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The role of hot electrons in catalysis science

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One long-standing observation in the field of heterogeneous catalysis is that the activity and selectivity in certain reactions is dramatically affected by the oxide onto which the metal nanoparticles are deposited, even though the oxide itself is not active in catalysis. Recently, studies which detected hot electron formation at metal surfaces helped to explain these curious findings. Pulse probe experiments have detected hot electron formation within femtoseconds when photons are incident on a metal surface. Experiments indicate that the mean free path of these hot electrons is on the order of 5 nm, which is in the range of the size of catalyst nanoparticles. Further studies indicate that exothermic catalytic reactions can also produce hot electrons readily, for example CO oxidation or the reaction of hydrogen and oxygen to form water. We have constructed a "catalytic nanodiode" in our laboratory whereby we carry out catalytic reactions at high and continuous turnover and, using a Schottky barrier, collect hot electrons. Simultaneous measurement of turnover frequency and hot electron current during CO oxidation has shown that the hot electron current and the turnover rate for the reaction are correlated. This implies that the catalytic activity at the oxide-metal interface in certain catalytic reactions is associated with the hot electron flow.