Electrochemical and Surface Engineering – SURF

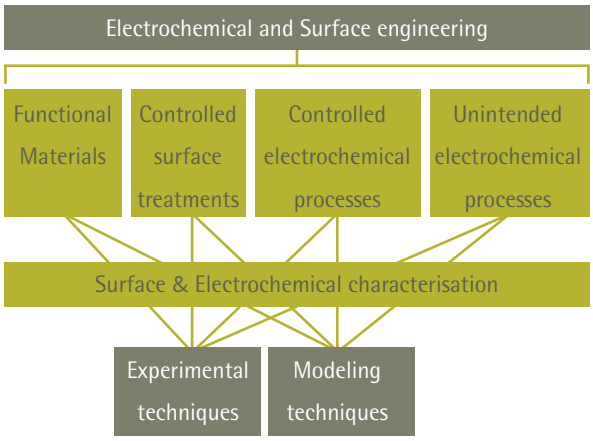
Vrije Universiteit Brussel
Faculty of Engineering
Pleinlaan 2 – B-1050 Brussels – Belgium

Phone: +32 (0)2 629 32 52
Fax: +32 (0)2 629 32 00
Url: www.vub.ac.be/SURF
Head: Annick HUBIN
Email: anhubin@vub.ac.be
Scientific Contact: Herman TERRYN – hterryn@vub.ac.be
Johan DECONINCK - jdeconin@vub.ac.be
Iris DE GRAEVE – idgraeve@vub.ac.be
Els TOURWÉ - etourwe@vub.ac.be
Group SURF: 35 researchers + 9 administrative & technical staff

Keywords

surface engineering, electrochemical processing, surface characterization, functional surface properties, corrosion, electrochemical process modeling, functional modelling

Objectives



Electrochemical engineering covers the area of the study of controlled electrochemical processes (such as electrolysis) as well as the study of unintended electrochemical processes, with corrosion as a typical example.

The connection to the domain of surface engineering is through the development and optimization of processes to perform dedicated surface treatments, such as the anodisation of aluminium. Another important link is the ability to make functional materials, for example self-healing materials.

The aim is twofold: (i) gaining fundamental insight in the mechanisms governing the processes and (ii) using this knowledge to design and optimize these processes.

SURF's approach to deal with both fundamental and application driven aspects is one of combining experimental and modeling techniques. Experimental techniques are oriented towards surface and electrochemical characterisation. We combine expertise in both electrochemical methods and in-situ and ex-situ surface analytical techniques. Modeling in SURF's context means (i) construction of models and (ii) developing numerical tools to handle the mathematics behind the models. Modeling techniques are implemented at different levels: (i) to model controlled or unintended electrochemical processes, (ii) to model physical properties of materials (such as charge transport through oxide layers) and (iii) to support the interpretation of experimental data (e.g. in fitting tools). The continuous interaction between data obtained from measurements and data calculated by models allows to acquire fundamental knowledge and to predict real life behaviour.

Research Orientations

The unique combination of expertise in experimental and modeling techniques in the area of electrochemical and surface engineering promotes a multidisciplinary research focus in the domains listed below.

Dimension 'downscaling' to nanometer resolution

Our state of the art lab infrastructure puts us in the position of analyzing and manipulating the material surface on the very localized, submicron and nanotechnological scale.

Multifunctional metals

Controlled surface modifications that can create a unique combination of functional properties are the next generation

of processes for metals. Our metal surface research is not only directed towards mechanical properties, corrosion and coating adhesion, also additional properties such as optical properties (colour, gloss and reflection), biocompatibility, electrical conductivity, anti-fouling are studied. Also the so-called 'smart coatings' are more and more being explored for future applications.

Process and technique modeling

Process modeling consists of quantitative modeling of processes and electrochemical reactors to optimize production techniques, to predict durability of materials (corrosion), and to save energy. Emerging topics are e.g. fuel cell design and electrochemistry in microfluidic applications.

Technique modeling is developed to maximize the interpretation of experimental data and to extract reliable parameters as input for process and functional modeling. An example is the technique of electrochemical impedance spectroscopy (EIS) where we implemented a new data collection technique to optimize the reliability of the parameter extraction.

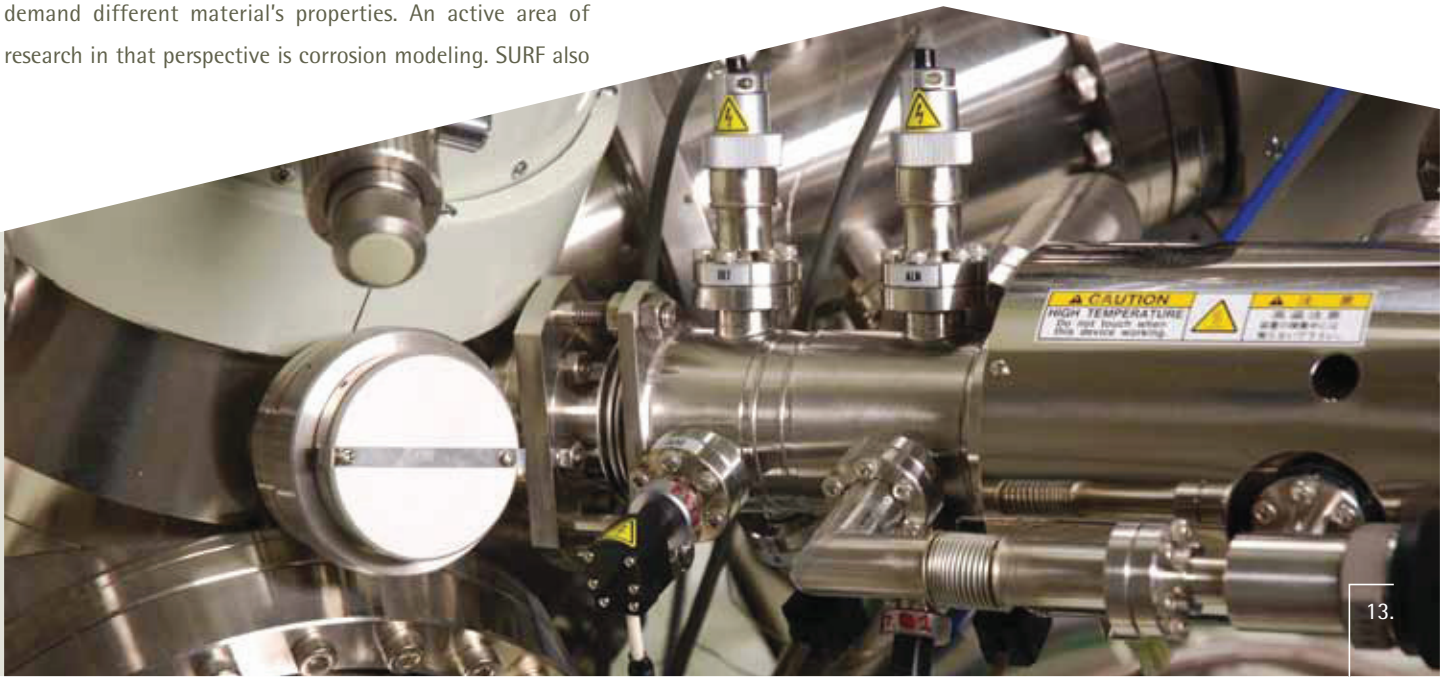
Functional modeling

Functional means modeling of the physical properties of the materials. The ultimate goal is to be able to modify on demand different material's properties. An active area of research in that perspective is corrosion modeling. SURF also has strong expertise in optical modeling. We can e.g. predict the appearance (colour, reflectivity etc.) of modified surfaces.

Equipment & Infrastructure

SURF is in the unique position of having an advanced technological infrastructure and electrochemical software/ modeling tools.

- Complementary electrochemical methods
  - Electrochemical Impedance Spectroscopy Methods
  - Electrochemical Stationary and Non Stationary Methods
  - Electrochemical reactors operating under different flow regimes (e.g. rotating disc reactor, wall jet reactor, parallel flow reactor)
- In-situ & ex-situ surface analytical techniques
  - Scanning electron microscopy (FE-SEM)
  - Auger electron spectroscopy (FE-AES)
  - X-ray photoelectron spectroscopy (XPS)
  - In situ Spectroscopic ellipsometry (visual and infrared)
  - Confocal Raman spectroscopy
  - In situ AFM-STM
- Electrochemical modeling tools
  - Numerical software for macro, meso & micro scale systems
  - Dedicated fitting tools based on maximum likelihood estimator



Collaboration

The spectrum of our projects goes from fundamental research (FWO) through basic research (IWT, SBO, IWOIB, European Programmes) to applied research (IWT, bilateral with industry).

Intra-university

SURF has close collaboration with research groups of the faculty of Engineering, the faculty of Sciences and others:
Applied Physics and Photonics (TONA), Physical Chemistry & Polymer Science (FYSC), High Resolution NMR Centre, Fundamental Electricity and Instrumentation (ELEC), Architectural Engineering (ARCH), General Chemistry (ALGC), Mechanical Engineering (MECH), Chemical Engineering (CHIS), Art Sciences and Archaeology (SKAR).
The group also decided strategically to partner with the team Technological Entrepreneurship, bringing in some economic & business DNA into the research group.

VUB Spin-off

Elsyca NV (1997)

Inter-university & research centres

Through a vast portfolio of interdisciplinary research projects, SURF has built up a broad network of academic contacts and research groups, both nationally and internationally.
Recently, SURF has set up a strategic alliance with the Metals Science and Technology (MST) research group of University of Ghent. The entire chain of metallurgical research from manufacturing till observation and testing can be done there in-house, which offers a truly unique environment for an academic research facility. The interuniversity research group 'Materials and Surface Science & Engineering' (MASS) is combining the competences of the two individual groups: MST being a very strong group in Physical Metallurgy of Metals and SURF being a very strong group in Surface Technology.
SURF has important collaborations (non exhaustive) with:
Center of Excellence in Surface Technology and Materials (CEST) – Austria; Chalmers University – Sweden; Institute of Physical Chemistry – Bulgarian Academy of Sciences (IPCBAS); Instituto Superior Tecnico – Technical University of Lisbon (ICEMS); Interuniversitair Micro-Elektronica Centrum (IMEC); Katholieke Universiteit Leuven; Universiteit Antwerpen; University of Birmingham – UK; University of Bourgogne – France; Universitatea Tehnica Cluj-Napoca – Romania; Universiteit Gent; Université Libre de Bruxelles; University of Paderborn – Germany; Materials Innovations Institute (M2i) at TU Delft; Max Planck Institute –MPEI Düsseldorf; Swiss Federal Laboratories for Materials Testing and Research (EMPA); VITO; von Karman Institute; Warsaw University of Technology (WUT) – Poland.

Industrial partners

Afga Gevaert, Aleris, ArcelorMittal/OCAS, Asco, BASF, Bekaert, Bodycote, Chemetall, Coil, Cormet Testing Systems, Corus, EADS/Airbus, Elsyca, FLAMAC, Henkel, Hydro, Infineon Technologies, SEZ AG (division of Lam Research Corporation), Technikon, Umicore.

Networks

SURF participates in various networks:

- EAA European Aluminium Association with EATP European Aluminium Technology Platform
- HERCULES project network: 'Hoog technologisch multidisciplinair meetcentrum van de Universitaire Associatie Brussel'
- IWT: virtual helpdesk for surface analysis
- Scientific Research Community of FWO Flanders – on Structural and chemical characterisation of Materials at the Micro- and Nanometre scale
- Scientific Research Community of FWO Flanders – on Surface modification
- Scientific Research Community of FWO Flanders – on Tuning the functional properties of nanoparticles and nanowires
- SIM: Strategic Initiative Materials; steering committee member for surface technology
- International Society of Electrochemistry (ISE)
- SIRRIS, the collective centre of the Belgian technological industry