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**Exploration of surface chemistry and structure of catalysts under reaction condition and during catalysis with surface-sensitive in-situ techniques<sup>1</sup>**

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In heterogeneous catalysis, each catalytic event occurs on a catalytic site. The catalytic site typically consists of a couple of or a few atoms of a catalyst which pack into a structure to offer specific electronic state to turn on a catalytic reaction. Surface structure and chemistry are the key for understanding a catalytic mechanism. From thermodynamic point of view, the surface structure of a catalyst depends on the environment of reactant gases or liquid around the catalyst. Thus, the surface chemistry and structure of a catalyst under a reaction condition or during catalysis (in an environment of reactant(s) with certainly pressure) could be different from those from ex-situ studies. In-situ surface science characterization techniques have been developed for disclosing the hidden surface chemistry and structure of catalysts under reaction conditions or during catalysis. In-situ ambient pressure XPS (AP-XPS) and ambient pressure STM (AP-STM) are two of these surface-sensitive techniques appropriate for exploring surface chemistry and structure, respectively. In this talk, I will present the origin of pressure dependent surface chemistry and structure from thermodynamic point of view. AP-XPS and AP-STM techniques will be introduced briefly. I will focus on (1) the evolution of surface composition and oxidation state of a reducible oxide and how the evolution is correlated to the corresponding catalytic performances, (2) the distribution of surface elements on surface of a bimetallic catalyst under a reaction condition and how a restructuring is used to generate a new surface with different catalytic performance, and (3) geometric restructuring of a metal catalyst surface at atomic scale and how it is related to its catalytic performances.

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