GIST SEED

Enhanced Photoelectrochemical Glycerol Oxidation Efficiency via Layered Double Hydroxide Catalysts for Solar Hydrogen Production System

Hosted by MRS KOREA

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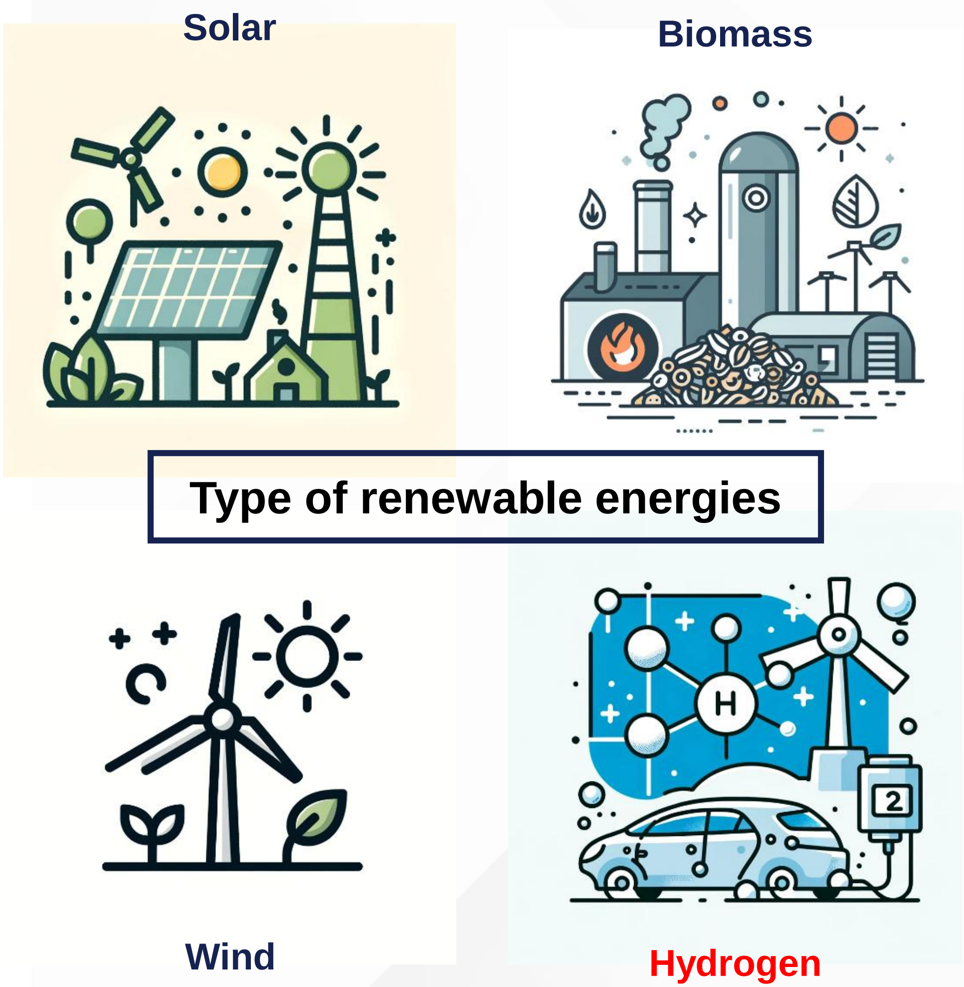
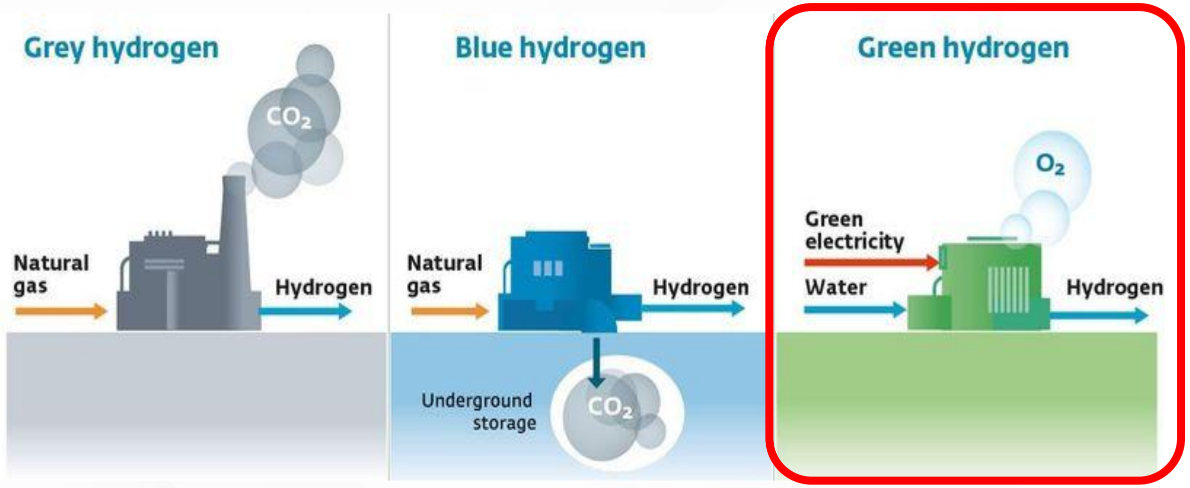
❖ Needs of renewable energy source : green hydrogen

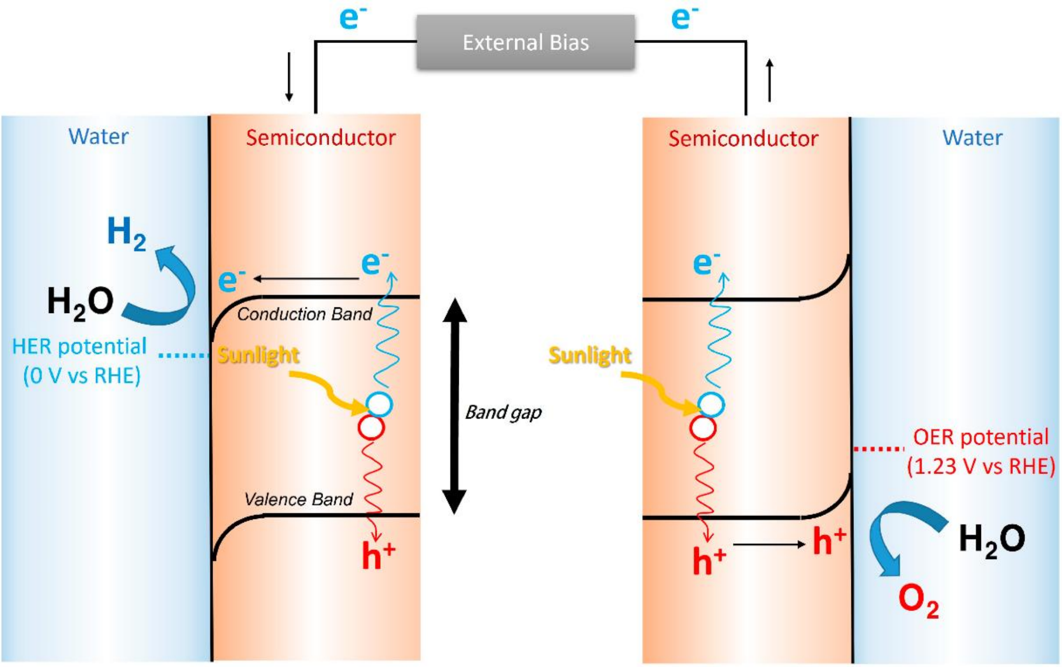




ref. Energy education

- Production through water electrolysis
- Sustainable and environmentally friendly method

❖ Photoelectrochemical system for water splitting



Photocathode **Photoanode**

ref. *Nanomaterials* 2023, 13(24), 3142

Hydrogen evolution reaction (HER) : $2H^+ + 2e^- \rightarrow H_2$

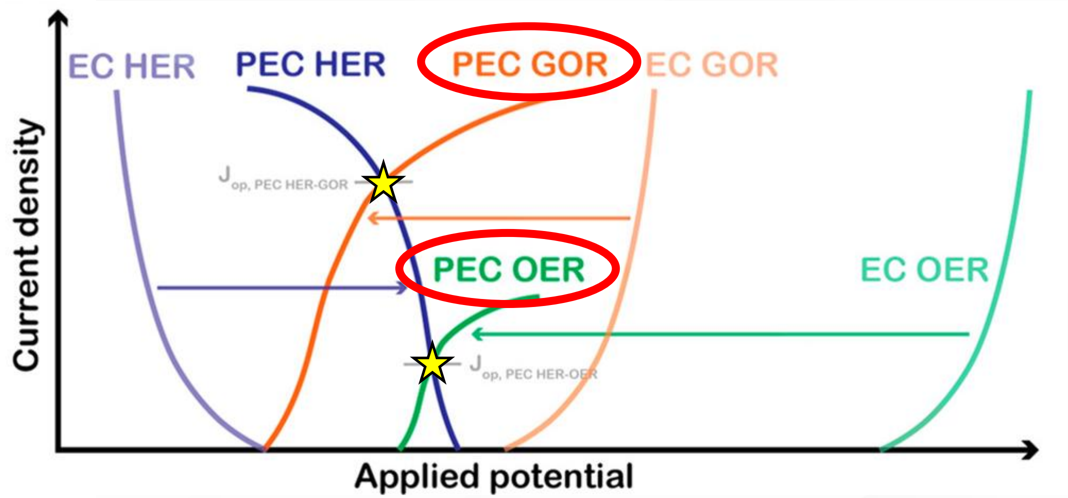
Oxygen evolution reaction (OER) : $2H_2O + 4h^+ \rightarrow 4H^+ + O_2$

Overall water-splitting reaction : $2H_2O \rightarrow 2H_2 + O_2$

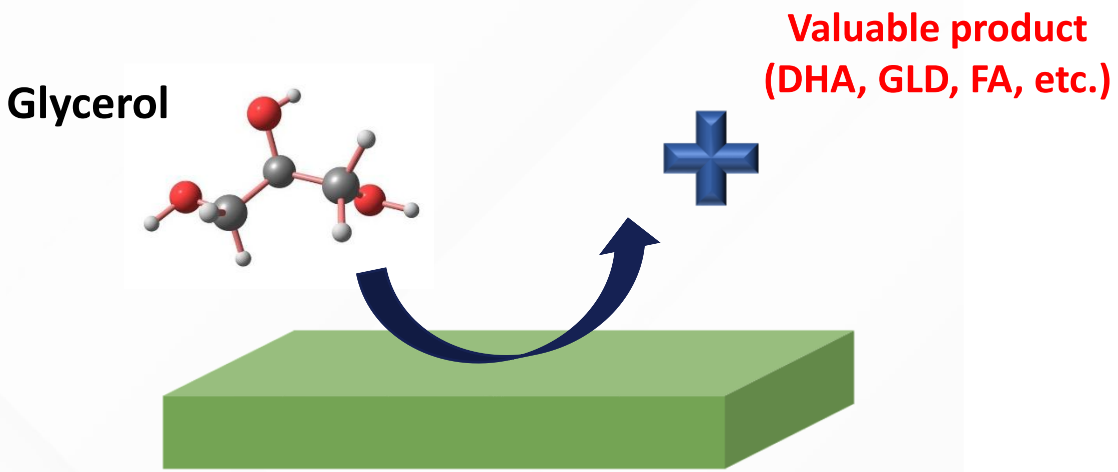
- Hydrogen production using solar energy
- Sluggish four-electron water oxidation reaction

→ **Bottleneck of the overall redox process of water splitting**

❖ Photoelectrochemical glycerol oxidation



ref. *J. Am. Chem. Soc.* 2023, 145, 24, 12987–12991

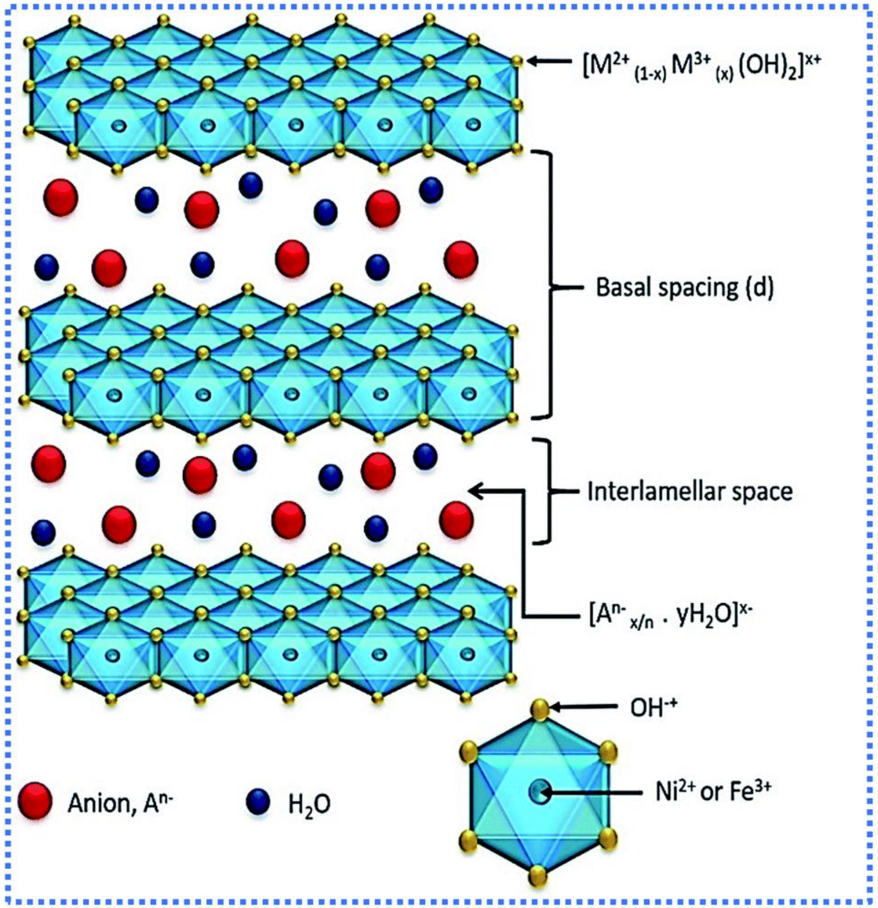


- Substituting sluggish oxygen evolution reaction (OER) for glycerol oxidation reaction (GOR)

→ ***Improved energy conversion efficiency* for the whole electrolyze**

- **Potential for *valorization* of waste biomass**

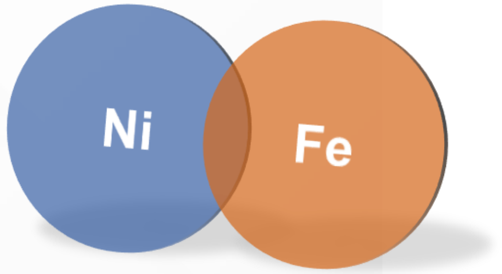
❖ Bifunctional catalysts



ref. *J. Mater. Chem. A,* 2021,9, 3180-3208

Metal-layered double hydroxide (M-LDH)

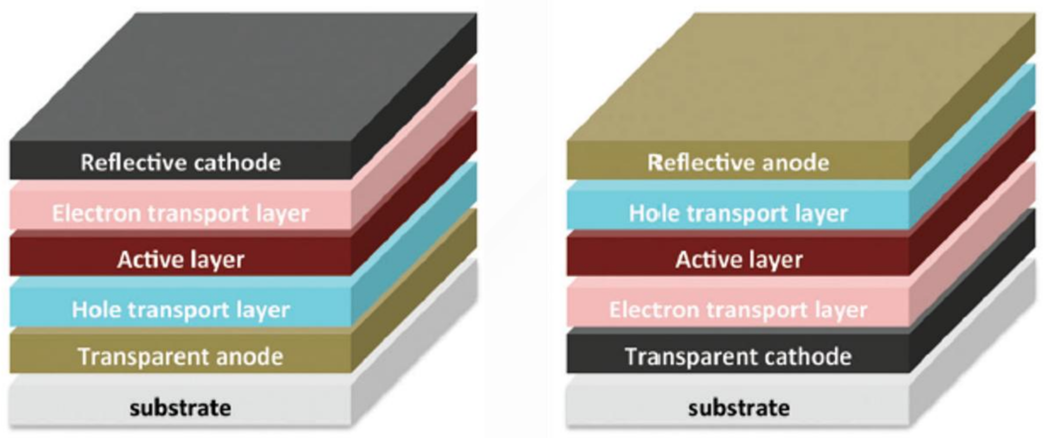
- Unique 2D-layered structure with large surface areas
- High activity and catalytic durability
- Environmentally friendly



Excellent catalytic performance

in the selective oxidation of glycerol to valuable products

❖ Organic semiconductor based photoelectrodes



Ref. *Chem. Soc. Rev.*, 2015,44, 78-90

Advantages

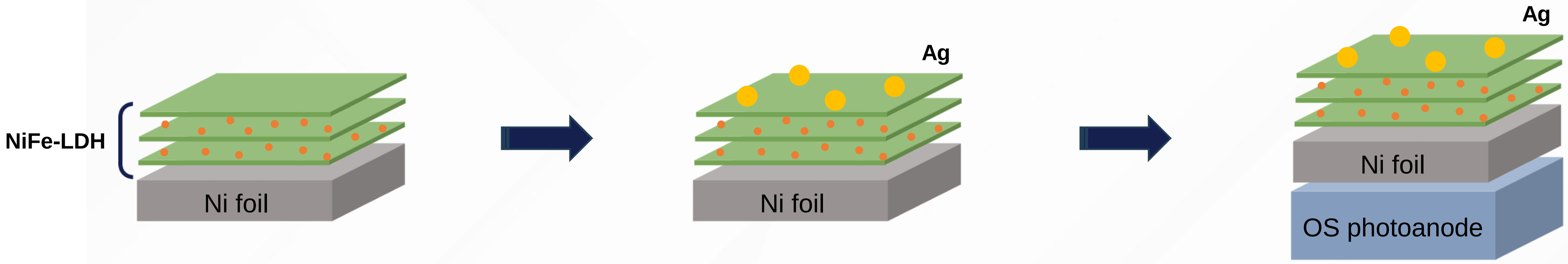
- Superior charge transport mobility
  (Photoinduced charge transfer ~ 100% efficiency)
- High V_{oc} (> 1.0 V) and J_{SC}
- Wide range of light absorption
- Print processability (low temp. & solution process)

Drawback

- *Poor stability in aqueous environment*

→ At the prototype scale,
this can be done with metal foil encapsulation methods

❖ Device fabrication flow



NiFe-LDH / Ni foil

by Electrodeposition

Ag / NiFe-LDH / Ni foil

by Chemical reduction method

Ag / NiFe-LDH / Ni foil / OPV

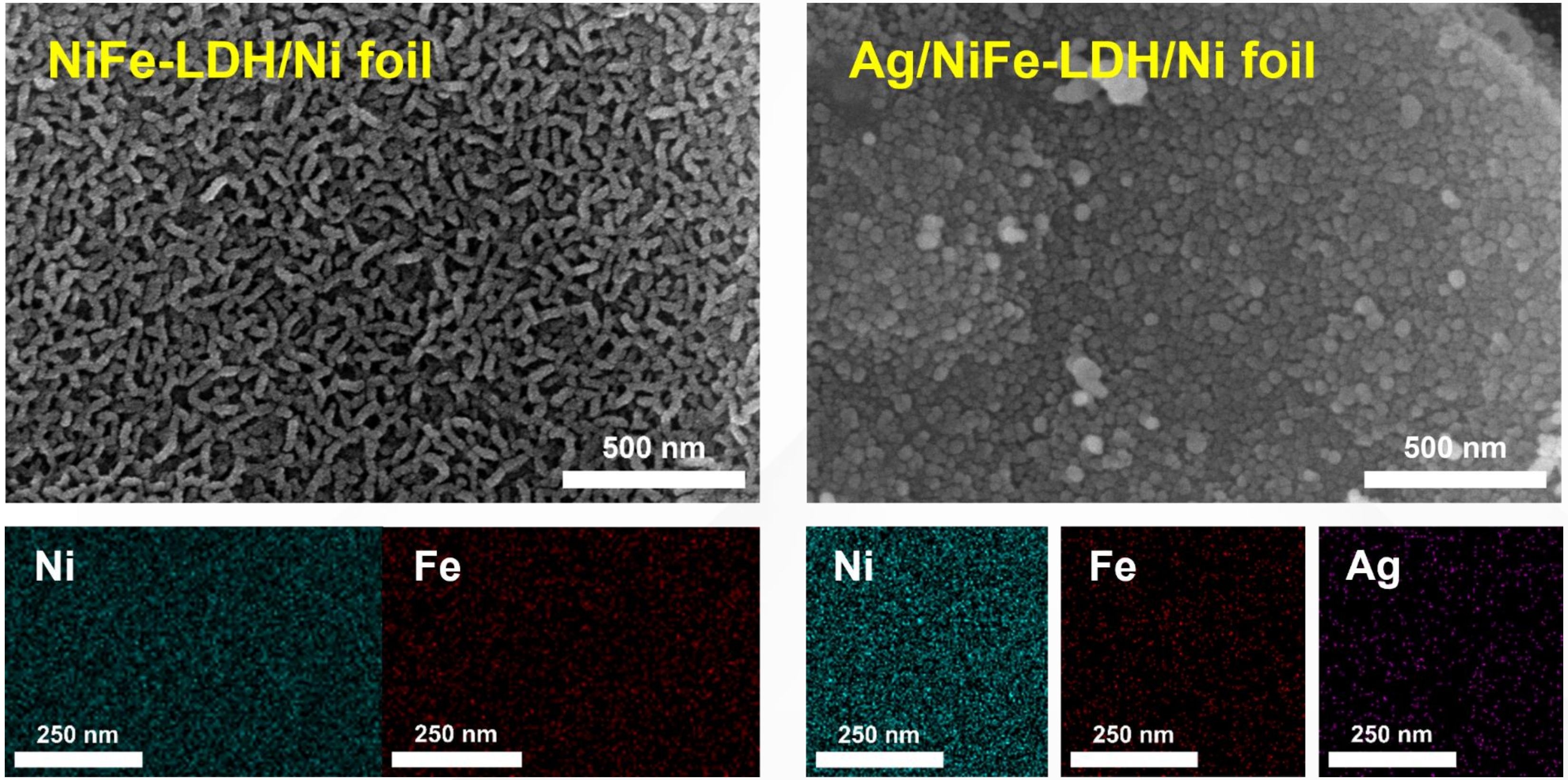
by Metal foil encapsulation

By integrating NiFe-LDH and Ag-synthesized Ni foil with an OS photoelectrode,

the efficiency of glycerol selective oxidation is significantly enhanced.

❖ Characterization

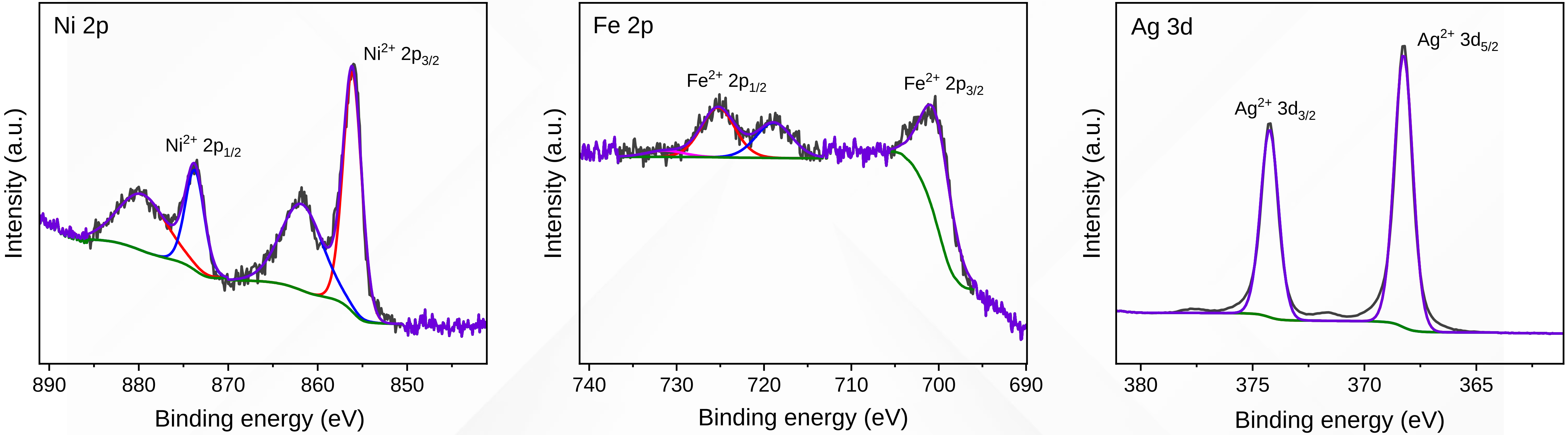
< Scanning Electron Microscope >



- ✓ NiFe LDH : Nanostructure
- ✓ Ag : Nanoparticle

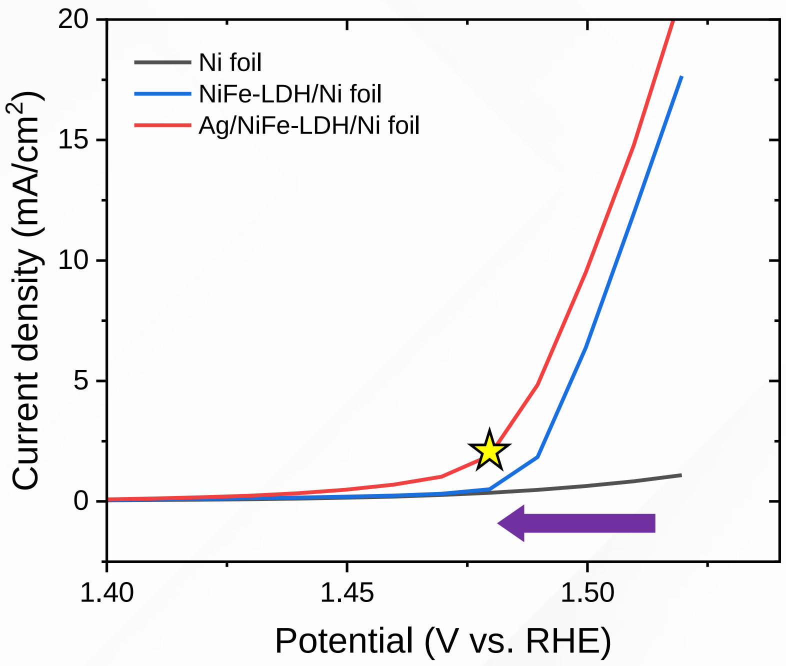
❖ Characterization

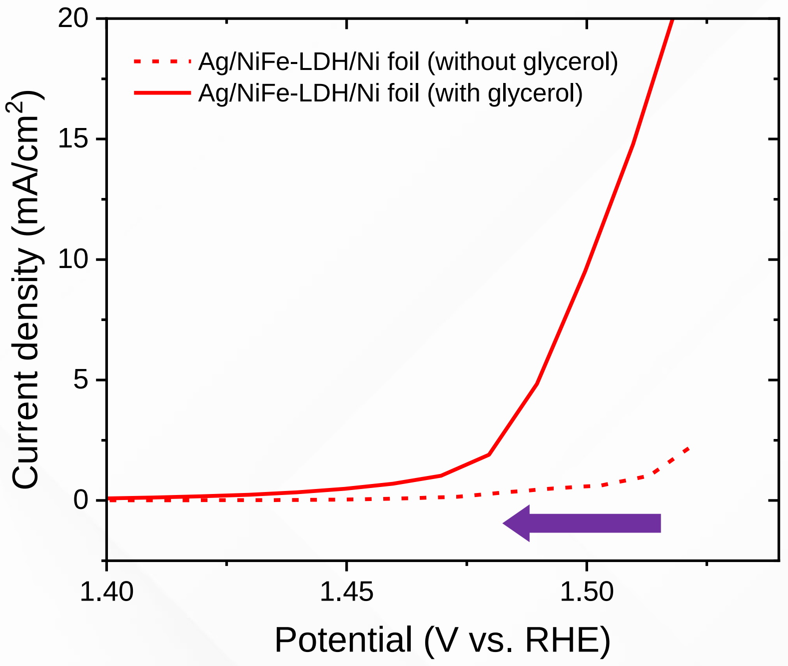
< X-ray Photoelectron Spectroscopy >



✓ Confirmed the successful synthesis of Ag/NiFe LDH catalyst on Ni foil.

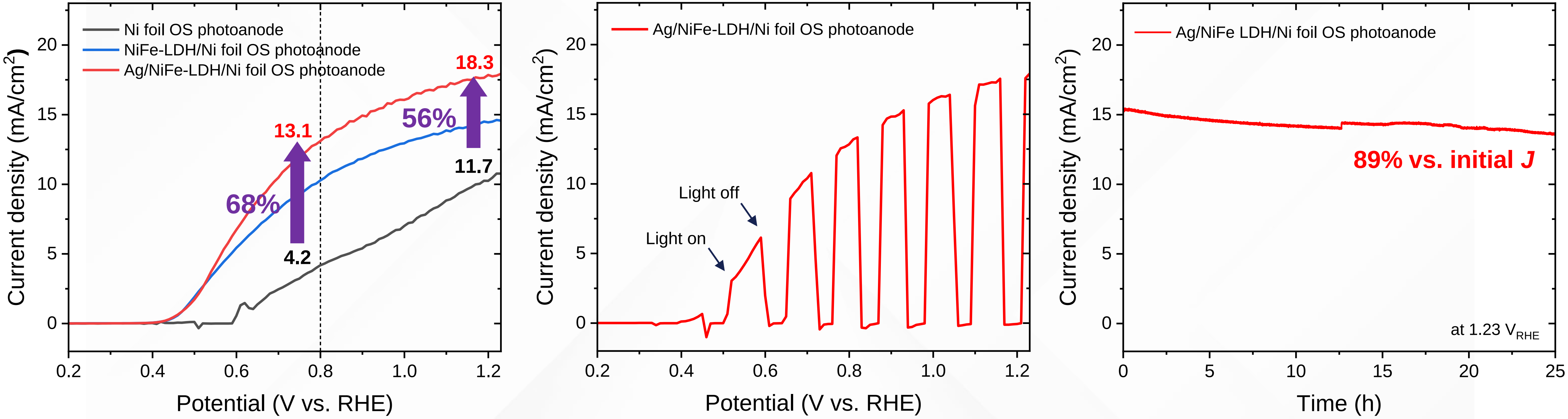
❖ Electrochemical performance





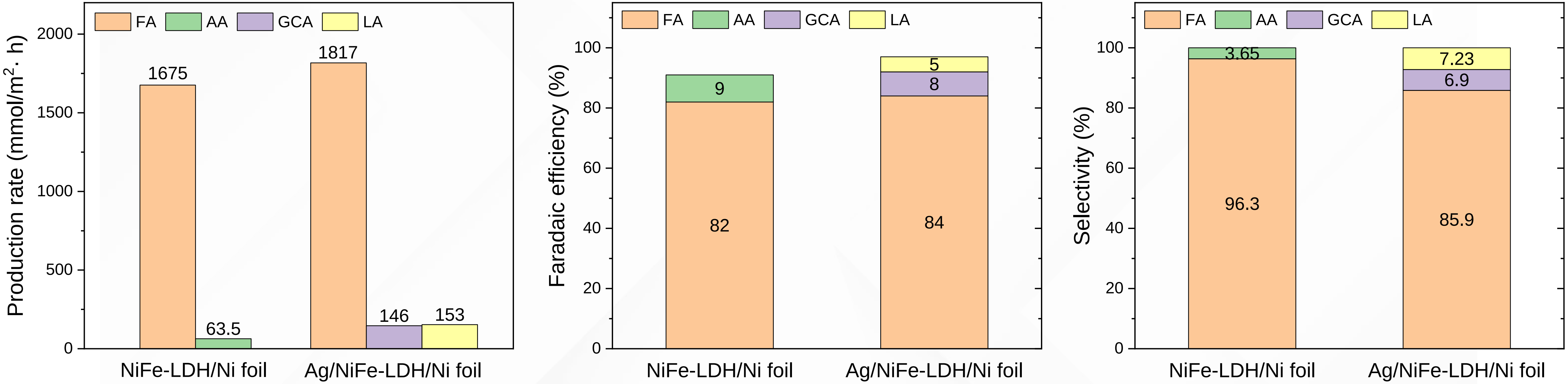
- ✓ **Electrochemical performance enhancement using the Ag/NiFe-LDH/Ni foil catalyst**
- ✓ Potential shift in the cathodic direction with the addition of glycerol

❖ Photoelectrochemical performance



- ✓ Photoelectrochemical performance enhancement using the Ag/NiFe-LDH/Ni foil catalyst
- ✓ **Long-term stability of the Ag/NiFe-LDH/Ni foil OS photoanode**

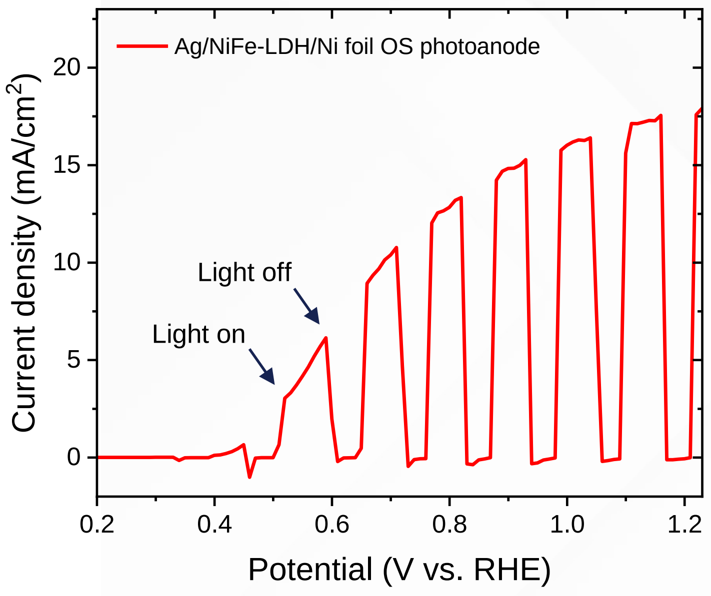
❖ Quantitative analysis

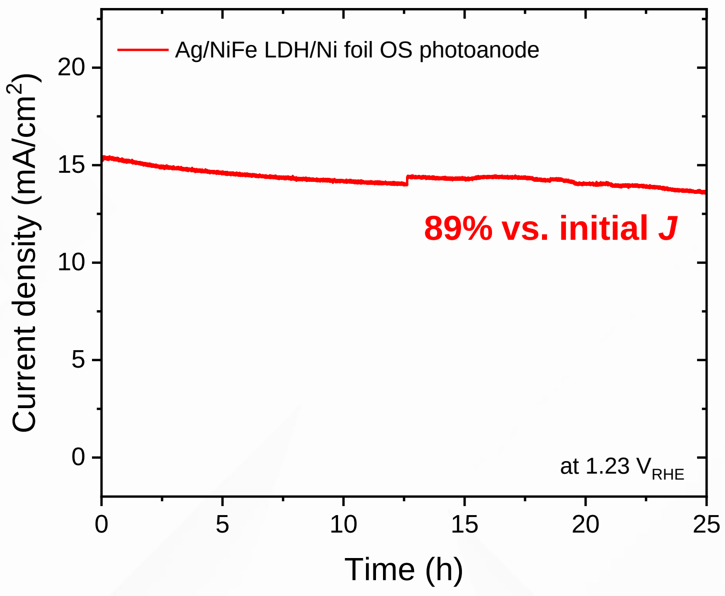


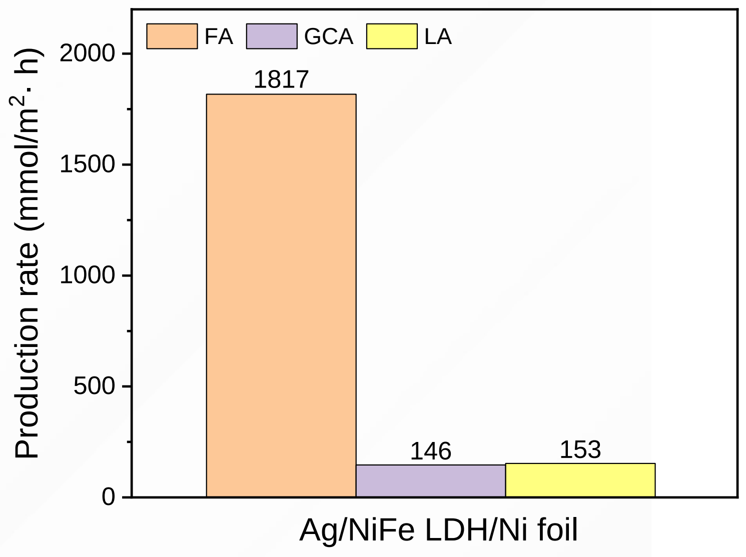
✓ **Selectivity oxidation of glycerol to formic acid (FA)**

✓ Glycolic acid (GCA) and lactic acid (LA) production from Ag/NiFe-LDH/Ni foil OS photoanode only

4. Summary







- The **Ag/NiFe-LDH/Ni foil catalyst** was successfully synthesized using electrodeposition and chemical reduction reactions.
- By integrating the fabricated catalyst with the organic semiconductor based photoelectrode, **a significant performance enhancement was achieved.**
- Glycerol was **selectively oxidized mainly to formic acid,** which exhibited an overwhelming production yield.

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Thank you

for your attention

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