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The structure of a working catalyst ; from flat surfaces to nanoparticles

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Stellingen

behorende bij het proefschrift

"The structure of a working catalyst: from flat surfaces to nanoparticles"

1. *In-situ* AFM is not only a logical step after *in-situ* STM, it is essential as it allows bridging of the *materials gap*. Chapter 2 of this thesis.
2. To obtain atomic resolution with AFM under catalytic conditions, it is necessary to use functionalised tips that are stable under high-temperature, high-pressure conditions. Chapter 2 of this thesis.
3. Surface stress can be the dominant cause of adsorbate-induced surface restructuring. Chapter 5 of this thesis.
4. The effects observed for CO oxidation on supported palladium nanoparticles, and NO reduction by H_2 on supported platinum particles, are direct analogues of the effects on the corresponding flat single crystal surfaces. The morphology of the metal phase and the presence of a support do not establish a *materials gap* for these systems. Chapter 6 and 7 of this thesis.
5. In catalysis research, there is a *resolution gap* that separates spatially resolved observations at the nanometre scale (e.g. microscopy) from large-area averaging techniques (e.g. spectroscopy) and macroscopic observables (e.g. catalyst activity).
6. The combination of a high-pressure gas environment with high sample temperatures during experiments on catalytic reactions is not enough to bridge the *pressure gap*.
7. There is ongoing debate on the nature of the active phase in the high-reactivity regime of CO oxidation over palladium. A multi-scale theoretical approach from first principles may be the only way to settle this issue. M. J. Hoffmann and K. Reuter, Topics in Catalysis **57**, 159 (2013).

8. The catalytic growth of graphene on metal surfaces by chemical vapor deposition is a promising way to create large pieces of high-quality graphene, but has several intrinsic difficulties. Growing graphene on a liquid metal surface could circumvent these problems. D. Geng et al., PNAS **109**, 7992 (2012)

9. Software is an increasingly important aspect of scientific instrumentation, but it receives insufficient attention in instrumentation development projects in academic research environments.

10. Given the emphasis on scientific output (publications), long-term instrumentation development programs may become unsustainable in academia.

11. People should realize that there's no app to control the forces of nature.

Sander Roobol
Leiden, 2 december 2014