



**24-27 JULY 2022**

**BERTINORO (FC) ITALY**

# Metallurgy Summer School

## SURFACE ENGINEERING OF METALS

**T**he Metallurgy Summer School on Surface Engineering of Metals organized by CoMET is focused on the treatments of metals which modify their surface characteristics to meet the specific needs of different industrial applications.

The scope of the school is to provide a deep understanding of fundamental concepts, processing and characterization techniques, as well as experimental and numerical approaches to the involved problems. It is organized in lectures on both theoretical aspects and applications, and the attendees will be involved in the analysis of case studies under tutor guidance.

The program proceeds from basic concepts to applications. An introductory section is devoted to the solid-state diffusion and the solution of related problems, through analytical and numerical approaches. The experimental techniques most commonly used for investigating the structural and chemical surface properties, will be then illustrated with a selection of representative practical examples. The lectures of the second day will describe and discuss the design criteria, strategies and classification of surface treatments for structural and functional applications, with particular attention to the techniques for manufacturing engineered surfaces from vapour and liquid phase. In conclusion, the program will focus on specific applications, regarding current scientific and technological challenges: batteries and fuel cells, functionalization, corrosion and protection of metal surfaces in automotive, aerospace and medical fields. The school is mainly addressed to PhD students of engineering, materials science, physics and chemistry but post-docs and master students are also welcome.



### Directors

**Prof. Benedetto Bozzini**  
Politecnico di Milano

**Prof. Roberto Montanari**  
Università di Roma 'Tor Vergata'

### Scientific and organising committee

**Prof. Massimo Pellizzari**  
Università di Trento

**Prof. Paolo Piccardo**  
Università di Genova

**Prof. Alessandro Morri**  
Alma Mater Studiorum - Università di Bologna

### Program

#### Sunday, 24 July

17.00 - 19.30 Arrivals

20.00 Welcome buffet

21.30 **Introduction to the Summer School**  
Roberto Montanari - Università di Roma 'Tor Vergata'

#### Monday, 25 July

#### Basic concepts of surface engineering

9.00 **What is Surface Engineering?**  
Benedetto Bozzini

9.30 **Fundamentals of diffusion: Fick's laws, Kirkendall effect, physical mechanisms of diffusion (the role of points defects, pipe diffusion and grain boundary diffusion)**  
Roberto Montanari

10.30 Coffee break

11.00 **Solution of typical diffusion cases**  
Alessandra Varone

12.00 **Numeric solution of problems in systems where diffusion and chemical reactions occur**  
Ivonne Sgura



**24-27 July 2022**



#### Centro Residenziale Universitario

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### Program

#### Monday, 25 July

##### Experimental techniques / Exercises

- 14.30 **Experimental techniques for surface analysis I (structure)**  
Nora Lecis and Roberto Montanari
- 15.30 **Experimental techniques for surface analysis II (micro-chemistry)**  
Alessio Mezzi and Saulius Kaciulis
- 16.30 Coffee break
- 17.00 **Case studies: exercises of students with tutor assistance**
- 19.30 Aperitif

#### Tuesday, 26 July

##### Engineered surfaces

- 9.00 **Classification and design criteria for thermo-chemical treatments of metal parts**  
Massimo Pellizzari
- 10.00 **Design and strategies of surface optimization for structural and functional applications**  
Antonio Gloria
- 11.00 Coffee break
- 11.30 **Techniques for manufacturing engineered surfaces (from liquid phase)**  
Carla Martini
- 12.15 **Techniques for manufacturing engineered surfaces (from vapour phase)**  
David Dellasega

##### Batteries and fuel cells / Exercises

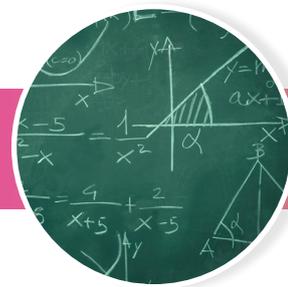
- 14.30 **Modified surfaces for batteries and fuel cells**  
Claudio Mele
- 15.30 **Engineered surfaces of interconnects for the stacking of fuel cells**  
Paolo Piccardo and Roberto Spotorno
- 16.30 Coffee break
- 17.00 **Surface analyses: exercises of students with tutor assistance**
- 20.00 Social dinner

#### Wednesday, 27 July

##### Corrosion and protection of metallic surfaces

- 9.00 **Structure and applications of layered double hydroxides (LDHs)**  
Maria Richetta
- 10.00 **Corrosion and protection of metallic surfaces (part I) Aerospace and automotive applications**  
Tullio Monetta
- 11.00 Coffee break
- 11.30 **Corrosion and protection of metallic surfaces (part II) Biomedical applications**  
Annalisa Acquesta
- 12.30 **Conclusions and closing remarks**  
Benedetto Bozzini and Roberto Montanari

# Metallurgy Summer School



## Monday, 25 July

### **Benedetto Bozzini - What is surface engineering?**

A range of functional properties of diverse technological components, crucially depend on the structure and composition of their surface. For this reason, materials scientists try to gain fundamental understanding of the surface properties of materials and to tailor them, in view of achieving optimal performance. The physics of surfaces is a subject in its own right, surface analytics is a dedicated field of science and surface modification processes are dreadfully varied in physical and chemical nature. All this makes surface engineering a complex and sometimes chaotic sea, that this talk has the ambition of helping to chart and navigate, providing a common and comprehensive logical framework, in support of the lessons that will follow.

### **Roberto Montanari - Fundamentals of diffusion**

The lecture aims to introduce the basic concepts of solid state diffusion. The Fick's laws and the Kirkendall effect will be presented. The physical mechanisms of diffusion, the role of point defects, pipe diffusion and grain boundary diffusion will be discussed.

### **Alessandra Varone - Solution of typical diffusion cases**

Diffusion plays a key role in the kinetics of many phenomena and processes such as surface oxidation of metals, heat treatments, surface hardening of steels, gas storage etc. In the lecture the analytical solution of some typical diffusion cases will be presented and discussed.

### **Ivonne Sgura - Numerical solution of problems in systems where diffusion and chemical reactions occur**

The lecture focuses on some reaction-diffusion differential models for electrodeposition where morphological patterns, like spiral waves and Turing patterns, are present. We focus on their numerical approximation, on comparisons with experiments and related parameter identification.

### **Nora Lecis and Roberto Montanari - Experimental techniques for surface analysis I (structure)**

The lecture will provide an overview of the principal experimental techniques commonly used to investigate the structural features of the metallic surfaces: X-ray diffraction, micro-hardness test, nano-indentation test, mechanical spectroscopy. The analysis of wear resistance and adhesion will also be described, with a focus on the wear resistance and scratch test. Examples of structural analysis will be given.

### **Alessio Mezzi and Saulius Kaciulis - Experimental techniques for surface analysis II (micro-chemistry)**

One of the most important aspects in the surface engineering of metallic materials is the determination of surface chemical composition and its modification in the working conditions. In this direction, a significant role is played by surface electron spectroscopies, because they are conceived as a tool for the investigation of the surface chemical composition, identifying the chemical state of the elements and their lateral distribution down to the micrometric scale. Here an overview will be given of basic principles and experimental case studies of the main surface analysis techniques employed to investigate the surface of metallurgical materials: X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES) and electron energy loss spectroscopy (EELS). The information depth of these techniques is limited to the first monolayers (< 10 nm), but it can be extended further by using depth profiling with ion sputtering.

## Tuesday, 26 July

### **Massimo Pellizzari - Classification and design criteria for thermo-chemical treatments of metal parts**

Thermochemical surface treatments represent a powerful tool to increase surface hardness, load bearing capability, wear and fatigue resistance of steel and metal parts. Nevertheless, these achievements can be obtained if the most suitable process is selected, as well as the optimum processing parameters. Aim of present lecture is to introduce the main thermochemical surface treatments, their selection and design criteria.

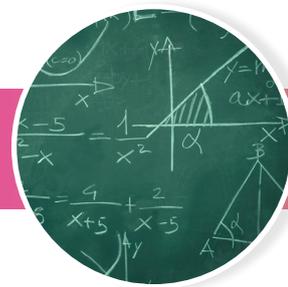
### **Antonio Gloria - Design and strategies of surface optimization for structural and functional applications**

The increasing applications of advanced technologies in industrial production have currently led to product reimagination from a new standpoint. Over the past years, great efforts have also been made to develop surface modification strategies. An approach towards topography optimization will be described to fine-tune topology-optimized models. Even though methods for manufacturability will be considered when performing topology optimization, manufacturability for topography optimization will be also analysed.

### **Carla Martini - Techniques for manufacturing engineered surfaces (from liquid phase)**

Techniques for manufacturing engineered surfaces (from the liquid phase): deposition methods from aqueous solution, widely applied in the field of engineering components, will be presented and discussed in terms of process, coating microstructure and properties. The following topics will be covered: (i) electrodeposition of Cr and autocatalytic (electroless) deposition of Ni-P; (ii) anodising (both by conventional and innovative methods, such as Plasma Electrolytic Oxidation).

# Metallurgy Summer School



## Tuesday, 26 July

### David Dellasega - Techniques for manufacturing engineered surfaces (from vapour phase)

The properties of a metallic surface can be properly tailored through the growth of a film or a coating where the constituents are in vapour phase. In the present lecture different physical vapour deposition techniques, such as magnetron sputtering (DC, RF, HiPIMS), cathodic arc, thermal evaporation and pulsed laser deposition will be presented and discussed. The role of the process parameters in determining the features (e.g. stoichiometry, crystalline structure, mechanical and optical properties, etc.) of the deposited films will be shown. Relevant examples will also be presented and discussed.

### Claudio Mele - Modified surfaces for batteries and fuel cells

Batteries, fuel cells and other electrochemical devices play an important role on the energy storage stage. Most electrochemical reactions occur on the electrode-electrolyte interface and interface components, surface structure and properties determine the performance of the devices. Thus, to improve their performance, the surface and interface in batteries and fuel cells can be efficiently modified and tuned. Recent research about surface modification in electrodes will be presented and discussed.

### Paolo Piccardo and Roberto Spotorno - Engineered surfaces of interconnects for the stacking of fuel cells

The power scalability of fuel cells is achieved by introducing interconnects, joining elements providing mechanical support and electrical contact between the cells. The severe operating conditions lead to the careful selection of ferritic stainless-steel grades matching mechanical and chemical properties for the application of such components. The classes will focus on the materials selection and usage, best practice and case studies from the lab and real application.

## Wednesday, 27 July

### Maria Richetta - Structure and applications of layered double hydroxides (LDHs)

Layered double hydroxides (LDHs) are ionic lamellar materials belonging to the group of anionic clays, whose structure is based on brucite-like layers, which can host even complex organic molecules. Engineered LDHs can find a large variety of applications such as additives in organic anticorrosion coatings, in flame retardants, for water treatment and purification or for biomedical applications. Several synthesis techniques have been successfully applied. A wide variety of structures can be obtained under different preparation conditions, but a good control of composition and morphology of the deposited film is still a challenging task. It will be shown that the LDHs morphology is strongly affected by the microstructure of the substrate on which they grow.

### Tullio Monetta - Corrosion and protection of metallic surfaces (part I) Aerospace and automotive applications

Several different metals and alloys are used in the aerospace and automotive field. When exposed to the working environment, their thermodynamic and kinetic behaviour is quite diverse, causing rapid parts degradation. After a short enumeration of the metal families used in aerospace and automotive applications, the types of degradation mechanisms affecting them will be shown, and the most suitable industrial surface treatment to improve their durability will be proposed. To do this, a rapid overview of the surface characterization techniques used to evaluate their effectiveness will be shown, too.

### Annalisa Acquesta - Corrosion and protection of metallic surfaces (part II) Biomedical applications

The interaction of biomaterials with the human body involves complex phenomena at the biomaterial/tissue interface. Biomaterials must have mechanical or surface properties to meet the needs of a particular application. For this reason, different metals are used, such as 316L stainless steel, cobalt-chromium alloys, titanium-based alloys and others. This lesson will present an overview of metals biomaterials degradation problems and possible surface treatments to protect or functionalize them.

## Secretariat



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### General informations

#### Location

The Course will be held in Ce.U.B - Centro Residenziale Universitario Bertinoro - Via Frangipane, 6 Bertinoro (FC), Italy - [www.ceub.it](http://www.ceub.it)

#### Accommodation

Half board (Breakfast and Lunch) in the old seminary (included in the registration fee).  
(Please communicate any dietary requirements: allergies, intolerance, particular diet, etc)

#### Laptop

Attendees to the Summer School are requested to bring a personal laptop.

#### CTS

The attendance to the School will provide 3 CTS.

#### Language

The Summer School will be held in English.

#### Registration information

The Summer School has a limited number of available places. **Registrations will close on June 15 or as soon as the maximum number of participants will be reached.** Therefore, in case of interest, we strongly recommend to register as soon as possible.

#### Registration fees (per person)

##### AIM MEMBERS FEES

Single Room	€ 420,00	(revenue stamp included)
Double Room	€ 390,00	(revenue stamp included)

##### NON MEMBER FEES

Single Room	€ 510,00*	(22% VAT included)
Double Room	€ 480,00*	(22% VAT included)

##### ACCOMPANYING PERSON

Double Room	250,00 (22% VAT included)
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Registration fees include admittance to the Summer School, half board accommodation (breakfast and lunch), coffee breaks, welcome buffet on 24 July, aperitif on 25 July and social dinner on 26 July.

**Fee for attendees** who do not need accommodation:  
Euro 250,00

For information on AIM membership please visit [www.aimnet.it](http://www.aimnet.it) or contact AIM Secretariat ([aim@aimnet.it](mailto:aim@aimnet.it)).

AIM Junior members are required to pay the registration fee.

#### Payment and remittance

- by bank transfer, to the order of Associazione Italiana di Metallurgia - AIM at "CREDITO EMILIANO SpA", Branch no. 052 Milano - Via Andegari, 14 - 20121 Milano - Italy, account no. 010000480455- cod. ABI 03032- CAB 01600- - cin M IBAN: IT33M0303201600010000480455, swift code BACRIT22MIL. The transfer order must specify the name of the participant and the reference "Summer School 2022". A copy of the transfer order must be sent to AIM, together with the Registration Form.
- by credit card online: [www.aimnet.it](http://www.aimnet.it)

#### Cancellation and refund policy

A refund, less 20% deduction for administrative costs, will be issued for written cancellations received **by 15 June, 2022**. For attendees who notify their cancellation **after 15 June, 2022** or will not attend the Summer School, a charge of 100% of the registration fee will be withheld and a copy of the documentation will be sent after the event.

#### Insurance

The Organising Secretariat cannot assume any responsibility for personal accident, loss or damage to the private property of participants and accompanying persons, which may either occur during or arise from the Summer School. Participants should therefore take whatever steps they consider necessary as regards insurance.

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