In situ mesoscopic and microscopic visualisation of catalytic reactions on metal-oxide systems

Yuri Suchorski

Institute of Materials Chemistry • Vienna University of Technology

SFB F45 04

Research Goals and Project Strategy

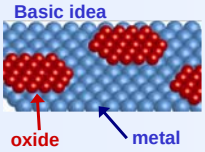
***Research Goals**: to understand the role of the oxide-metal interface in the hydrogen oxidation reaction*

***Project Strategy**: to apply surface sensitive analytics to an in situ study of catalytic H_2 oxidation on ZrO_2/Pt (Ni) model systems (surface science approach to catalysis)*

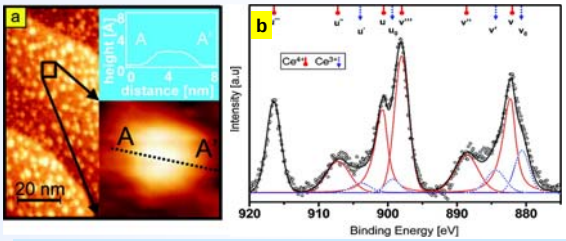
Inverse Model Catalysts

Preparation and characterization

Basic idea



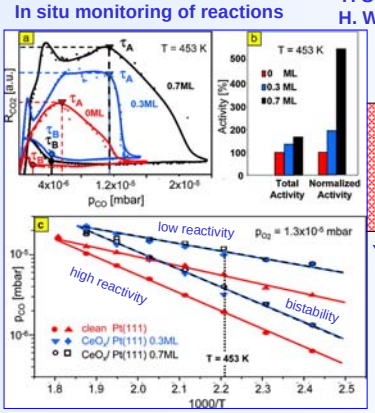
(i) well defined systems
(ii) accessible by most of surface techniques



(a) An STM image of a CeO_x/Pt(111) inverse model catalyst
(b) Corresponding Ce 3d XP-spectrum. Ce oxidation state 3.9

In situ monitoring of reactions

Y. Suchorski, R. Y. Suchorski, R. Wrobel, S. Becker, H. Weiss, J. Phys. Chem. C 112 (2008) 20012

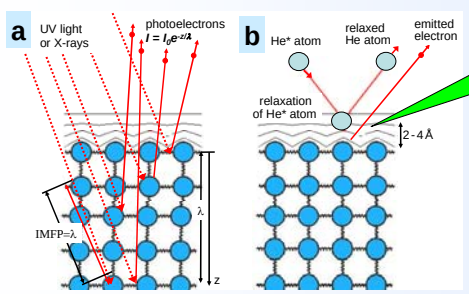


Ceria-induced promoting effects for CO oxidation on Pt: mainly interface effects

Y. Suchorski, R. Wrobel, S. Becker, B. Strzelczyk, W. Drachsel H. Weiss, Surf. Sci. 601 (2007) 4843

Methods (ii)

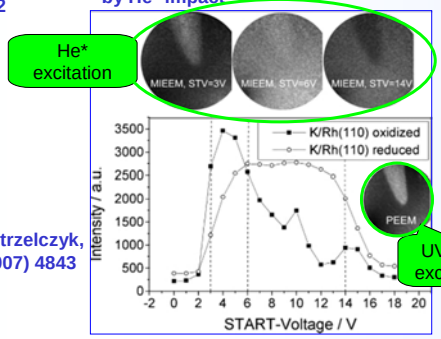
Spectromicroscopy of Surfaces by Metastable He* Atoms



Differences in the information depth between
(a) UPS/XPS spectroscopy and
(b) MAIES spectroscopy.

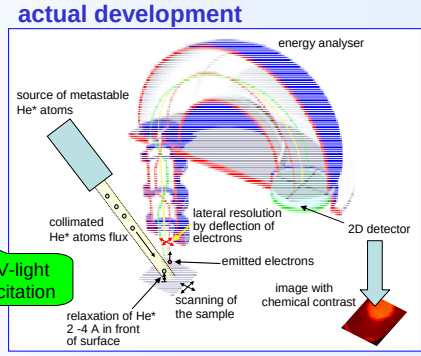
preliminary work:

first visualization of H_2 oxidation by He* impact



G. Lilienkamp and Y. Suchorski, Surf. Interf. Anal. 38 (2006) 378

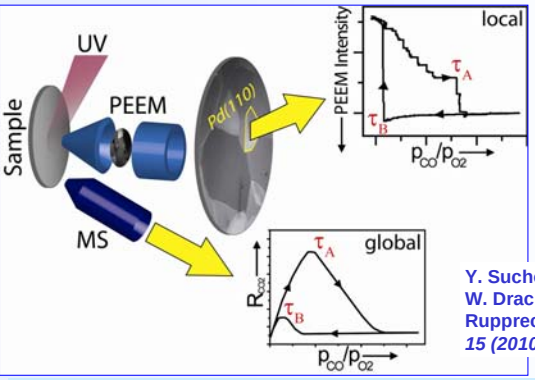
actual development



Innovation Project, granted by TUW
Start-up: spring 2011

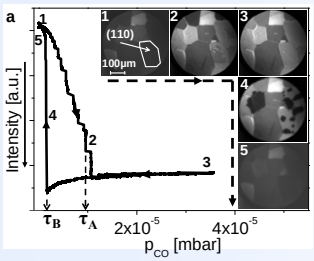
Methods (i)

Local reaction kinetics via PEEM imaging

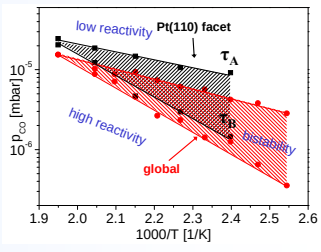


Y. Suchorski, Ch. Spiel, D. Vogel, W. Drachsel, R. Schlögl, G. Rupprechter, *ChemPhysChem, 15 (2010) 3231*

Usually reaction kinetics is studied by means of mass-spectrometry (MS). Such approach suffers from spatial averaging and does not allow parallel local measurements even on a on μm-scale. In contrast to the spatially-averaged kinetics obtained by mass spectroscopy, locally-resolved reaction kinetics can be obtained by the intensity analysis of PEEM images (comparable to MS using a micrometer-size nozzle "sniffer"). Processing of the videoframes allows to detect the kinetic transition points and to construct the locally obtained kinetic phase diagrams



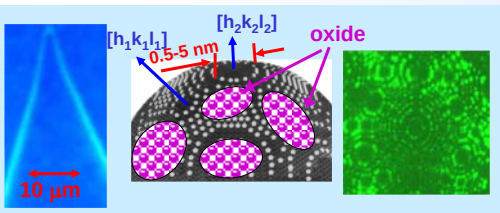
(a) Local PEEM intensity for an [110]-oriented domain during cyclic variation of CO pressure at constant P_{O2} = 1,3x10^{-5}mbar



(b) Spatially-resolved kinetic phase diagram for an individual domain on a Pt foil in comparison with a global phase diagram measured by MS

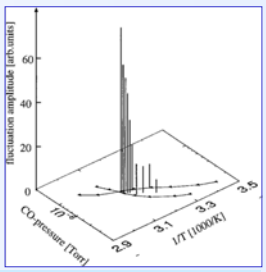
Methods (iii)

Field ion microscopy (FIM) and field electron microscopy (FEM)



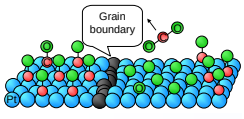
Y. Suchorski and W. Drachsel, Top. Catal. 46 (2007) 201

An apex of a nanosized field emitter tip (Pt, Ni) serves as a model of a single catalytic particle. In contrary to such a particle, field emitter tip can be prepared and characterized on a nanoscale. Reaction can be monitored in situ by FIM or FEM, fluctuation-induced effects, which are not accessible by other methods, can be studied.



Critical fluctuation behaviour in CO oxidation on Pt.
Y. Suchorski et al. Phys.Rev. B63 (2001) 165417

Roadmap



Mesoscopic studies (planar model systems)	Microscopic studies (apex of a nanosized tip)
Preparation and characterisation of planar inverse catalyst model systems	Preparation and characterisation of inverse catalyst model systems on an apex of a nanotip
Adsorption and reaction on mono- and polycrystalline samples	Adsorption and reaction on nanosized systems
Adsorption and reaction on inverse catalyst model systems	Modeling of the intermediate pressure condition (field-compression effect)
Adsorption and reaction on model systems modified by yttria and ceria	Adsorption and reaction on nanosized systems modified by yttria and ceria

first year · second year · third year · fourth year · TIME