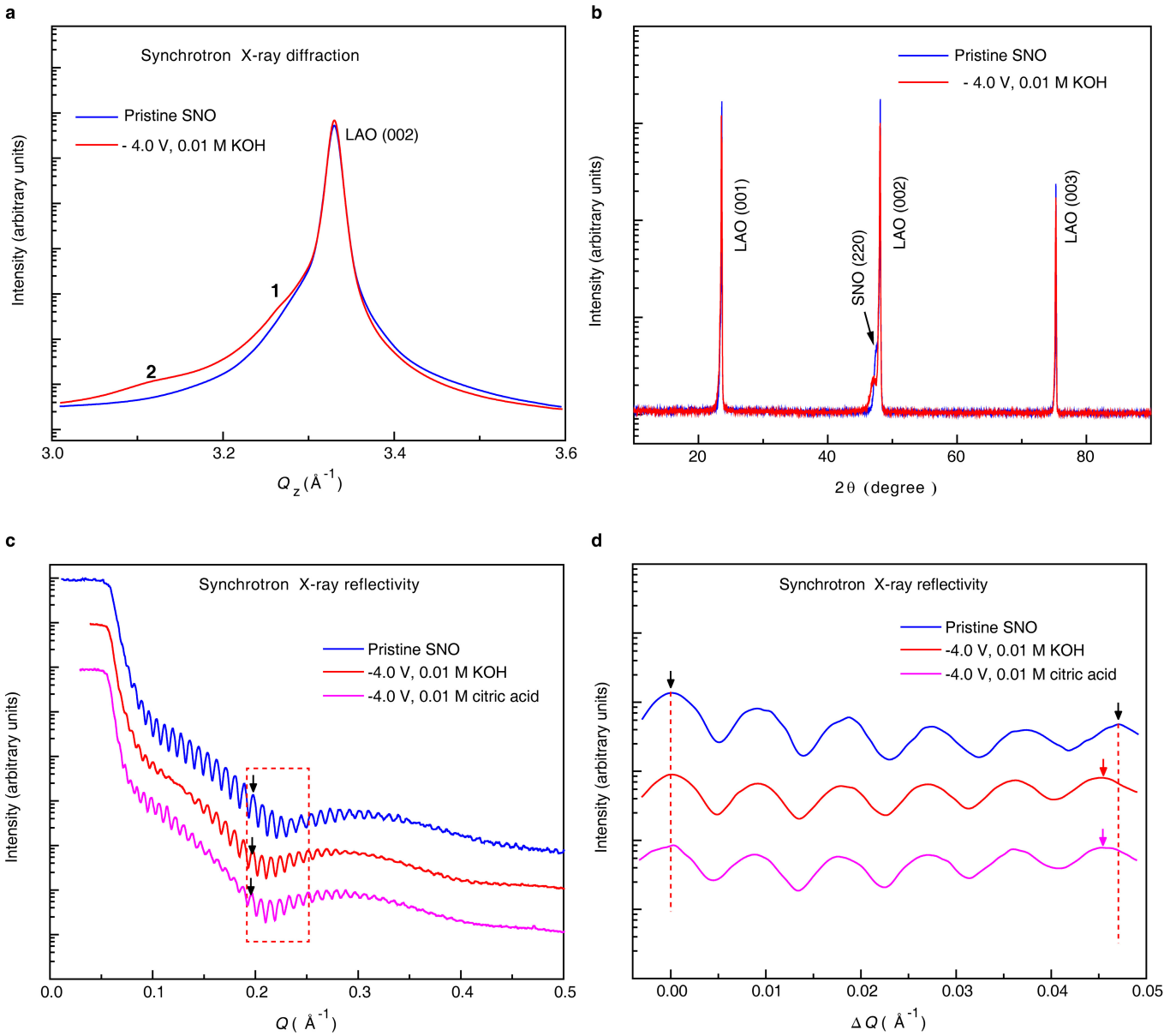

Extended Data Figure 6 | X-ray diffraction and X-ray reflectivity of water-treated SNO. a, Synchrotron X-ray diffraction curves taken from a SNO/$LaAlO_3$ thin film after treatment in a 0.01 M KOH aqueous solution at −4.0 V for 30 s. The (220) peak of pristine SNO (orthorhombic notation) appears at $Q_1 \approx 3.29$ Å^{-1} as a shoulder with slightly lower scattering vector Q_z than the $LaAlO_3$ (002) diffraction peak (pseudocubic notation), demonstrating the epitaxial growth of SNO on $LaAlO_3$. After the water treatment, the epitaxial relationship of SNO on $LaAlO_3$ is preserved. Peak 1 shifts to a lower Q_z. Peak 2 appears at $Q_z = 3.11$ Å^{-1}, which corresponds to increase of the lattice constant by 5.7%. LAO stands for $LaAlO_3$. **b**, X-ray diffraction profiles of SNO and water-treated SNO over a wide range of scattering angles 2θ. No new peaks appear, in contrast to what has been observed in other oxides, such as cobaltites, upon exposure to water. **c**, Comparison of synchrotron XRR curves for SNO after applying a bias of −4.0 V for 5 min in 0.01 M citric acid and 0.01 M KOH aqueous solutions. **d**, A selected area of the XRR curves, normalized to the oscillation peak at $Q \approx 0.19$ Å^{-1} (marked by black arrows in **c**). Upon treatment, the XRR oscillation period decreases, demonstrating film expansion regardless of solution type, which indicates a general mechanism of phase change of SNO in various aqueous solutions caused by proton incorporation.