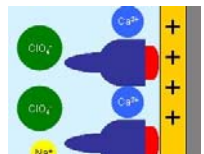
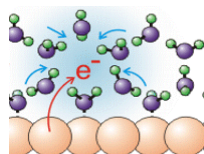
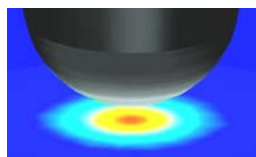


## Physical Chemistry and Nanotechnology of Interfaces



### Research

- fs-Laser excitation of self-organization processes of biological, organic and inorganic solid state surfaces in the nano-scale
- fs-Laser far field nanostructuring
- Femto-Electrochemistry with hot electrons
- Nanostructuring and microscopy in an aperture-free femtosecond laser nearfield scanning probe microscope (a-SNOM)
- Laser cleaning of artifacts (polymers, paper, parchment, textiles)
- Mobile UV-Laser-induced Breakdown spectroscopy and stratigraphy
- fs-Laser ophthalmology
- Bioelectrochemistry of proteins, self-organization
- Electrochemical in-situ diagnostics: FT-IR, quartz microbalance, scanning force microscopy.

Comparison between amplified laser system (CPA) and high energy oscillators concerning repetition rate and output energy.

The activity of "Physical Chemistry and Nanotechnology of Interfaces" relies on pioneering work for more than 15 years in demonstrating femtosecond machining down to the nanoscale of a broad variety of materials soon after fs-laser got available in the early nineties. Experience exists in top-down femtosecond laser ablation allowing micro- and nanomachining of 1D, 2D, and 3D structures in metals, transparent solids and biological tissues that cannot be made any other way. A special advantage is the unique possibility of congruent machining of highly inhomogeneous composite materials. Pulse durations of less than 80fs provide the unique possibility to deterministically excite the electronic system by multi photon excitation resulting in unique precision in contrast to "conventional" fs-laser applications (>100 fs) where stochastic avalanche processes result in poor ablation qualities.

A novel optical setup coupling sub-60 fs-pulses into a high precision microscope will allow ultrahigh-precision processing. fs-pulses are necessary to avoid large heat affected zones (> 1 $\mu$ m) common with conventional ns-pulse lasers. Such non-linear phenomena can be exploited to reach supercritical intensities only in the focus of transparent bulk materials enabling laser direct-writing of 3D devices containing optical and microfluidic networks. This new approach to set up nano and microstructures can be applied to almost any transparent composite and functional material.

It was recently demonstrated that fs-laser-induced self assembly of nanostructures on solids opens a new bottom-up approach to nano-structure surfaces.

Fs-Laser ablation of solids in liquid contact allows to synthesize nanoparticles and nanotubes/nanorods. Thus uniformly small particles precipitate in solution.

Electrochemical scanning force microscopy allows to investigate the molecular structure of double layers and nanomanipulate electrified interfaces.

Electrochemical scanning microscopy is used to investigate the electrochemistry of graphene.

Bioelectrochemistry is demonstrated on crystalline single layer proteins on electrodes.

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## Cooperations

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**Publications (2009-2014)**

- C. Zafiu, G. Trettenhahn, D. Pum, U.B Sleytr, and W. Kautek, *Phys. Chem. Chem. Phys.* 13 (2011) 3478.  
„Electrochemical control of adsorption dynamics of surface layer proteins on gold“.
- M. Forster, W. Kautek, N. Faure, E. Audouard, and R. Stoian, *Phys. Chem. Chem. Phys.* 13 (2011) 4155-4158.  
„Periodic nanoscale structures on polyimide surfaces generated by temporally tailored femtosecond laser pulses“.
- M. Forster, L. Égerházi, C. Haselberger, C. Huber and W. Kautek, *Appl. Phys. A* 102 (2011) 27.  
„Femtosecond laser interaction with pulsed-laser deposited carbon thin films of nanoscale thickness“.
- C. Zafiu, G. Trettenhahn, D. Pum, U.B Sleytr, and W. Kautek, *Phys. Chem. Chem. Phys.* 13 (2011) 13232.  
„Structural Control of Surface Layer Proteins at Electrified Interfaces investigated by In Situ Fourier Transform Infrared Spectroscopy“.
- V. Ljubić Tobisch, H. Weitensfelder, W. Kautek, *Blätter für Technikgeschichte* 74 (2012) 135-161. „Die Anfänge der Galvanoplastik und Galvanografie in Österreich“.
- S. Arif, M. Forster, S. Bushuk, A. Koutmouk, H. Tatur, S. Batishche, W. Kautek, *Applied Physics A* 110 (2013) 501-509.  
“Mechanistic comparison of pulsed laser induced phase separation of particulates from cellulose paper at 213 nm and 532 nm“.
- S. Arif, O. Armbruster, W. Kautek, *Appl. Phys. A* 111 (2013) 309-317.  
„Pulse laser induced particle separation from polymethyl methacrylate: a mechanistic study“.
- S. Arif, W. Kautek, *Appl. Surf. Sci.* 276 (2013) 53– 61.  
“Laser cleaning of particulates from paper: Comparison between sized ground wood cellulose and pure cellulose“.
- S. Arif, O. Armbruster, W. Kautek, *Appl. Phys. A* 111 (2013) 539-548.  
„Pulse laser particulate separation from polycarbonate: surface acoustic wave and thermomechanical mechanisms“.
- S. Arif, W. Kautek, *Appl. Surf. Sci.* 288 (2013) 9–14.  
“Pulse laser machining and particulate separation from high impact polystyrene“.
- S. Arif, S. Bushuk, A. Kouzmouk, H. Tatur, S. Batishche, W. Kautek, *J. Cultural Heritage* (2014) <http://dx.doi.org/10.1016/j.culher.2013.11.011>.  
“Middle-ultraviolet Laser Cleaning of particulates from sized ground wood cellulose and pure cellulose paper“.
- S. Arif, W. Kautek, *Appl. Surf. Sci.* 276 (2013) 53-61.  
„Laser cleaning of particulates from paper: Comparison between sized ground wood cellulose and pure cellulose“.
- J. Colson, J. Nimmrichter, W. Kautek, *Appl. Surf. Sci.* 302 (2014) 314-317.  
“Interaction of pulse laser radiation of 532 nm with model coloration layers for medieval stone artefacts“.
- C. Huber, A Trügler, U. Hohenester, Y. Prior, W Kautek, *Phys. Chem. Chem. Phys.* 16 (2014) 2289-2296.  
“Optical near-field excitation at commercial scanning probe microscopy tips: a theoretical and experimental investigation“.
- T. Nagy, U. Pacher, H. Pöhl, W. Kautek, *Appl. Surf. Sci.* 302 (2014) 189-193.  
„Atomic Emission Stratigraphy by Laser-Induced Plasma Spectroscopy: Quantitative Depth Profiling of Metal Thin Film Systems“.
- T. Nagy, U. Pacher, A. Giesriegl, L. Soyka, G. Trettenhahn, W. Kautek, *Appl. Surf. Sci.* 302 (2014) 184–188.  
“Laser-Induced Electrochemical De- and Repassivation Investigations on Plasma-Oxidized Aluminium Alloys“.
- C. Huber, Y. Prior, W. Kautek, *Meas. Sci. Technol.* 25 (2014).  
„Laser-induced cantilever behaviour in apertureless scanning near-field optical microscopes“.

**Invited Conference Presentations (2009-2014)**

- 2nd International Symposium on Surface Imaging/Spectroscopy at the Solid/Liquid Interface (ISSIS 2009), May 31 - June 3, 2009, Cracow.  
*„In-situ Investigations of adsorption and conversion processes of electrified metallic solids“.*
- 4th European Pulse Plating Seminar, March 5, 2010, Wien.  
*„Pulse laser electrochemistry, a potential approach to micro pulse plating“*
- 2nd International School on Laser-surface interactions for new materials production: tailoring, structure and properties, July 11-18, 2010, S. Servolo Island (Venice, Italy).  
*„Lasers in Cultural Heritage: Fundamentals of Paper and Textile Conservation“.*
- Communication of Excellences for Restoration by Optoelectrical Techniques (ConCERTO), October 1-2, 2010, Bucharest.  
*„Laser Techniques in Artwork Investigation, Diagnostics, Conservation“.*
- Molecular Bionics - From Biomineralization to Functional Materials, October 3-6, 2010, Schloss Ringberg.  
*„Electrochemical Control of Crystalline Protein Self-Organization on Solid Conductors“.*
- 110th Bunsentagung (Annual German Conference on Physical Chemistry), June 2 - 4, 2011, Berlin.  
*„Femtosecond laser interaction with cornea and dermal tissues“.*
- Engineering and Functional Interfaces (ENFI 2011), July 18-20, 2011, Linz.  
*„Photonic Interface Processing Diagnostics“.*
- 17th Annual Schrödinger Lecture, November 28, 2011, Dublin.  
*„The Move into the Nano World by Femtosecond Pulse Lasers“.*
- International Symposium on Surface Imaging/Spectroscopy at the Solid/Liquid Interface (ISSIS 2012), May 27 - June 1, 2012, Cracow.  
*„Laser-induced In-situ diagnostics of electrified solid-fluid interfaces“.*
- 3rd Venice International School on Lasers in Materials Science (SLIMS 2012), July 8-15, 2012, S. Servolo Island (Venice, Italy).  
*„Material response to laser energy deposition: non-thermal processes“.*
- Workshop „Nanostructured Materials for Biomedical Applications“, 16 October 2012, Brno.  
*„Physical Chemistry of proteins on electrified interfaces“.*
- 3rd Balkan Symposium on Archaeometry, 29-30th October 2012, Bucharest.  
*„Microparticle separation mechanism from historical cellulose papers by middle-ultraviolet (213 nm) and visible (532 nm) pulsed laser radiation“.*
- International High Power Laser Ablation and the International Beamed Energy Propulsion Symposium 2014 (HPLA/BEP), April 21-25, 2014, Santa Fe, NM, USA.  
*„Laser-matter interaction in the near and far field: fundamental aspects and applications“.*
- 4th Venice International School on Lasers in Materials Science (SLIMS 2014), July 13-20, 2014, S. Servolo Island (Venice, Italy).  
*„Material response to laser energy deposition: non-thermal processes“.*

## Projects

- Phonon generation by coherent photon excitation for optical modification (PHONOGEN), FWF 2014 - 2017
- Adaptive laser beam Engineering for Materials Processing (ADPRO), FFG
- In-situ laser diagnostics in conservation science and archaeology (LIST), Scientific and Technological Cooperation, Austria-Romania 2012 -2014
- Safety in the Application of Femtosecond Laser Technology (SAFEST), BMBF
- Modelling and Diagnostic of Pulsed Laser-Solid Interaction: Applications to Laser Cleaning (LASER CLEANING), EU
- Deployment of In-Situ Optical Monitoring Techniques for Tailoring Thin Film Properties for Specific Advanced Industrial Applications (ISOTECH), EU
- Paper Restoration using Laser Technology (PaReLa), EU
- Investigations of the electrochemical deposition mechanism of aluminium from aprotic metal alkyl electrolytes (MECHAL), Industrial Grant, D
- Electrochemically isolating, wearresistant housing systems by pulse plasma anodizing of aluminum (Pulsanox), MNT ERA-Net