Performance of Nickel-Iron nanostructured electrodes at different temperatures

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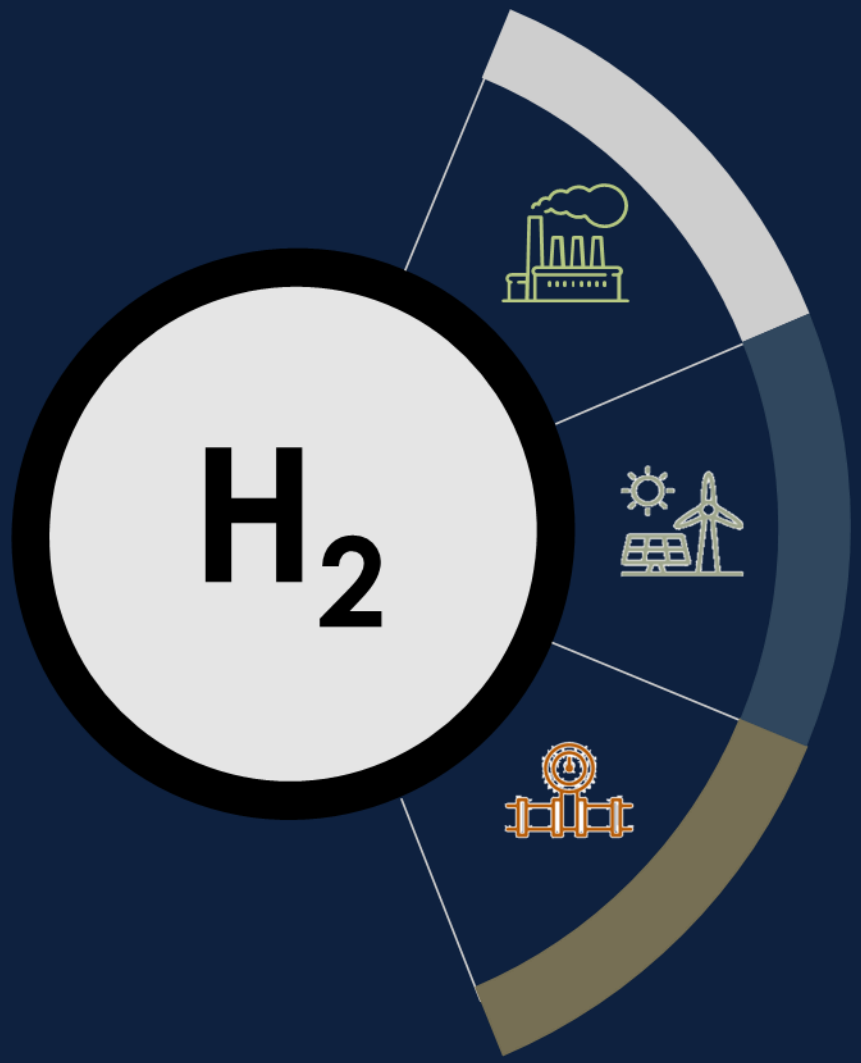
CATALYSIS
October 26-28, 2023


H2



Decarbonization

- zero CO_2 emissions
- green production: Electrolizers

Flexibility and resiliance of energy system

support function for non-programmable renewable forms of energy

Easy integration with the existing **gas distribution network**

01

ELECTRODES FABRICATION

02

MORFOLOGICAL CHARACTERIZATION

03

CARATTERIZZAZIONE ELETTROCHIMICA

ELECTRODES FABRICATION

ELECTRODES FABRICATION

Template electrodeposition

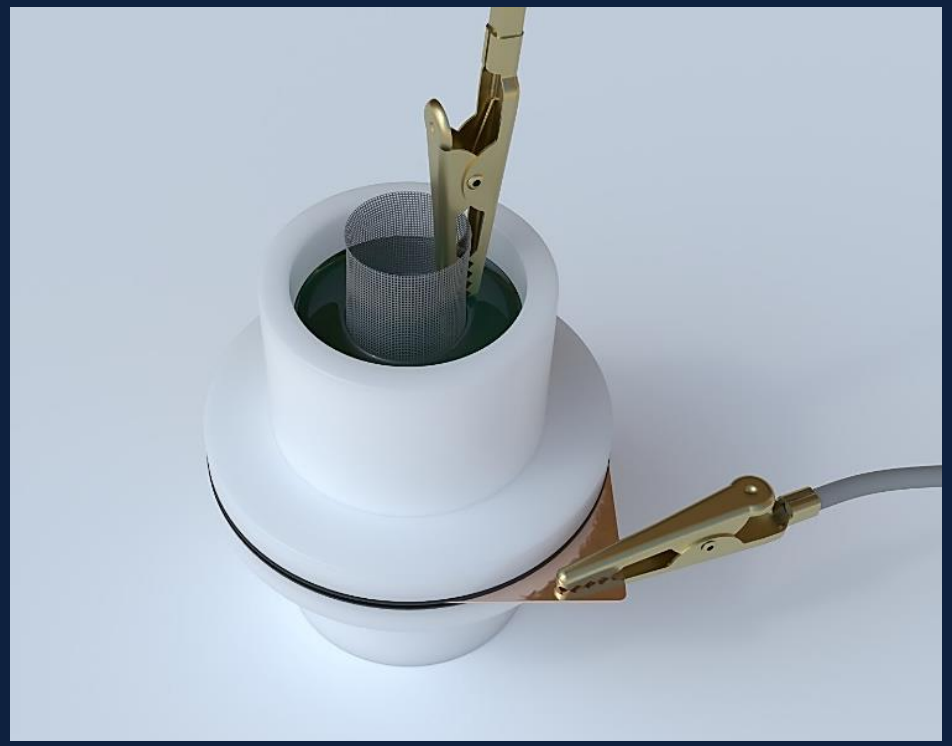
1. Sputtering

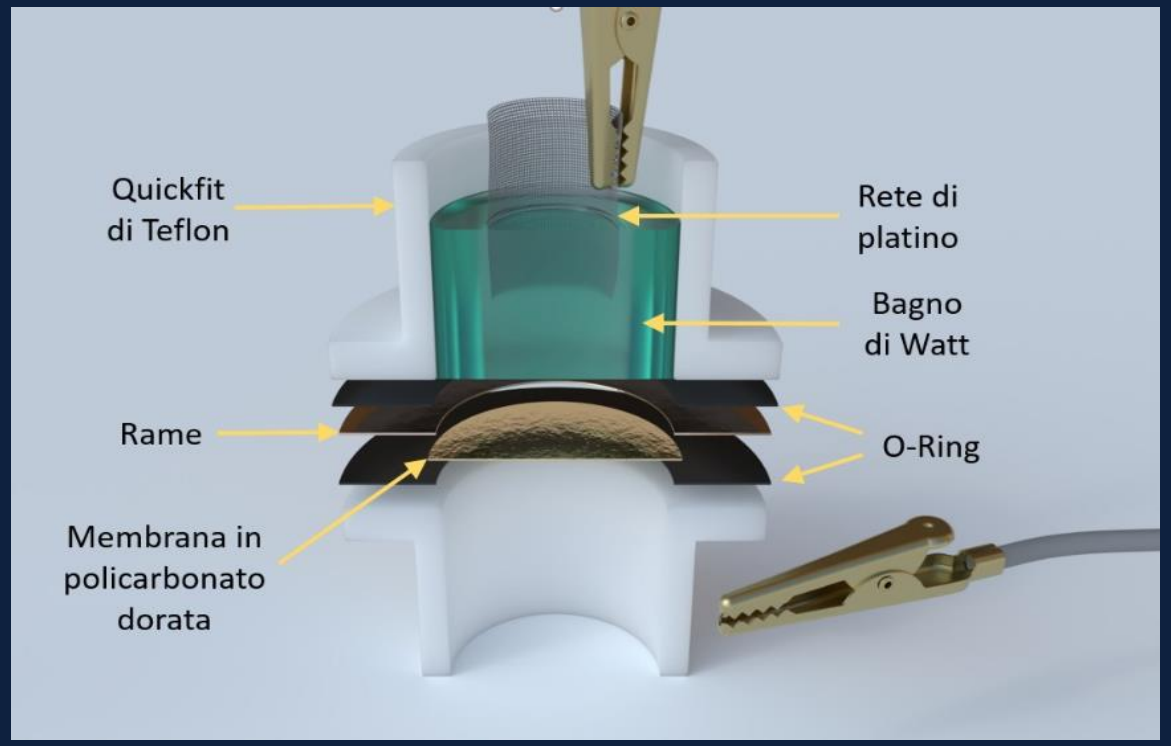
2. Deposition Ni Collector

3. NWs Deposition

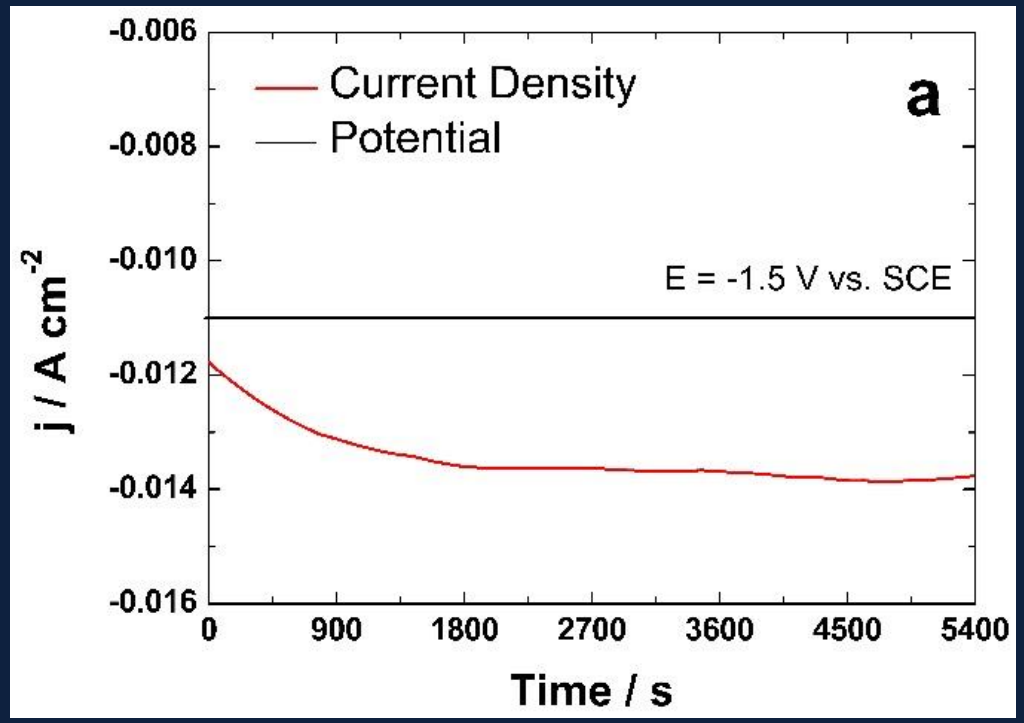
4. Membrane dissolution

ELECTRODES FABRICATION

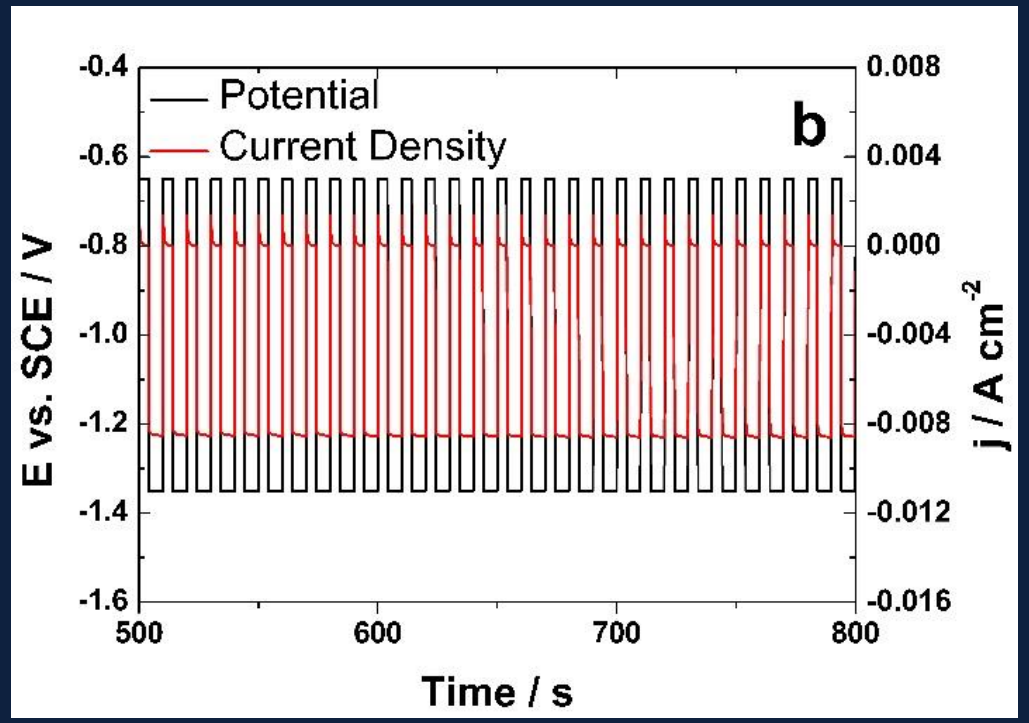




ELECTRODES FABRICATION



Solution:
30 mL Watt' bath ⟶
- 300 g/L $NiSO_4 \cdot 6H_2O$;
- 45 g/L $NiCl_2 \cdot 6H_2O$;
- 45 g/L H_3BO_3.

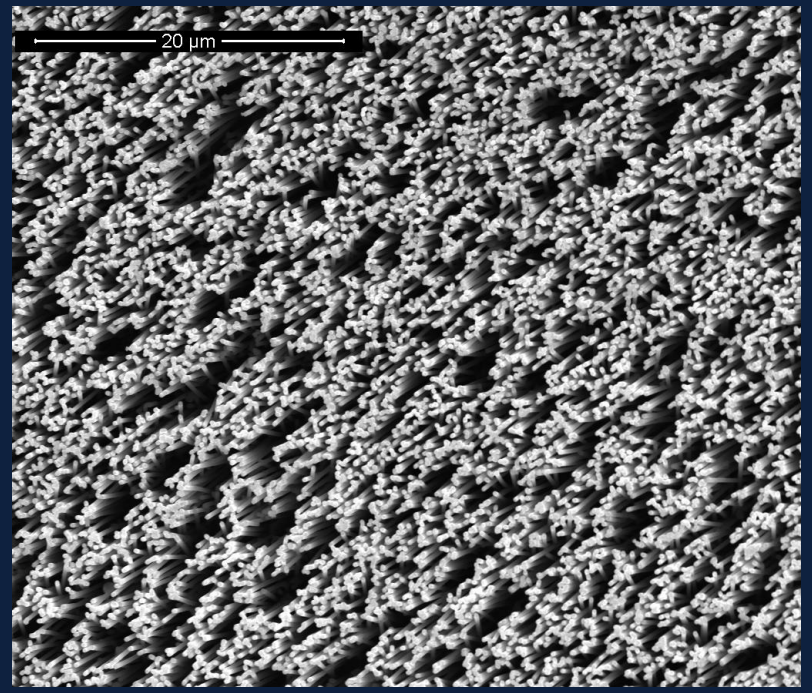


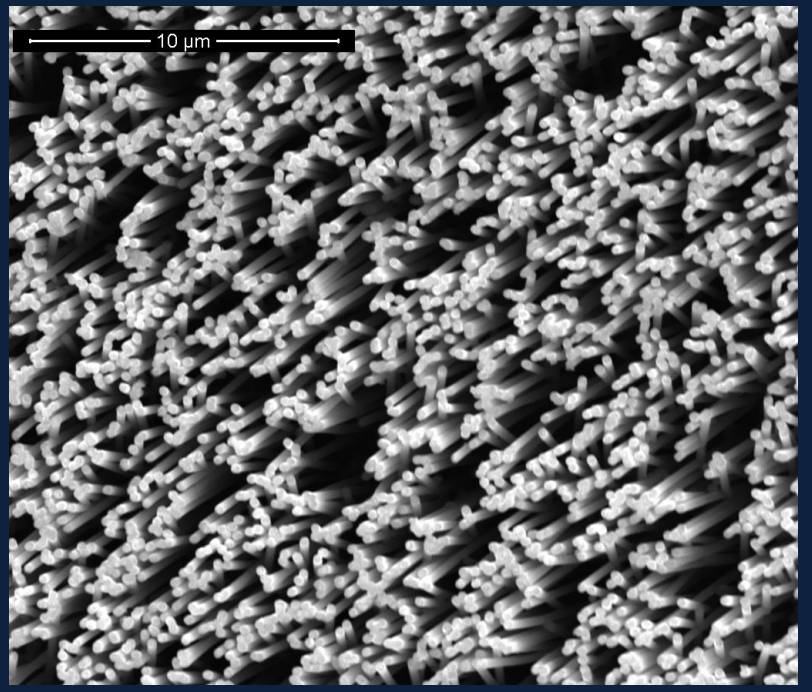
Solution:
- 30 mL Watt's bath;
- 3,7 g/L $FeSO_4 \cdot 7H_2O$

MORFOLOGICAL CHARACTERIZATION

MORFOLOGICAL CHARACTERIZATION

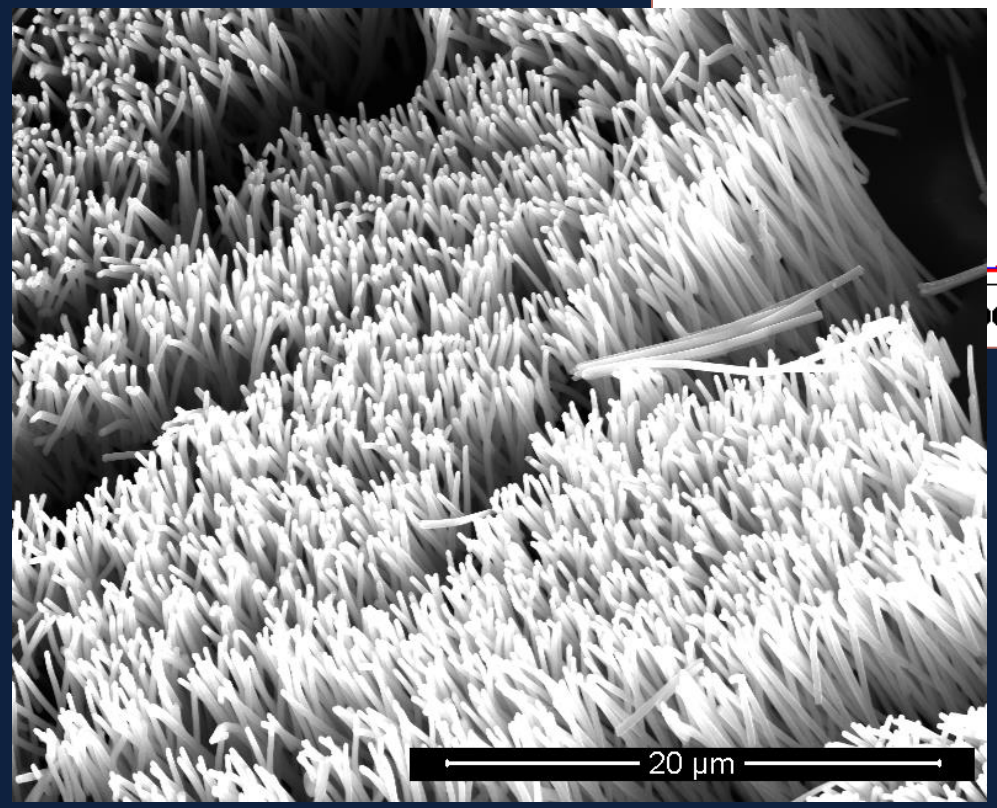
SCANNING ELECTRON MICROSCOPY (SEM)

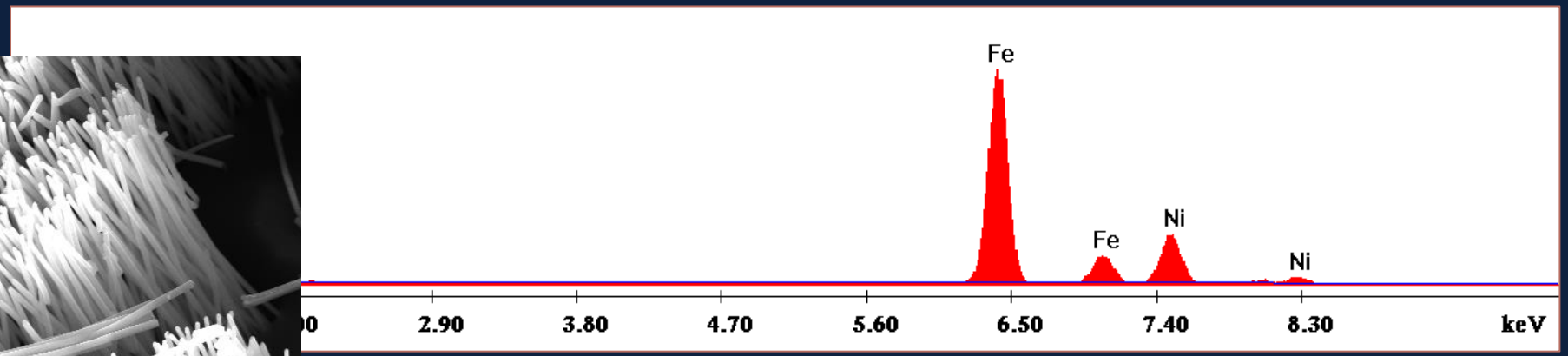




MORFOLOGICAL CHARACTERIZATION

ENERGY DISPERSIVE X-RAY SPECTROMETRY (EDS)





Element	Wt %	At %
FeK	71,95	**72,94**
NiK	28,05	27,06
Total	100,00	100,00

ELECTROCHEMICAL CHARACTERIZATION

ELECTROCHEMICAL CHARACTERIZATION

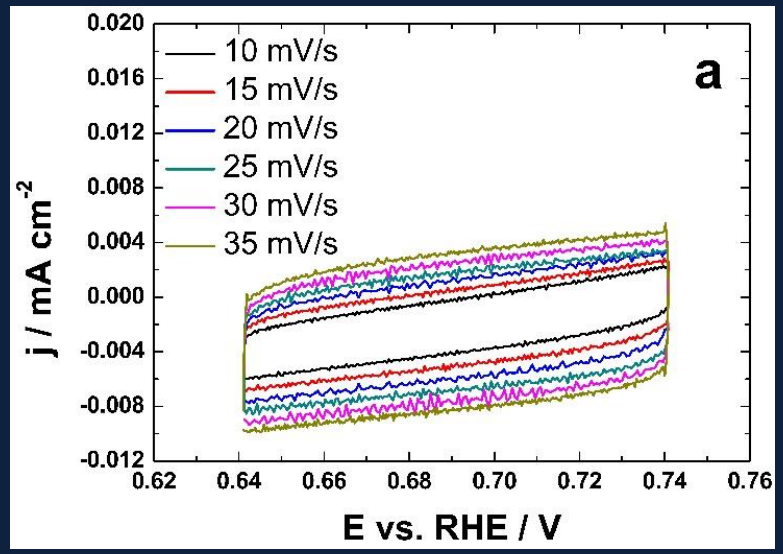
CYCLOVOLTAMMETRY TEST (CV)

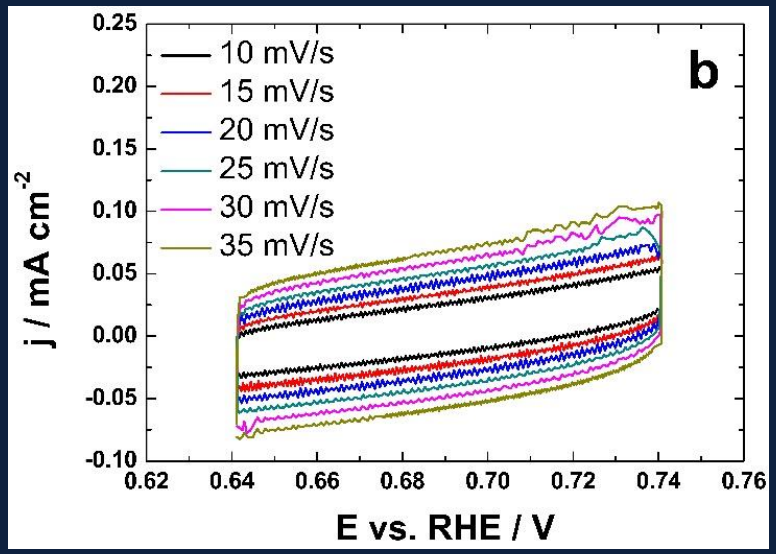
Cyclovoltammetry test at room temperature (a) Nickel Strip (b) NiFe NWs

Solution: KOH 30 wt%

Temperature: 25 °C

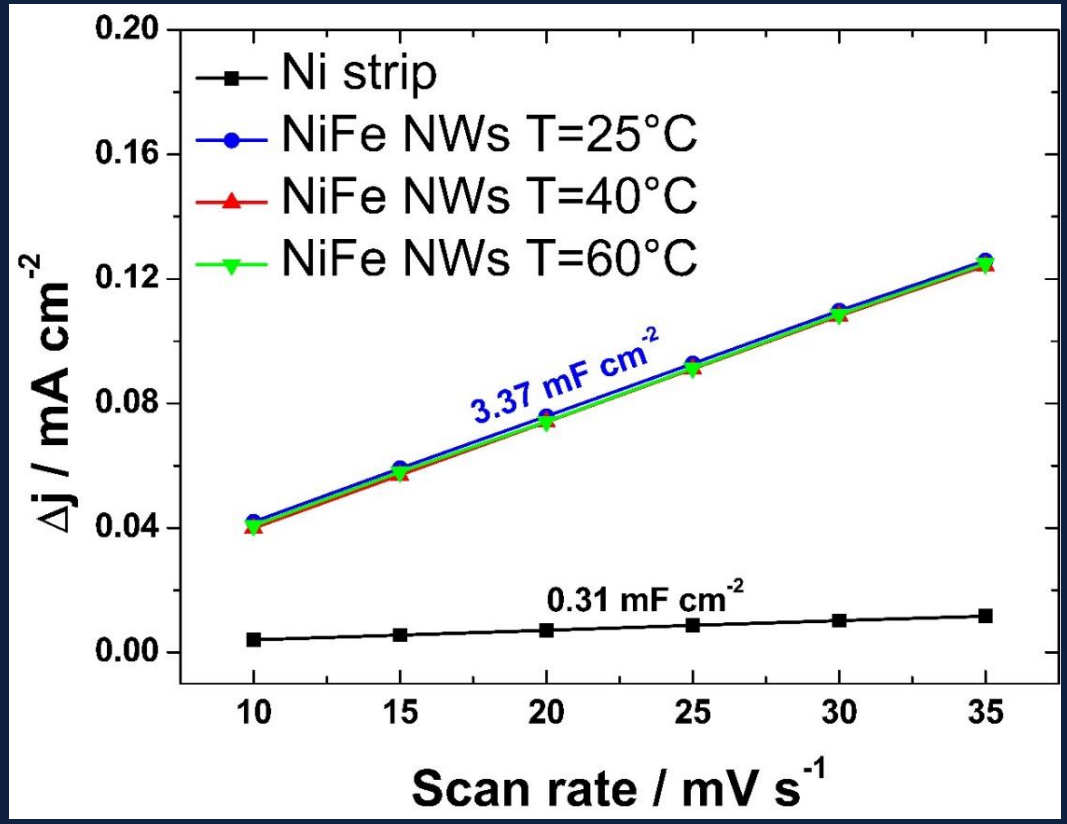
Scan rate: 20, 25, 30, 35, 40 mV s^{-1}





ELECTROCHEMICAL CHARACTERIZATION

CYCLOVOLTAMMETRY TEST (CV)



ELECTROCHEMICAL CHARACTERIZATION

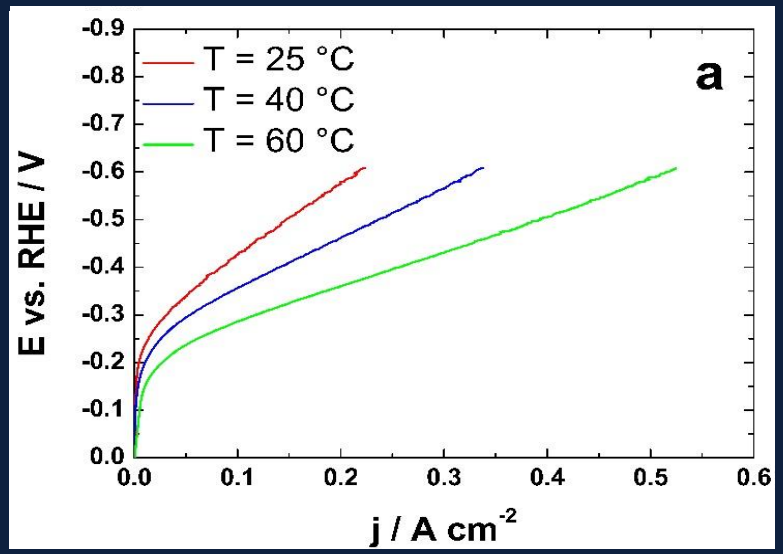
QUASI STEADY STATE POLARIZATION (QSSP)

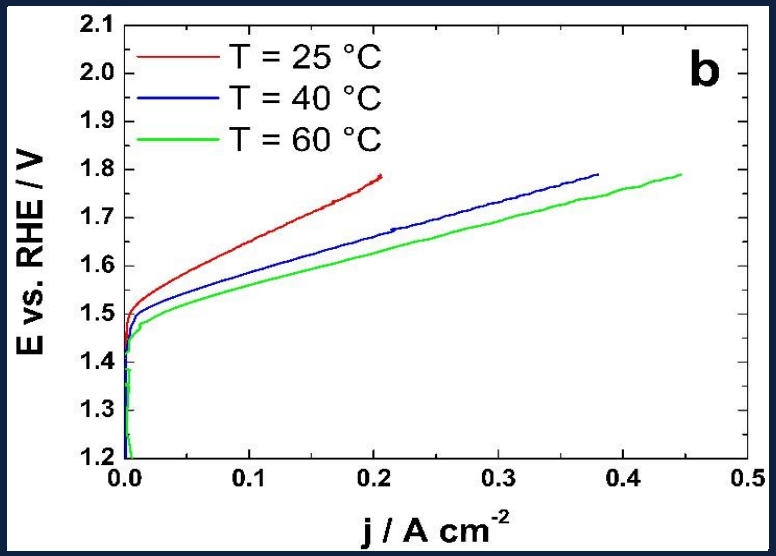
QSSP for (a) HER and (b) OER at 0.1667 mV s-1 relative to the three temperatures

Solution: KOH 30 wt%

Temperature: 25 °C, 40 °C, 60 °C

Potential range: 0,7 V

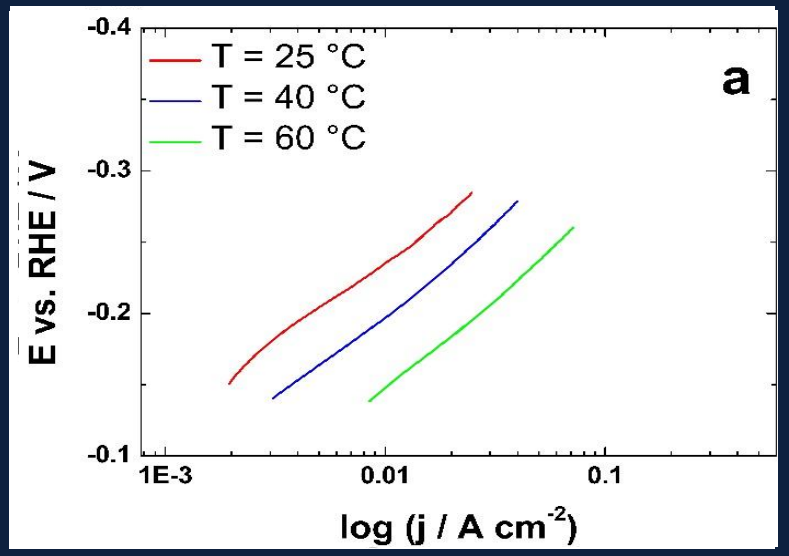


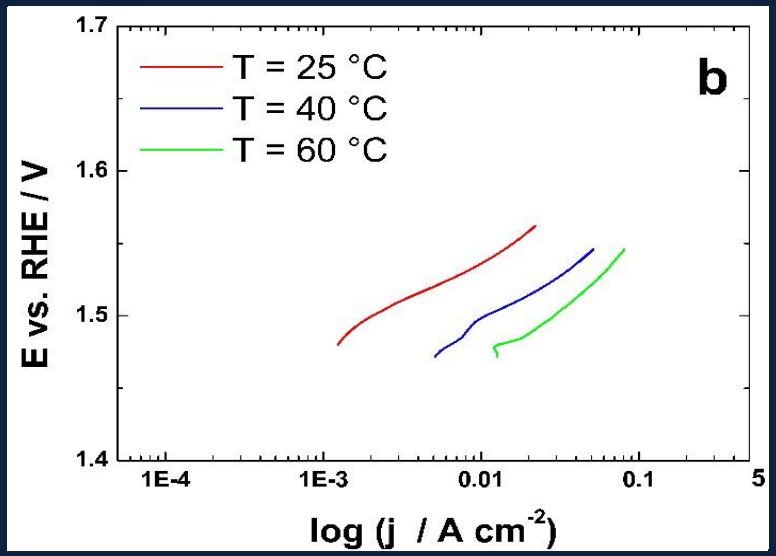


ELECTROCHEMICAL CHARACTERIZATION

QUASI STEADY STATE POLARIZATION (QSSP)

Linearity range of QSSP curves for both (a) HER and (b) OER





Fitted Tafel's parameters

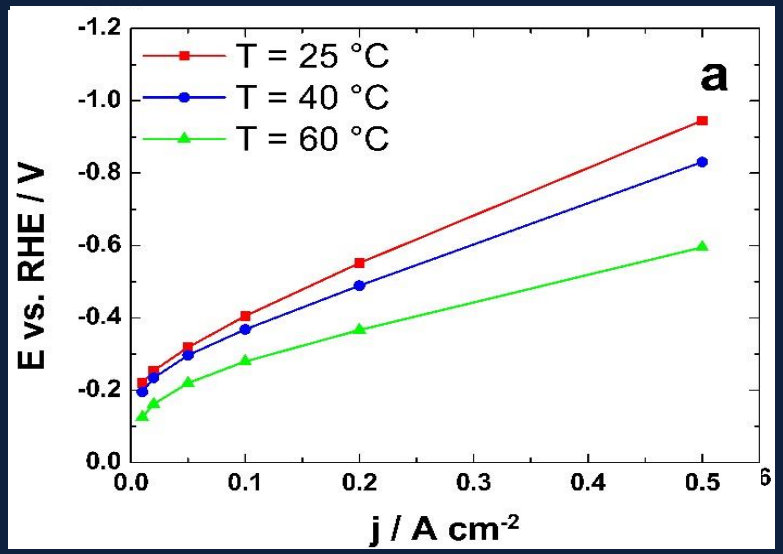
Tafel Equation $\eta = a + b \log j$

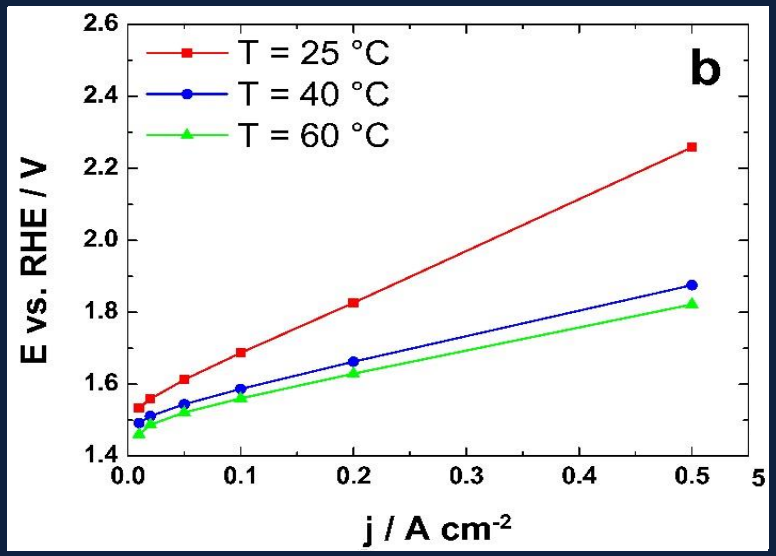
Temperature	HER			OER		
	a (V)	b (V)	R^2 (%)	a (V)	b (V)	R^2 (%)
25 °C	-0,47	-0,120	99,17	1,62	0,055	99,6
40 °C	-0,44	0,119	99,6	1,56	0,053	98,7
60 °C	-0,41	0,118	99,8	1,55	0,049	99,1

ELECTROCHEMICAL CHARACTERIZATION

GALVANOSTATIC STEP TEST (GS)

Galvanostatic Step polarization for (a) HER and (b) OER relative to the three temperatures

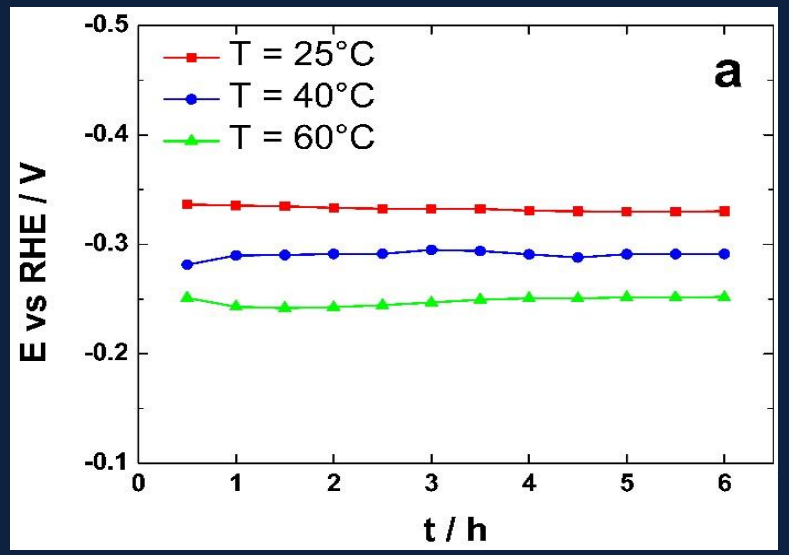


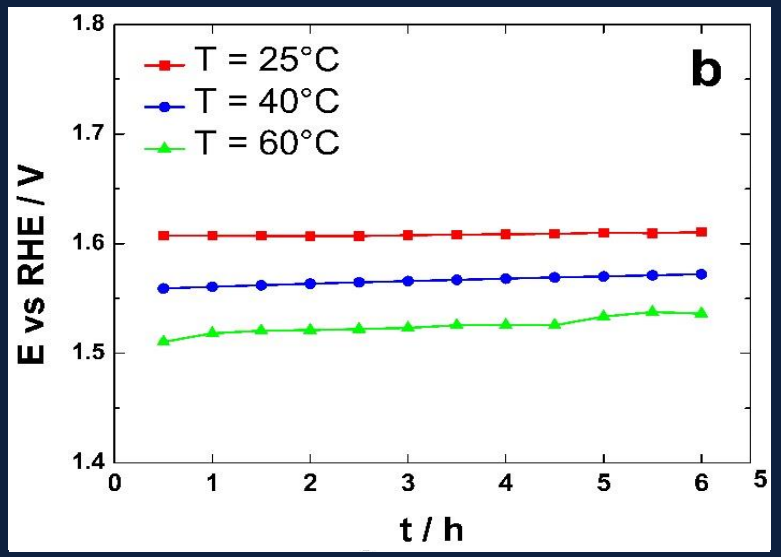


ELECTROCHEMICAL CHARACTERIZATION

GALVANOSTATIC TEST (GS)

Mid-term stability test for 6 hours for (a) HER at -50 mA cm^{-2} and b) OER at +50 mA cm^{-2} relative to the three temperatures.



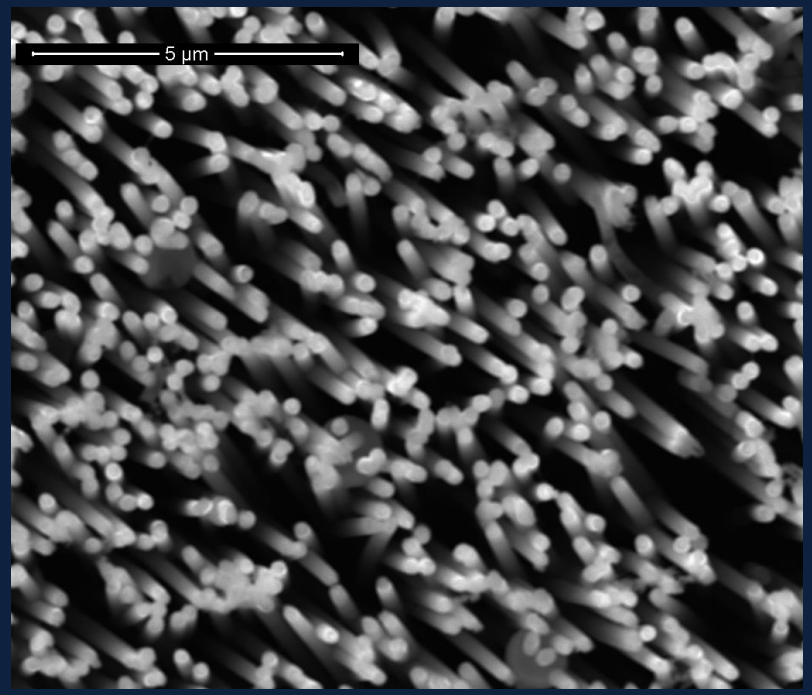


MORFOLOGICAL CHARACTERIZATION

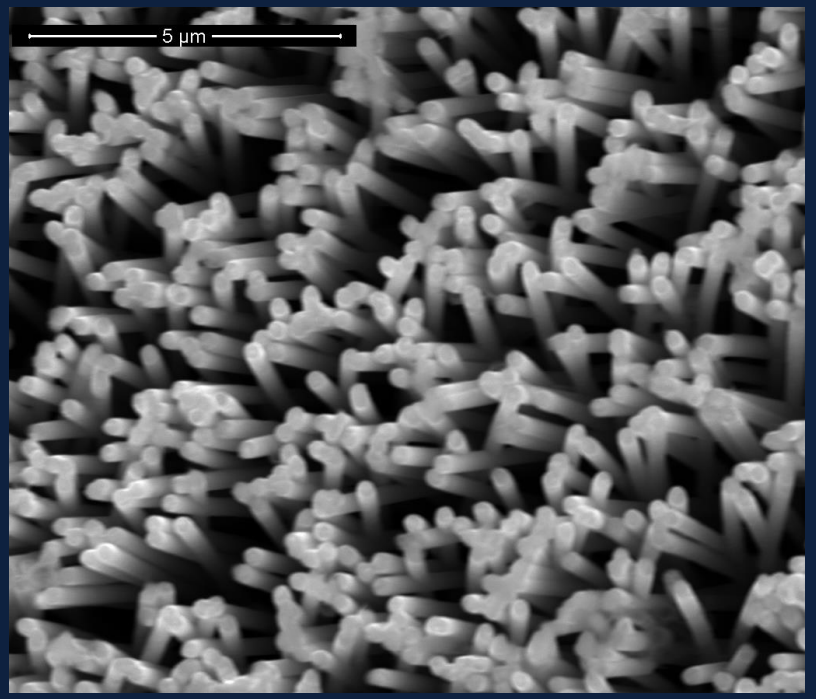
POST ELECTROCHEMICAL TESTS

MORFOLOGICAL CHARACTERIZATION

SCANNING ELECTRON MICROSCOPY (SEM)



Before



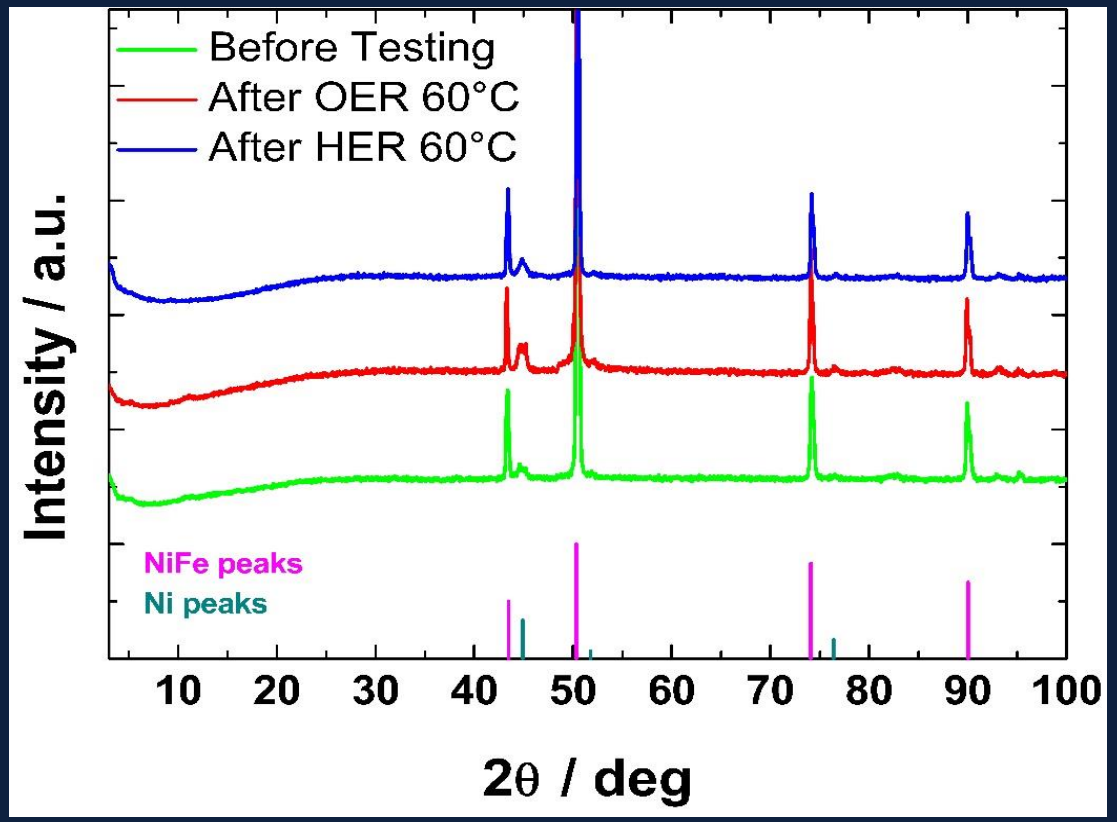
After

MORFOLOGICAL CHARACTERIZATION

X-RAY SPECTROSCOPY (XRD)

XRD pattern of NiFe NWs:

- **Green**: before testing;
- **Red**: after mid-term galvanostatic test OER at 60°C;
- **Blue**: after mid-term galvanostatic test HER at 60°C



CONCLUSIONS

- Nanostructured electrodes were produced with a simple and low cost process, electrodeposition via template, and showed excellent performance compared to the planar type, thanks to the large availability of active surface
- Nanostructured Ni-Fe NWs electrodes achieved excellent performance in electrochemical tests, both for the oxygen evolution reaction and the hydrogen evolution reaction
- Temperature played a fundamental role, in fact the best performances were obtained in the tests at 60 °C
- In the future we will try to carry out tests to evaluate long-term stability, also hypothesizing a possible use with sea water.

THANK YOU FOR YOUR KIND ATTENTION

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