H.-J. Freund

*The author presented on this page has recently published his **20th article** since 2000 in Angewandte Chemie:* "Analysis of the Broadening of X-ray Photoelectron Spectroscopy Peaks for Ionic Crystals": C. J. Nelin, P. S. Bagus, M. A. Brown, M. Sterrer, H.-J. Freund, *Angew. Chem.* **2011**, 10.1002/anie.201100964; *Angew. Chem. Int. Ed.* **2011**, 10.1002/ange.201100964.

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Awards:	**1995** Leibniz-Award of the German Research Foundation (Germany); **2002** William Draper Harkins Lecturer, University of Chicago (USA); **2005** Langmuir Lecturer, 230th ACS Meeting (USA); **2006/07** Centenary Award and Lecturer, Royal Society of Chemistry (UK); **2007** Gabor A. Somorjai Award of the American Chemical Society for Creative Research in Catalysis (USA); **2008** V. N. Ipatieff Lecturer, Northwestern University Center for Catalysis and Surface Science (USA); **2011** G. B. Kistiakowsky Lecturer, Harvard University (USA); **2011** Arthur D. Little Lecturer in Physical Chemistry, Massachusetts Institute of Technology (USA); **2011** Karl-Ziegler-Award, German Chemical Society (Germany)
Current research interests:	Physical Chemistry at interfaces has been and still is my research interest. The field is so diverse! Our idea was to take a second step towards catching some of the complexity of a real catalyst by incorporating the metal oxide interface in model studies, going beyond the use of metal single crystals, an approach so brilliantly pursued in Gerhard Ertl's group. In the late 80s and in the 90s, we developed epitaxial growth techniques to prepare thin metal oxide films as supports for metal nanoparticles in order to model disperse metal catalysts. We have studied a variety of oxide supports, supported clusters, and nanoparticles of different metals and sizes. A number of experimental tools have been developed to be able to study reactions in ultrahigh vaccuum and under ambient conditions; instrument development is an important part of our activities. Recently, we focused on the very interesting chemical activity of ultrathin (ca. two atomic layers) oxide films.
Hobbies:	Cycling, reading

When I was eighteen I wanted to be … either a physicist or a chemist.

I am waiting for the day when someone will discover … a cure for Alzheimer's disease.

Science is fun because … it allows one to be creative.

Looking back over my career, I … am happy to be a scientist.

The most significant historic event of the past 100 years was … the liberation from the Nazi regime after World War II.

If I could be any age I would be … the age I am now.

I admire … my wife.

The secret of being a successful scientist is … to be honest and authentic.

My favorite principle is … symmetry.

My science "heroes" are … Irving Langmuir, Michael Polanyi, and Gerhard Ertl.

The most important thing I learned from my students is … always be critical.

What I appreciate most about my friends is … reliability.

My favorite composer is … Mozart.

My favorite book is … "Surely, You're Joking, Mr. Feynman! (Adventures of a Curious Character)" by Richard P. Feynman.

My motto is … "Never give up".

Has your approach to publishing your results changed since the start of your career?

When I first started, I was very enthusiastic about seeing my work in print and it did not matter that much which journal it appeared in. I was disappointed about negative referee comments but I did not know about the influence of editors on what gets published and what does not get published. Today I know better and value the responsibility of editors and referees if they help to expose the scientific community to work that has been peer-reviewed by carefully selected, knowledgeable people, and not just rejected by editors according to their taste as it often happens with tabloid journals. I believe that the responsibility held by authors and editors to ensure that the brightest people stay in our field by making sure that the review process remains transparent, is often underestimated. I try to publish our best work in what I consider to be the prime journals of our field between physics and chemistry.

What do you think the future holds for your field of research?

Catalysis and surface science will have their place in the future of chemistry and physical chemistry; catalysis in particular because its economic importance cannot be overestimated and surface science because it has been declared "dead" so many times, and it comes back every time under a different label. Surfaces and interfaces are important everywhere, be it chemistry, physics, or biology. The solutions to many problems reside at interfaces. To understand and control the chemistry at interfaces will be an important factor to master our energy, mobility, food, and fresh water supply problems. So, the future of our field of research is bright, I believe!

My 5 top papers:

1. "Binding of Single Gold Atoms on Thin MgO(001) Films": M. Yulikov, M. Sterrer, M. Heyde, H.-P. Rust, T. Risse, H.-J. Freund, G. Pacchioni, A. Scagnelli, *Phys. Rev. Lett.* **2006**, *96*, 146804-1-4.
   By a combination of techniques (i.e. STM and a specifically developed electron resonance spectroscopy to be applied under UHV conditions at single-crystal surfaces) it was possible to identify individual Au atoms and determine their charge state and binding site by a study of the hyperfine coupling constants combined with isotopic labeling in comparison with DFT calculations.
2. "Influence of Carbon Deposition on the Hydrogen Distribution in Pd Nanoparticles and Their Reactivity in Olefin Hydrogenation": M. Wilde, K. Fukutani, W. Ludwig, B. Brandt, J.-H. Fischer, S. Schauermann, H.-J. Freund, *Angew. Chem.* **2008**, *120*, 9430 – 9434; *Angew. Chem. Int. Ed.* **2008**, *47*, 9289 – 9293.
   The formation of carbon deposits on metal nanoparticles during hydrogenation reactions and its influence on reactivity has been often described and discussed but not conclusively addressed. The combination of molecular beam techniques with resonant nuclear reaction analysis allowed us to disentangle surface hydrogen atoms on and dissolved hydrogen atoms in the particle and study their mutual influence on hydrogenation activity. Carbon deposits were shown to control the exchange between the surface and subsurface hydrogen atoms and determine hydrogenation activity and selectivity.
3. "Counting Electrons Transferred through a Thin Alumina Film into Au Chains": N. Nilius, M. V. Ganduglia-Pirovano, V. Brázdová, M. Kulawik, J. Sauer, H.-J. Freund, *Phys. Rev. Lett.* **2008**, *100*, 096802-1-4.
   Electronic states formed from the 6s electrons of Au in clusters exhibit nodal planes that allow one to relate the current images recorded with an STM to symmetry and to "count" the electrons on a cluster, as in the present case, a chain of Au atoms, and thus to identify charge transfer through thin oxide films with the help of density functional calculations.
4. "Formaldehyde Formation on Vanadium Oxide Surfaces $V_2O_3(0001)$ and $V_2O_5(001)$: How does the Stable Methoxy Intermediate Form?": D. Göbke, Y. Romanyshyn, S. Guimond, J. M. Sturm, H. Kuhlenbeck, J. Döbler, U. Reinhardt, M. V. Ganduglia-Pirovano, J. Sauer, H.-J. Freund, *Angew. Chem.* **2009**, *121*, 3750 – 3753; *Angew. Chem. Int. Ed.* **2009**, *48*, 3695 – 3698.
   Although it is frequently discussed that defects on oxide surfaces and in particular oxygen vacancies determine the chemistry at transition metal oxide surfaces, reliable, microscopic, and quantitative information is scarce. A combination of STM, infrared spectroscopy, thermal reaction spectroscopy, and density functional calculations allowed us to image the first reaction steps in methanol oxidation, to quantitatively account for the number of defects before and after the reaction, and to correlate these with several reaction products for two different vanadium oxide single-crystal surfaces.
5. "The Interplay between Structure and CO Oxidation Catalysis on Metal-Supported Ultrathin Oxide Films": Y.-N. Sun, L. Giordano, J. Goniakowski, M. Lewandowski, Z.-H. Qin, C. Noguera, S. Shaikhutdinov, G. Pacchioni, H.-J. Freund, *Angew. Chem.* **2010**, *122*, 4520 – 4523; *Angew. Chem. Int. Ed.* **2010**, *49*, 4418 – 4421.
   Epitaxially grown ultrathin oxide films can be designed to exhibit particular catalytic activities due to their structural flexibility. In this case it was possible to identify the active phase formed in the course of CO oxidation and image it with the STM. Support for the identification of the structure and a proposal for the mechanism of the reaction are provided by density functional calculations.

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