STM and XPS Studies of Titania-Ceria Mixed Oxide Thin Films

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The reducible oxides, Titania (TiO_2) and Ceria (CeO_2) are among the most widely applied oxide materials in various catalytic applications, where they are used as support to disperse catalytically active species like metal particles or oxide species or as catalysts in their own right. It has been found that titania and ceria actively participate in the catalytic reaction cycle and can have significant influence on the overall performance of the catalyst. Although they have been separately studied extensively, comparably little is known about the mixed compound $Ce_xTi_{1-X}O_2$. Recently, experimental and theoretical work suggested that mixed Ce-O-Ti phase is catalytically active for many reactions.[1] For instance, selective catalytic reduction (SCR) of NO_X,[2] selective dehydration of methanol,[3] etc. It is proposed that Ce^{3+} is stabilized in this mixed oxide phase and the reducibility of such mixed oxide is improved.[4] However, there is still lack of atomic understanding on the Ce-O-Ti phase and its exceptional catalytic activity.

In this work, we follow a rigorous surface science approach to grow atomically well-defined CeO_2(111) thin film on a Ru(0001) single crystal under ultrahigh vacuum (UHV) conditions. Scanning Tunnelling Microscopy (STM) and X-ray photo-electron spectroscopy (XPS) are applied to examine the topography and electronic properties of the CeO_2(111) thin film. Secondly, we explore different strategies to mix Ti with CeO_2. By sequential deposition or co-deposition and post annealing in O_2 or UHV, we systematically examine the obtained mixed oxide phases by STM and XPS. Based on the structural understanding gained in the above two steps, we further explore the adsorption behaviour of NH_3, NO and O_2 on these mixed Ce-O-Ti phases by STM and XPS, in combination with temperature programmed desorption (TPD). The current research provides systematic and atomic understanding of the titania-ceria mixed oxide and contribute to the rational synthesis of novel titania-ceria mixed oxide for catalysis.

References

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