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Oxide growth and oxide/metal interaction in CeO_x/Ni(111)

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Ni/ceria catalysts exhibit a high activity and selectivity for CO_2 methanation, making them very promising candidates for applications within a sustainable economy. The redox properties of cerium oxide allow it to readily switch between Ce^{4+} and Ce^{3+} states, facilitating CO_2 activation and conversion. We have studied the so-called strong metal-metal oxide interactions in the inverse catalyst configuration CeO_x/Ni(111) prepared by reactive molecular beam epitaxy in an oxygen atmosphere. Under specific growth conditions, the CeO_x (111)-oriented islands of different heights preferentially align in registry with the Ni(111) surface or are rotated azimuthally by $\pm 10°$, as observed by low-energy electron diffraction. Analysis by X-ray photoelectron spectroscopy reveals that during growth, partial oxidation of the Ni(111) surface leads to the formation of a NiO interface layer between the CeO_x islands and Ni substrate, resulting in a complex CeO_x(111)/NiO(111)/Ni(111) system with significant oxide-metal interactions. Finally, when we expose the system to H_2, O_2, and CO_2 atmospheres, we observe a complex behavior of the cerium and nickel oxidation states, which correlate with morphological changes in the oxide islands.

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