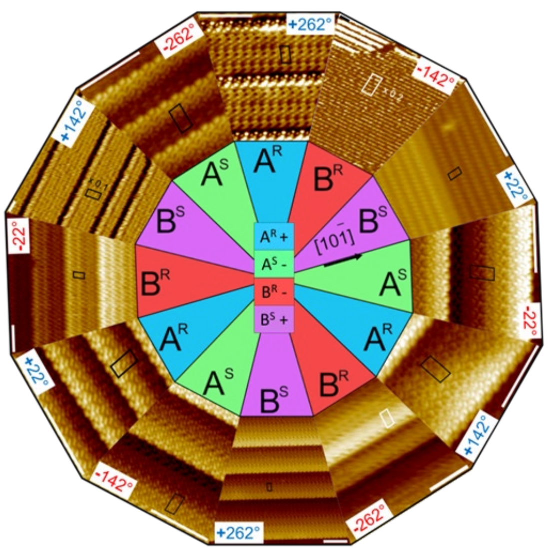
Templated Growth of a Homochiral Thin Film Oxide



A small degree of chirality induced by slight misorientation of a metal surface (1 site/20 nm^2) is amplified by oxidation to yield a homochiral oxide with a dense regular array of chiral oxide pores (~75 sites/ 20 nm^2).

Image credit: Charles Sykes





Collage of data showing how the local orientation of a custom-made domed Cu(111) single crystal dictates the local orientation and chirality of the '29' oxide. A chart in the center shows the different oxide orientations and chiralities at different locations around the dome.

Image credit: Charles Sykes

Project Outcome: We have demonstrated that the orientation and chirality of a surface oxide film can be controlled by the local orientation and structure of the underlying Cu surface before oxidation. The '29' copper oxide thin film exists in two enantiomeric forms, with each chirality having three equivalent orientations due to the three-fold rotational symmetry of the Cu(111) crystal. We discovered that the chirality of the underlying Cu surface could be used to template long-range homochiral growth of the oxide film with terraces up to 20 nm wide showing a predominance of just one enantiomer and rotational orientation of the oxide. Our data also revealed that the chiral templating effect can be understood in terms of the direction of the local step edges which align with the orientation of the '29' oxide on the associated terrace.

Impact & Benefits: Chiral surfaces are of growing interest for enantioselective adsorption and reactions. While metal surfaces can be prepared with a wide range of chiral surface orientations, chiral oxide surface preparation is more challenging. We demonstrate the chirality of a metal surface can be used to direct the homochiral growth of a thin film chiral oxide. This offers a general approach for making chiral oxide surfaces via oxidation of an appropriately "miscut" metal surface.

Background & Explanation: With this award, Gellman and Sykes continue to explore many fundamental interactions that underpin chiral separations and enantioselective reactions using advanced surface science and atomic scale imaging techniques. These systems include chiral molecule-surface interactions and restructuring, chiral surface structure and reactivity, and surface sensitive enantioselective separations and explosions. In addition to the research, Sykes runs a Reverse Science Fair with Medford High in which ~200 high schoolers, 10 teachers, and 15 graduate students participate in annually.

Schilling, Gellman, Sykes et al. *ACS Nano* 2020, 14 4682