



SVEUČILIŠTE U ZAGREBU  
METALURŠKI FAKULTET

UNIVERSITY OF ZAGREB  
FACULTY OF METALLURGY



# Experience & relevant research activity at the Faculty of Metallurgy

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## HISTORY

- ❑ The economic development of the mid-20<sup>th</sup> century created the need for rapid education of experts and specialists in the Republic of Croatia in technical areas, including metallurgy.
- ❑ The first activities were started in 1958 with efforts regarding the foundation of the Technical higher education school, which had metallurgy and technical areas of expertise.
- ❑ However, this solution was abandoned, and instead of that the **Faculty of Technology in Sisak** was founded, containing the **Department of Metallurgy** and the **Department of Oil Technology and Industry**.
- ❑ Instruction at both mentioned departments of the Faculty of Technology started in Sisak with the academic year 1960/1961, when 89 students enrolled (49 students of metallurgy and 40 at the Oil Industry and Technology).





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□ In 1963, the Faculty of Technology in Zagreb went through a restructuring, after which the higher education instruction in Sisak was separated into two departments:

the **Department of Metallurgy** and **Chemical-technological oil department**.

The Scientific and Educational Committee of the **Faculty of Metallurgy** was founded in November 1978 within Complex organization of joint labour of the Metallurgy Combine of Željezara Sisak

□ From late 1978 to 1991, the organization and management of the Faculty of Metallurgy took place at three structural levels:

- scientific,
- research-developmental
- and business.



□ in June 1991 **Faculty of Metallurgy** became an independent scientific and educational institution of the *University of Zagreb* for the following activities:

- Scientific and educational activities in technical sciences, field of metallurgy;
- Scientific and research activities in the field of metallurgy, chemical engineering and other technical and technological areas relevant to the field of metallurgy;
- Auxiliary scientific and research activities.



MATERIALS  
METALS AND NON-METALS



Industrial  
ecology



Metalurgical  
Engineering

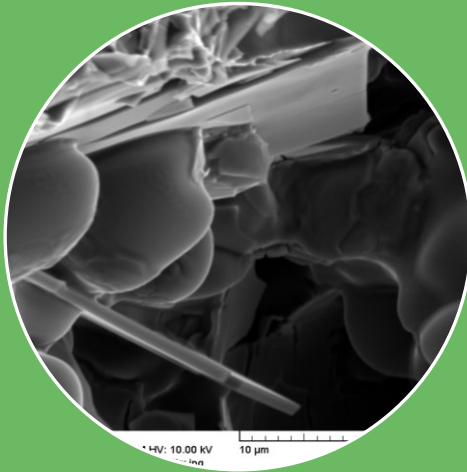
METALLURGY





## Department of Process Metallurgy

- Laboratory of Iron, Steel and Founding
- Laboratory of Chemistry, Hydrometallurgy and Corrosion Investigation
- Laboratory of Industrial Ecology



## Department of Physical Metallurgy

- Laboratory of Physics and Structure Investigation
- Laboratory of Materials Development and Application
- Chair of Mathematics and Information Technology



## Department of Mechanical Metallurgy

- Laboratory of Deformation Metal Processing
- Laboratory of Thermal Technique and Mechanical Engineering

**INTERNAL ORGANIZATIONAL STRUCTURE OF THE FACULTY OF METALLURGY**

# Schematics of scientific and research activities

## Department of Process Metallurgy

- the production of raw iron and steel,
- metal processing via founding,
- resistance of metals to various forms of corrosion,
- structure and properties of carbon material,
- extraction of metals from depleted raw materials
- and usage of waste and secondary products of metallurgical processes

## Department of Physical Metallurgy

- research of constitution and structure of alloys,
- production of complex alloys in the controlled laboratory conditions,
- testing of crystal structure of alloys by standard methods,
- thermal processing of metals materials,
- testing of hardenability by the Jominy method,
- thermal analyses (DTA, DSC, TGA),
- welding of metals by various procedures

## Department of Mechanical Metallurgy

- research of heat transfer,
- testing of deformability of metals materials,
- numerical analyses,
- material testing



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## **\*Applied and developmental investigations\***

in line with the needs of metal producing and processing SMEs' and industries

## **\*Support of economy\***

solving real technical and technological problems

## **\*L3 (Life-long learning)\***

3 levels of study  
International Foundrymen Conference  
Scientific-expert Seminar





# COLLABORATION INSTITUTIONS

with international institutions:

- National Metallurgical Academy of Ukraine, Dnipropetrovsk, Ukraine
- Faculty of Metallurgy Technical University of Košice, Košice, Slovakia,
- Faculty for Natural Sciences and Engineering University in Ljubljana, Ljubljana, Slovenia
- Institute for Metal Materials and Technologies, Ljubljana, Slovenia
- Montanuniversität Leoben, Leoben, Austria
- Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie, Krakow, Polska
- Technische Universität Clausthal, Clausthal, Germany
- Rheinisch-Westfälische Technische Hochschule Aachen Faculty of Georesources and Materials Engineering, Aachen, Germany
- Linnaeus University, Växjö, Sweden



# COLLABORATION INSTITUTIONS

with international institutions in ESEE region:

- Faculty of Metallurgy and Technology, University of Montenegro, Podgorica, Montenegro
- Faculty of Mechanical Engineering, University of Maribor, Maribor, Slovenia
- Technical Faculty in Bor, University of Belgrade, Belgrade, Serbia
- Faculty of Metallurgy and Materials in Zenica, University of Zenica, Zenica, Bosnia and Herzegovina
- University of Zenica, Metallurgy Institute " Kemal Kapetanović " Zenica, Zenica, Bosnia and Herzegovina
- University of Bihać, Bihać Biotechnical Faculty, Bihać, Bosnia and Herzegovina



# COLLABORATION INSTITUTIONS

and Croatian institutions:

- Faculty of Science, University of Zagreb, Zagreb
- Ruđer Bošković Institute, Zagreb
- Brodarski Institute Ltd., Zagreb
- Istrian Development Agency (IDA) Ltd., Pula
- Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb,
- Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb,
- Faculty of Chemical Engineering and Technology, University of Zagreb,
- Faculty of Chemical Engineering and Technology, University of Split, Faculty of Mechanical Engineering in Slavonski Brod, J. J. Strossmayer University of Osijek



# ***Scientific project funded by Ministry of Science and Education***

## **Independent scientific project:**

Metal Casting Solidification,  
Leader Professor Faruk Unkić

## **Program „Metal Materials – Properties, Processing and Energy Consumption“**

### **Active projects within the program:**

The Effect of High-Temperature Processes on Properties of High-Alloyed Steels,  
Leader Professor Mirko Gojić

Energetic Efficiency and Product Quality in Metal Plastic Deformation,  
Leader Professor Ladislav Lazić

Environment Assisted Degradation of Metals and Adsorption on Waste C Materials,  
Leader Professor Jadranka Malina

Structure, Properties and Separation of Metallic Materials,  
Leader Professor Tanja Matković



## ***Technological projects in cooperation with industry and SME's:***

- The Effect of High-Temperature Processes on Properties of High-Alloyed Steels
- Improved procedure for casting blocs from wrought aluminium alloys
- Production and testing of rotating casing engine
- Waste disposal of ferrous metallurgy and testing the possibilities of its recovery

## ***Croatian Science Foundation:***

- Design of microstructure and functional properties of Cu-based shape memory alloys
- Study of the Beginning of Plastic Flow of Metals During Cold Deformation



# INTERNATIONAL PROJECTS

## *EUREKA program*

- ❑ Rapidly Solidified Shape Memory Alloys, E! 3704 RSMA

## *Bilateral scientific research projects*

- ❑ Development of new shape memory alloys (HR-SI)
- ❑ Processing technology and heat treatment of steel semi-products for the automotive industry (HR-SI)
- ❑ Technologies of production and heat treatment of steel products for automotive industry (HR-SI)
- ❑ Topological properties of optical and photonic cells (HR-SRB)
- ❑ Development and characterisation of innovative shape memory alloys Cu-Al-Mn-Me (Me=Ag, Au, Ce) (HR-SRB)

## *Development Fund / International Cooperation – WORLD (HR-SRB)*

- ❑ Development of new shape memory alloys



# INTERNATIONAL PROJECTS

## *ESSEM COST Action*

- ❑ ESSEM COST Action ES1202 Conceiving Wastewater Treatment in 2020 - Energetic, environmental and economic challenges (Water\_2020)
- ❑ ESSEM COST Action ES1407 European network for innovative recovery strategies of rare earth and other critical metals from electric and electronic waste (ReCrew)

## *Croatian Qualifications Frameworks*

- ❑ Materials Engineering – a foundation of modern economy

## *European Fund for Regional Development*

- ❑ VIRTULAB – Integrated laboratory for primary and secondary raw materials, 1.6 M€
- ❑ Center for Foundry Technology – SIMET, 8 M€



# Waste disposal of ferrous metallurgy and testing the possibilities of its recovery

*Investigation of slag properties produced at steel production in electric-arc furnace  
Potential usage of slag as by-product*



**0-4mm**



**4-8mm**



**8-11mm**



# Waste disposal of ferrous metallurgy and testing the possibilities of its recovery

*Investigation of slag properties produced at steel production in electric-arc furnace  
Potential usage of slag as by-product*

*Road construction*

*Petrinja*



# Conducted research of soil treatment with steel slag

*UNIZG, Faculty of Metallurgy, Sisak, Croatia*

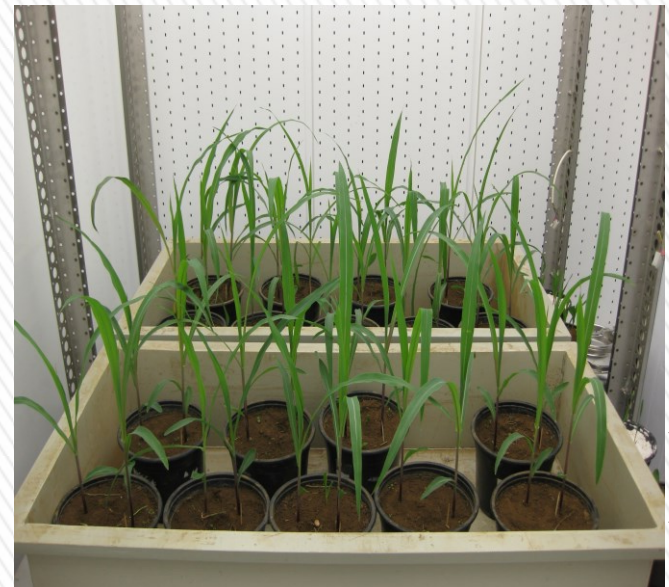
*UNIZG, Faculty of Agriculture, Zagreb, Croatia*

*Improved nutritional properties of soil*

*Regulated acidity of soil*

*Introduced elements into the ground*

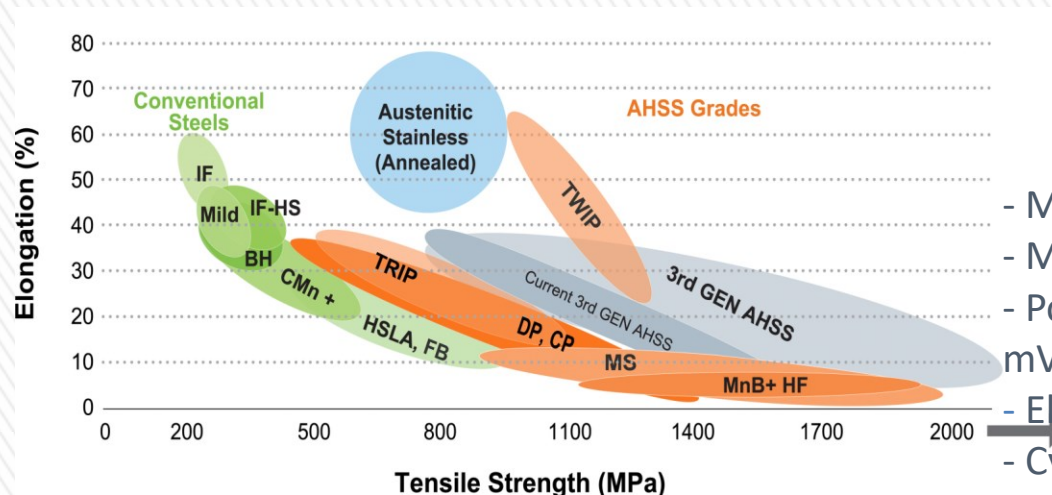
*Use of steel slag as a plant nutrition additive*



# Metallurgical aspects of degradation of metallic and carbon materials

## Environment Assisted Degradation of Metals and Adsorption on Waste C-Materials

**AUTOMOTIVE STEELS:** Corrosion resistance in different media (and with or without addition of inhibitor) and susceptibility to hydrogen embrittlement of Advanced High-Strength Steels (AHSS) in comparison to the Conventional High-Strength Steels (HSS) was investigated.



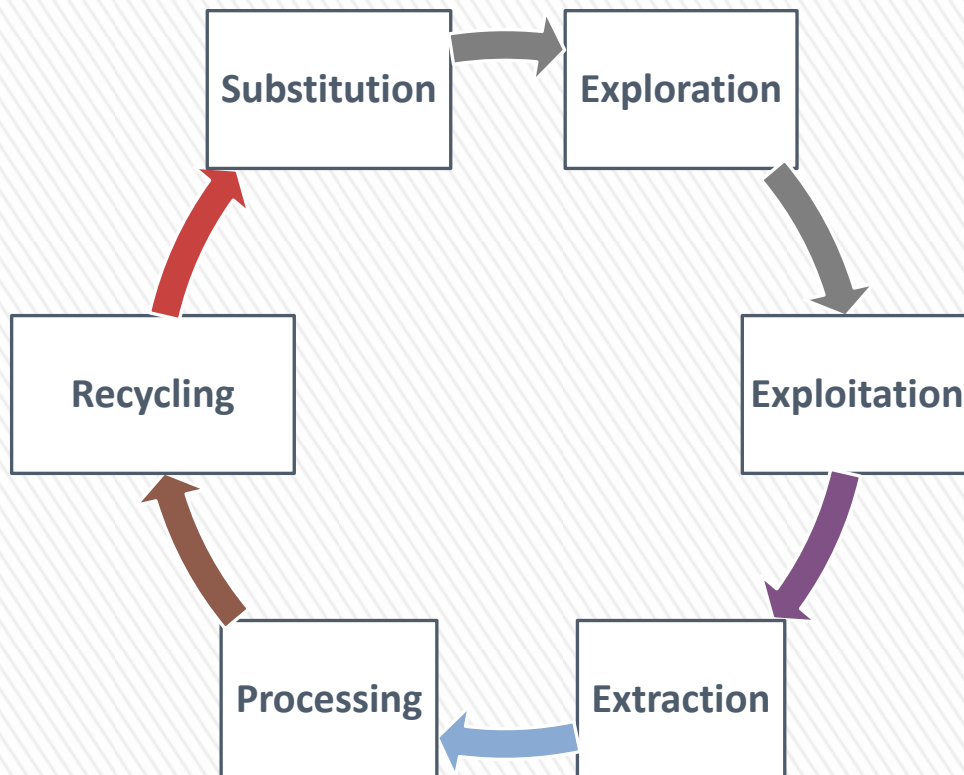
### ELECTROCHEMICAL MEASUREMENTS:

- Measurement of polarization resistance  $R_p$
- Measurement of open circuit potential  $E_{ocp}$
- Potentiodynamic polarization from -250 mV to +250 mV vs corrosion potential ( $E_{corr}$ )
- Electrochemical impedance spectroscopy
- Cyclic polarization
- Method of measurement of hydrogen permeation and determination of hydrogen uptake and transport in metals by an electrochemical technique (HRN EN ISO 17081:2008)



# VIRTULAB – Integrated laboratory for primary and secondary raw materials, EFRR

*University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering; Faculty of Metallurgy; Geotechnical Faculty; Faculty of Chemical Engineering and Technology; Faculty of Food and Biotechnology*



*Outcomes:*

- formation of Croatian research center for primary and secondary materials;*
- supporting multidisciplinary R&D and industrial projects,*
- straightening existing and*
- supporting new multidisciplinary Ms and PhD studies*



# Center for foundry technology - SIMET, EFRR

University of Zagreb Faculty of Metallurgy; Sisak-Moslavina County

The overall objective is the creation of scientific infrastructure for innovative research and development in the metal industry in Republic of Croatia in order to establish network between scientific & research institutions and the real sector.

## MATERIAL DEVELOPMENT

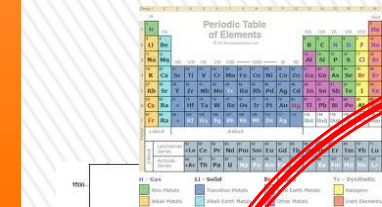
## PRODUCT DEVELOPMENT

## TECHNOLOGY DEVELOPMENT

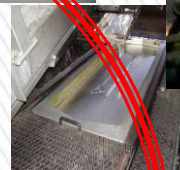
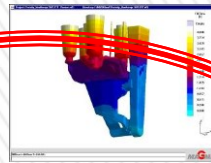
## PROCESS OPTIMIZATION

Specific objectives are:

1. to improve technology transfer and R&D results, as well as their expansion application,
2. to ensure a positive scientific and research environment by establishing a platform for cooperation between business, higher education, public administration and the Croatian Chamber of Commerce, and improve the competitiveness of SMEs in the field of metallurgy.



Chemical composition



Calculation of Phase Diagram

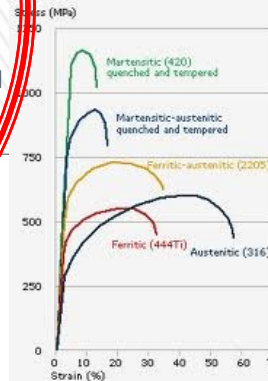
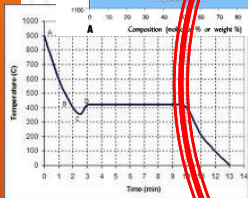
## INFLUENCED PARAMETERS OF PRODUCTION PROCESS

- solidification
- melt treatment
- technology
- post processing

Optimization of Technological Process

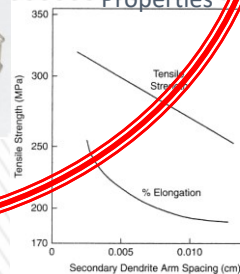
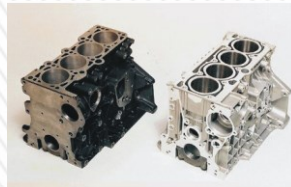
Mechanical and Technological Properties

Temperatures and Intensity of Phase Changes in Material



Phase Identification

Microstructural Properties

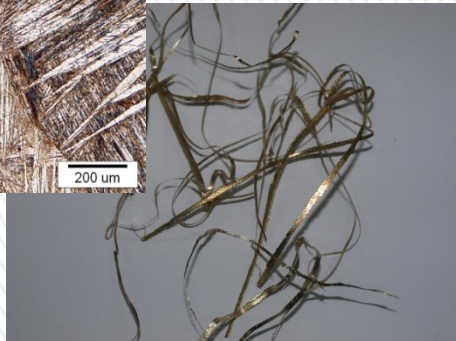
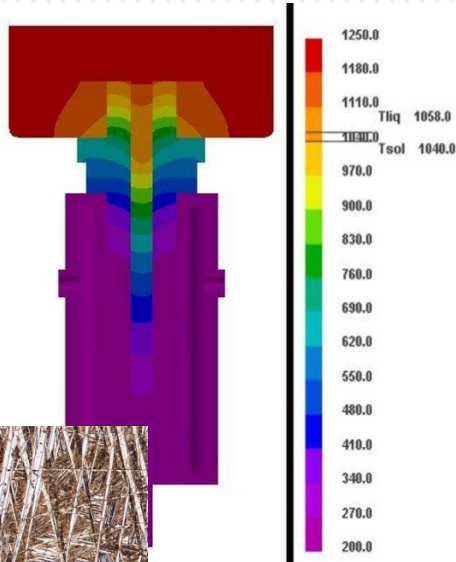


Experimentation & Modelling

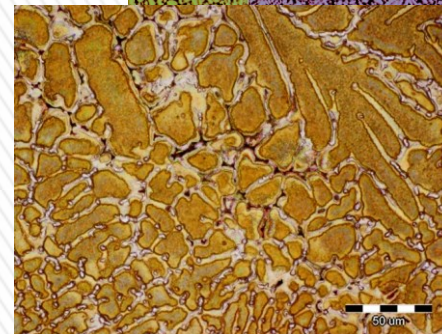
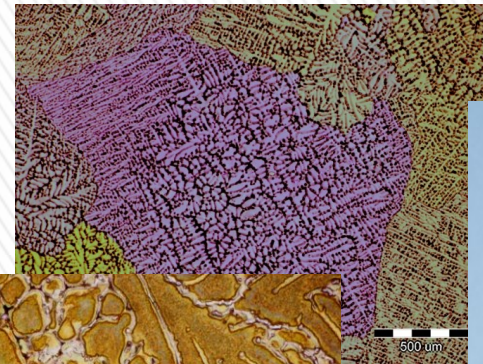
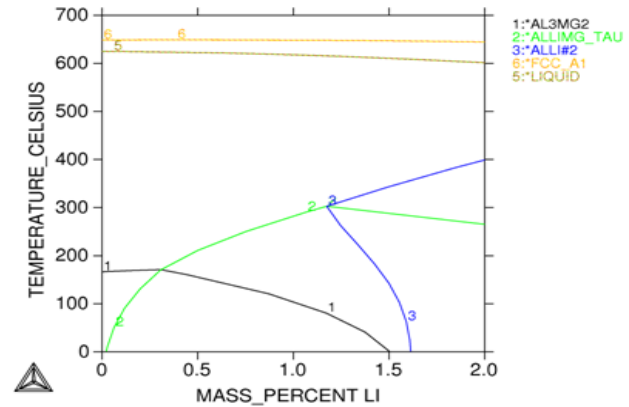
Info day: Research Fund for Coal and Steel, MINGO, Juni 30th, 2017

# Other projects and investigations

*Design of microstructure and functional properties of Cu-based shape memory alloys, IP-09-2014*  
*CuAlNi, CuAlNiMn alloys*



*Design and characterisation of innovative engineering alloys, FPI*  
*Al-Mg-Li alloy*





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# THANK YOU FOR YOUR ATTENTION!

