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Epitaxial Strain-Mediated Control of Oxygen Vacancies in SrRuO3 for Enhanced Thermoelectric Properties

Epitaxial strain in films grown on lattice-mismatched substrates plays a key role in tuning a wide range of physical and chemical properties of transition metal oxides (TMOs) through the modulation of oxygen vacancies. Strain has also shown potential for enhancing the thermoelectric (TE) properties of TMOs, enabling efficient heat-to-electricity conversion. Nevertheless, the effect of strain-mediated oxygen vacancies on TMO TE properties remains poorly understood. In this work, we explore the role of oxygen vacancies on the TE properties of epitaxial SrRuO3 (SRO) thin films by systematically varying strain using lattice-mismatched substrates to induce different strain states. In-situ X-ray diffraction reveals that compressive strain effectively reduces oxygen vacancy concentrations, thereby increasing charge carrier mobility without altering carrier density. compressively strained SRO films exhibit significantly improved electrical conductivity while maintaining consistent thermopower, resulting in a nearly threefold increase in power factor compared to relaxed films. Moreover, Time-domain thermoreflectance measurements demonstrate reduced thermal conductivity in compressively-strained films, leading to a greater than 50% improvement in the figure of merit when compared to bulk SRO. Our findings highlight the significant role of strain-controlled oxygen vacancies in modulating the TE properties of TMOs, providing a pathway to advanced materials design for high-temperature TE applications.

Topical Area

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