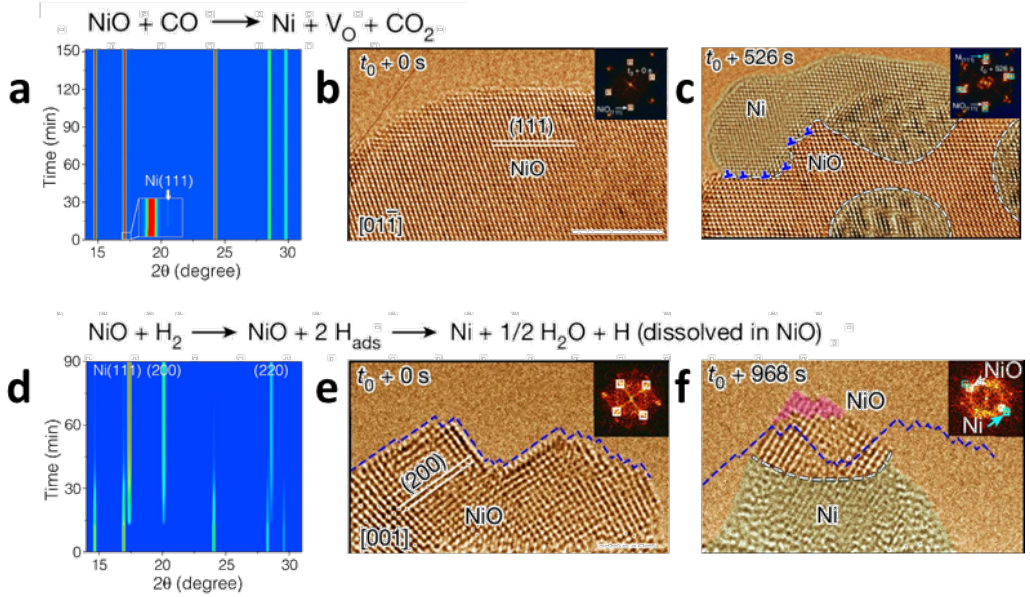
# Deciphering Oxide Reduction at the Atomic Scale




**(a)** In-situ synchrotron X-ray diffraction (XRD) measurements of NiO reduction under CO flow. A weak Ni(111) reflection appears early (inset), indicating rapid nucleation of metallic Ni, but its intensity remains low over time—suggesting self-limiting surface reduction. **(b, c)** Time-resolved HRTEM images showing NiO reduction at 400 °C under CO pressures of approximately 1 Pa. **(d)** Time-resolved XRD during NiO reduction under $H_2$ shows an initial incubation period, followed by rapid and sustained growth of Ni(111), (200), and (220) reflections, consistent with bulk phase transformation to metallic Ni. **(e, f)** In situ HRTEM images showing NiO reduction at 400 °C under H2 pressures of approximately approximately 0.08 Pa.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*Work was performed in part at NSLS-II*


## Scientific Achievement

Scientists reveal that CO and $H_2$ reduce metal oxides through fundamentally different atomic pathways that were once thought to be similar.

## Significance and Impact

This work paves the way for improved catalyst design and more efficient metal production.

## Research Details

- Distinct pathways were captured showing carbon monoxide's quick but shallow reduction and hydrogen's delayed onset followed by a rapid, deep reduction.
- *In-situ* X-ray diffraction was performed at the NSLS-II Quick X-ray Absorption & Scattering beamline to complement transmission electron microscopy data.