

### RESEARCH

The electrochemical techniques allow nondestructive in situ monitoring of metal surfaces of cultural heritage. In the case of monometallic surfaces (e.g. statues made of bronze, iron, lead, ...), an electrode-probe is used to evaluate the resistance to degradation of the surface of interest. The used techniques are: the linear polarization resistance ( $R_p$ ) and the electrochemical impedance spectroscopy (EIS). In the case of bi-metallic surfaces (e.g. gilded bronzes), specially designed galvanic sensors, which allow the continuous monitoring of the corrosion rate, are used.

### RESEARCH GROUP

#### MIDAr & CUSBO

<http://midar.chem.polimi.it>

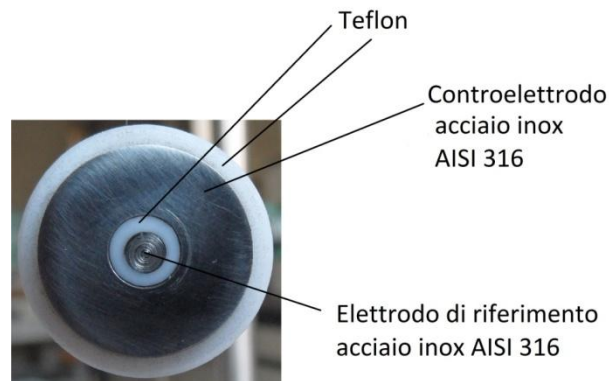
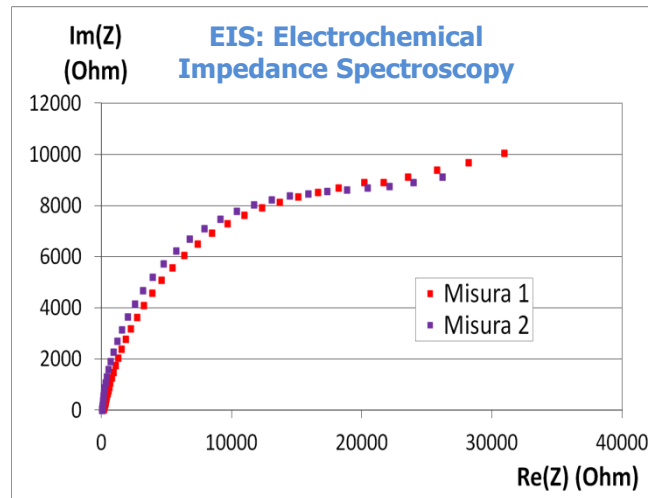
<http://www.laserlabeuropa.net/partners/partners-cusbo>

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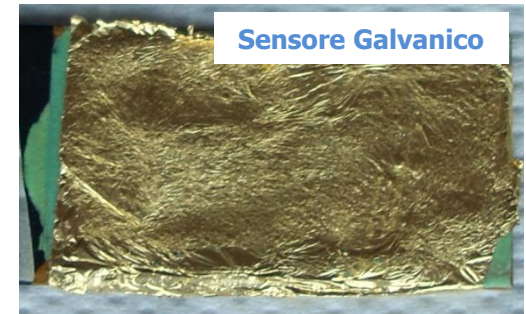
### In situ monitoring with electrochemical techniques



**Electrode-probe for in situ corrosion measurement (EIS e  $R_p$ )**

### ADVANTAGES

- The measurements are NOT destructive and can be made in situ
- The measurement is rapid (20-50 ')
- Gives information on the instantaneous speed of degradation
- Can be applied to monitor the effectiveness of protective treatments



### APPLICATION PORTFOLIO

- Monitoring of gilded bronzes
- Support to the choice of exposure conditions for the Porta del Paradiso by L. Ghiberti (Florence)
- Study of innovative protective
- Study of corrosion inhibitors

### RESEARCH ACTIVITIES

- The research in Nuclear Physics allowed to develop methods for applications in the Cultural Heritage field. They are based on the use of proton beams of different energies. In particular it is possible to use for applications 1.5 MeV low-energy protons (PIXE), 20 MeV intermediate energy protons (DPAA), and 60-80 MeV high-energy protons (HEPIGE).
- DPAA and HEPIGE allow to analyze interior and global composition of metallic objects.

### QUANTITATIVE CHARACTERIZATION OF ROMAN COINS



Roman coins (nummi) belonging to the Misurata Treasure (Lybia)

### MAIN RESULTS/PRODUCTS

- The DPAA technique (Deep Proton Activation Analysis) is currently the only one method that allows the analysis of metal alloys without the results being altered by the presence of surface patinas.
- The combined use of the portable PIXE-alpha and XRF systems it possible the quantitative investigation of the surface in metallic objects.

### RESEARCH STAFF

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### APPLICATIONS

- 1.3 MeV, PIXE: Analysis of some fragments of the Dead Sea Scrolls
- 20 MeV, DPAA: analysis of the interior composition of late Roman nummi
- 60 MeV, HEPIGE : Global composition of thick metallic targets (in progress))