INSTITUTE OF ELECTROCHEMISTRY AND ENERGY SYSTEMS
ACADEMICIAN EVGENI BUDEVSKI

Ti-Au-Pt AND Ti-Pd-Pt MULTY-LAYERED MAGNETRON SPUTTERED CATALYSTS FOR HYDROGEN ENERGY SYSTEMS

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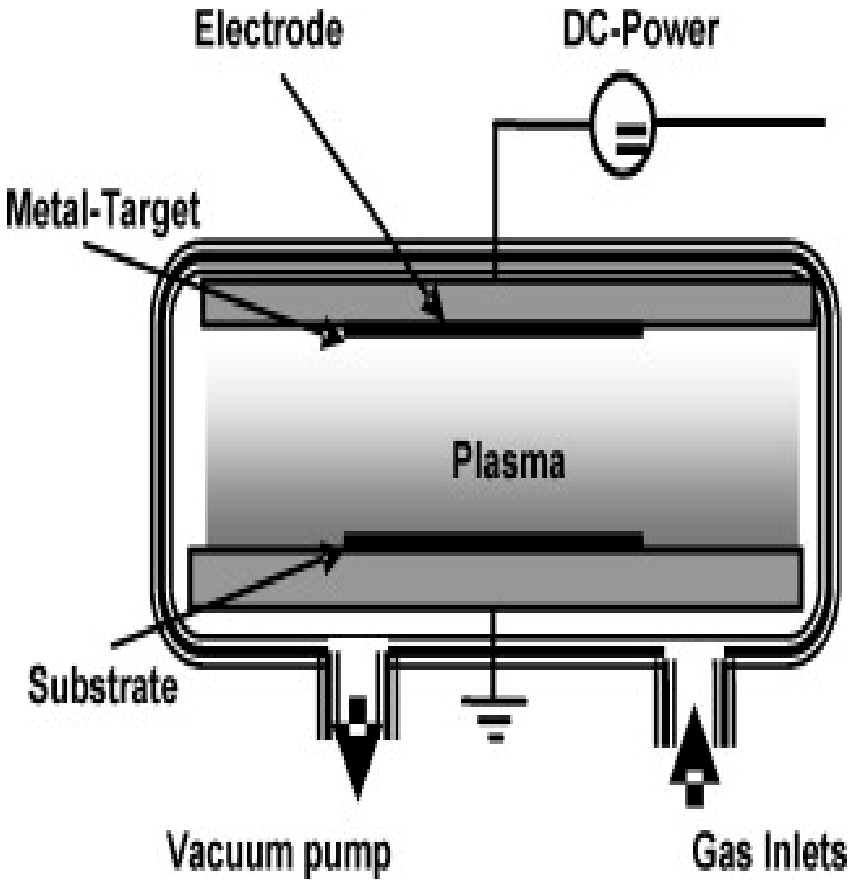
CONTENT

- DIRECT CURRENT (DC) MAGNETRON SPUTTERING METHOD
- CATALYST LAYER FORMATION
- SURFACE ANALYSIS
- ELECTROCHEMICAL TESTS
- CONCLUSIONS

DC MAGNETRON SPUTTERING METHOD



Scheme of the DCMS

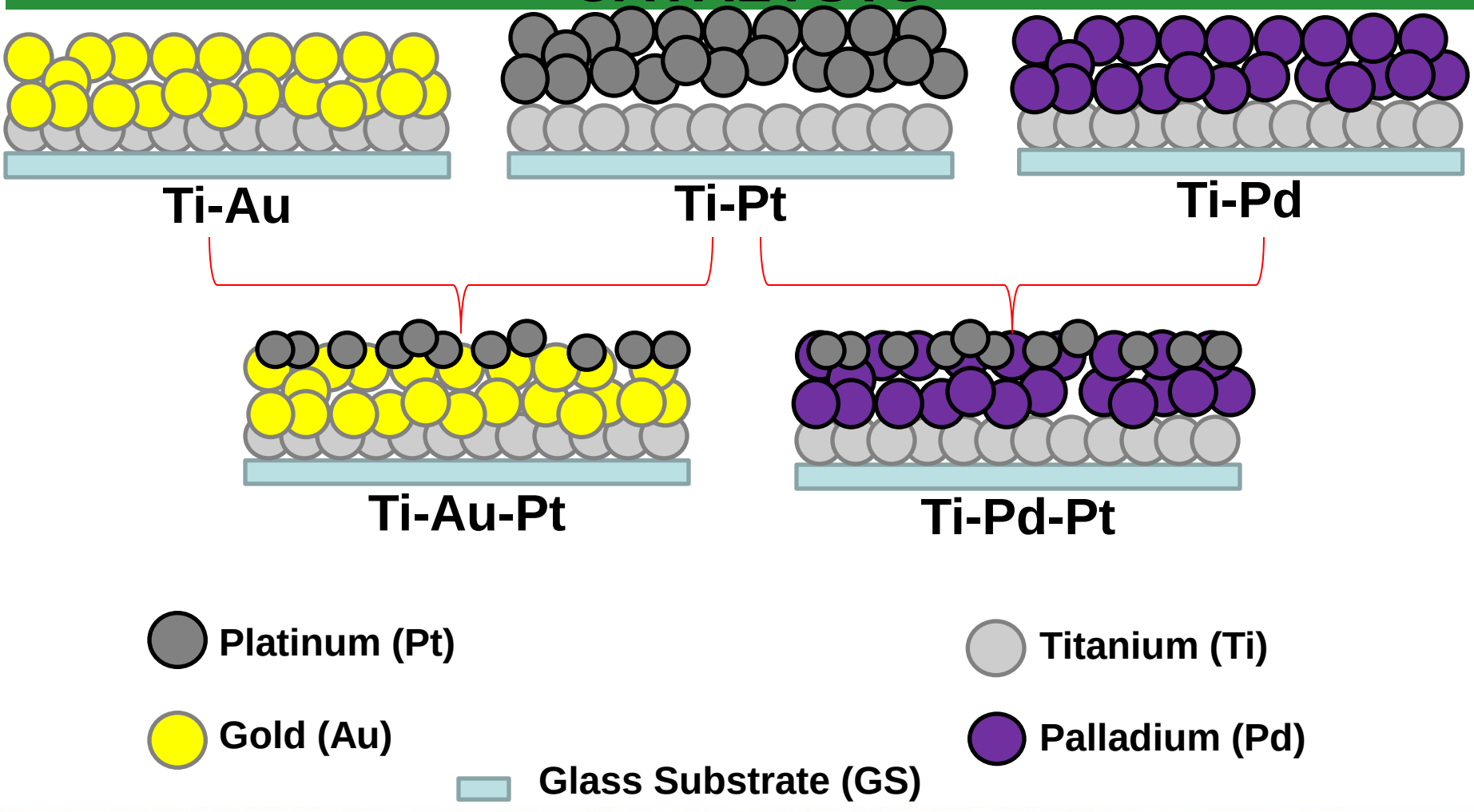
ADVANTAGES

- ✓ Thin compact mono, bi- or poly-metallic and/or oxide films
- ✓ Homogeneous distribution of the metal particles
- ✓ Low metal loading (down to 10 μg cm^{-2})
- ✓ Reduced preparation time

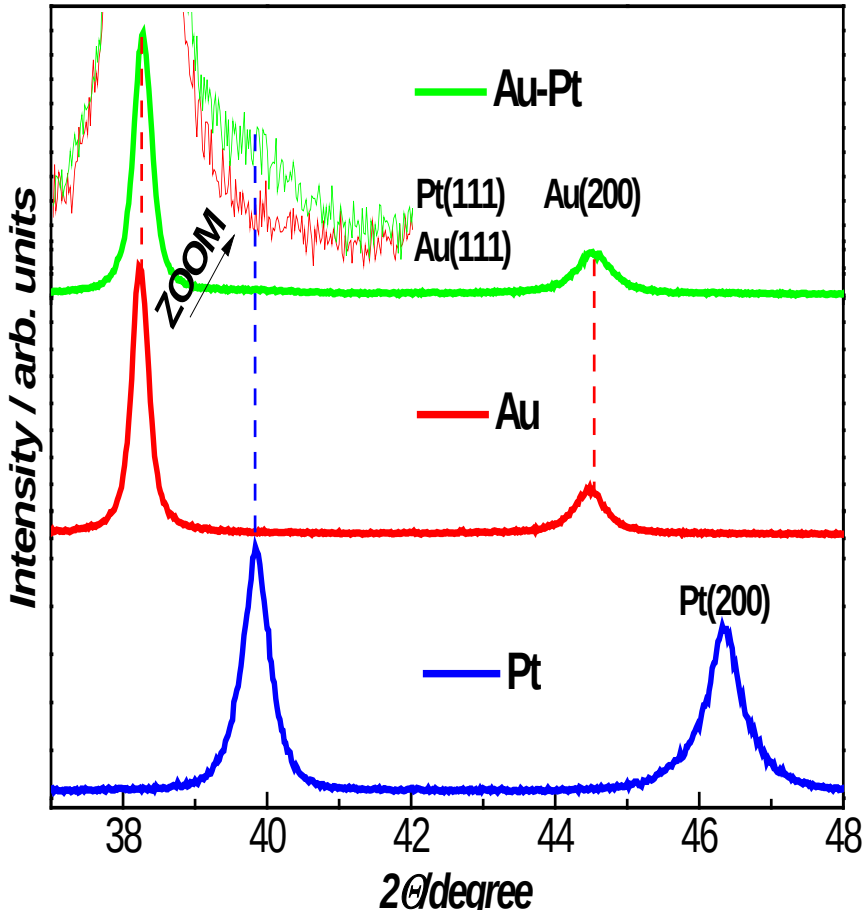
COMPOSITION OF THE SPUTTERED CATALYSTS

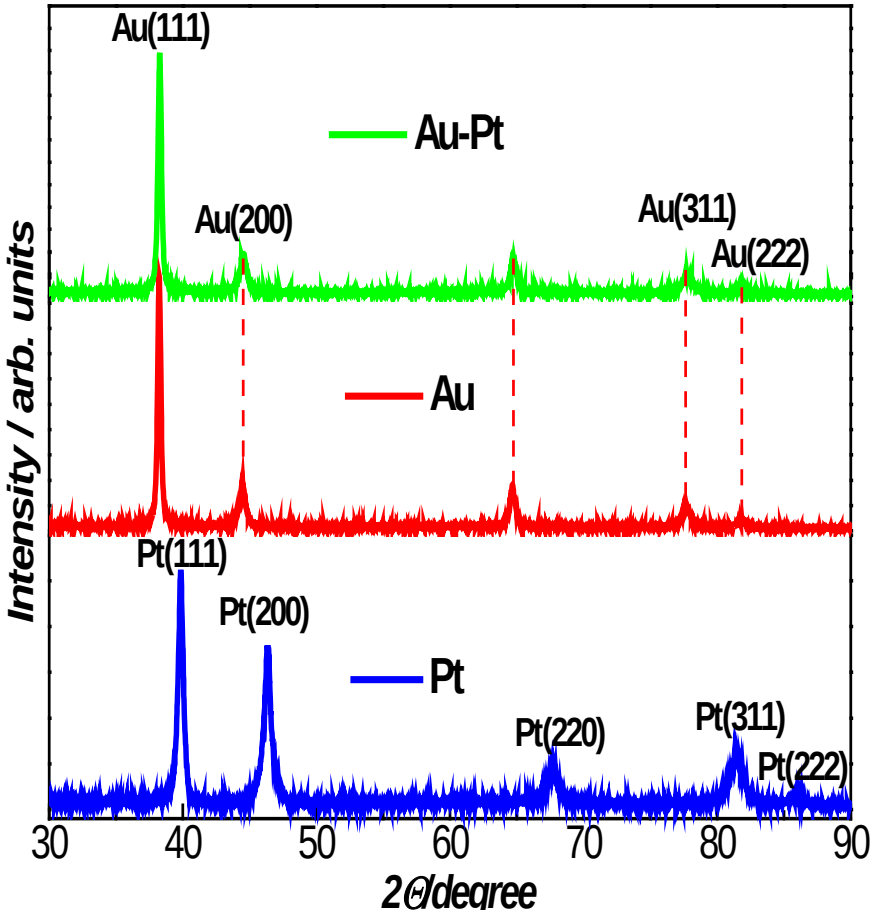
CATALYST	LAYER 1		LAYER 2		LAYER 3	
	Metal Type	Size (nm)	Metal Type	Size (nm)	Metal Type	Size (nm)
Ti-Pt	Ti	25	Pt	250	-	-
Ti-Au	Ti	25	Au	250	-	-
Ti-Pd	Ti	25	Pd	250	-	-
Ti-Au-Pt	Ti	25	Au	240	Pt	10
Ti-Pd-Pt	Ti	25	Pd	240	Pt	10

LAYER FORMATION OF THE SPUTTERED CATALYSTS



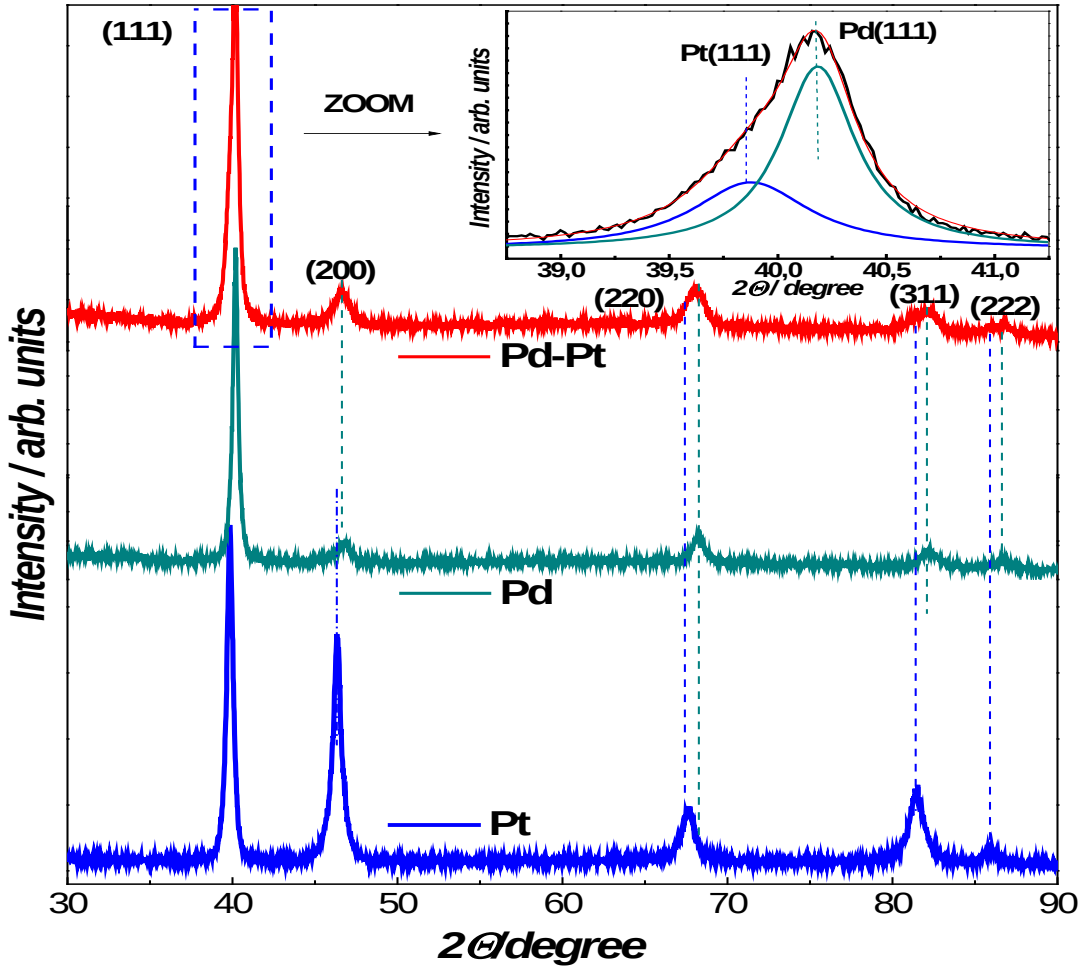
SURFACE ANALYSIS





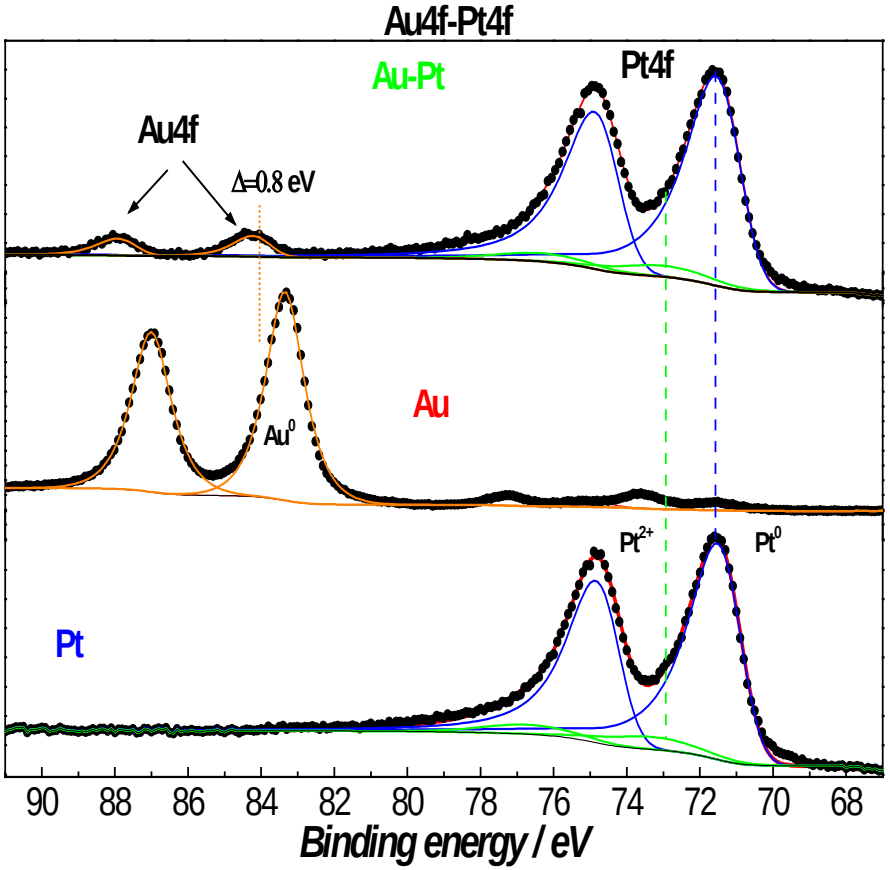
XRD spectra of Au, Pt, and Au-Pt sputtered films

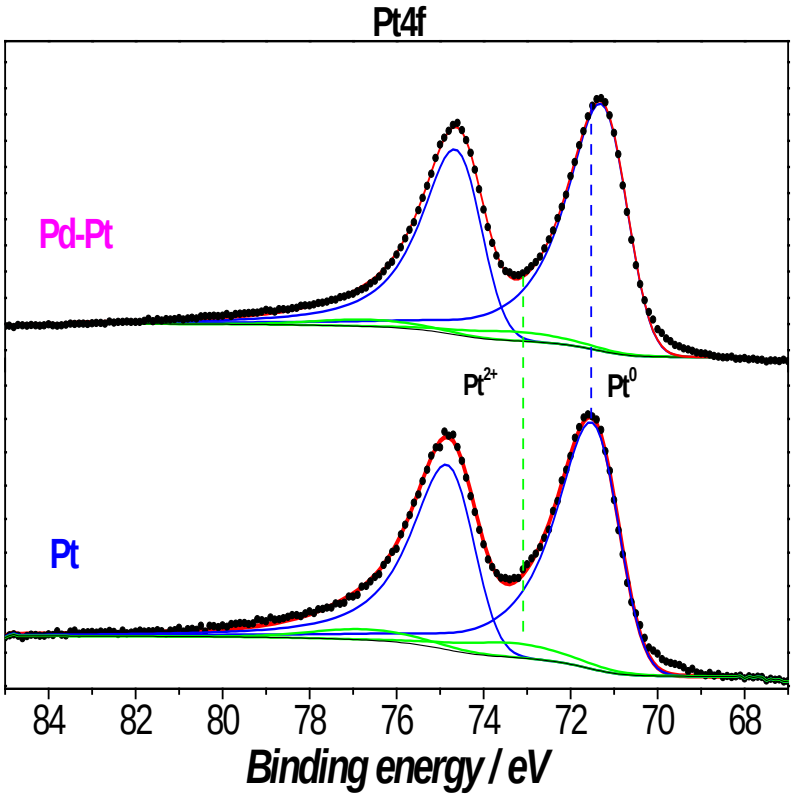
SURFACE ANALYSIS



XRD spectra of Pd, Pt, and Pd-Pt sputtered films

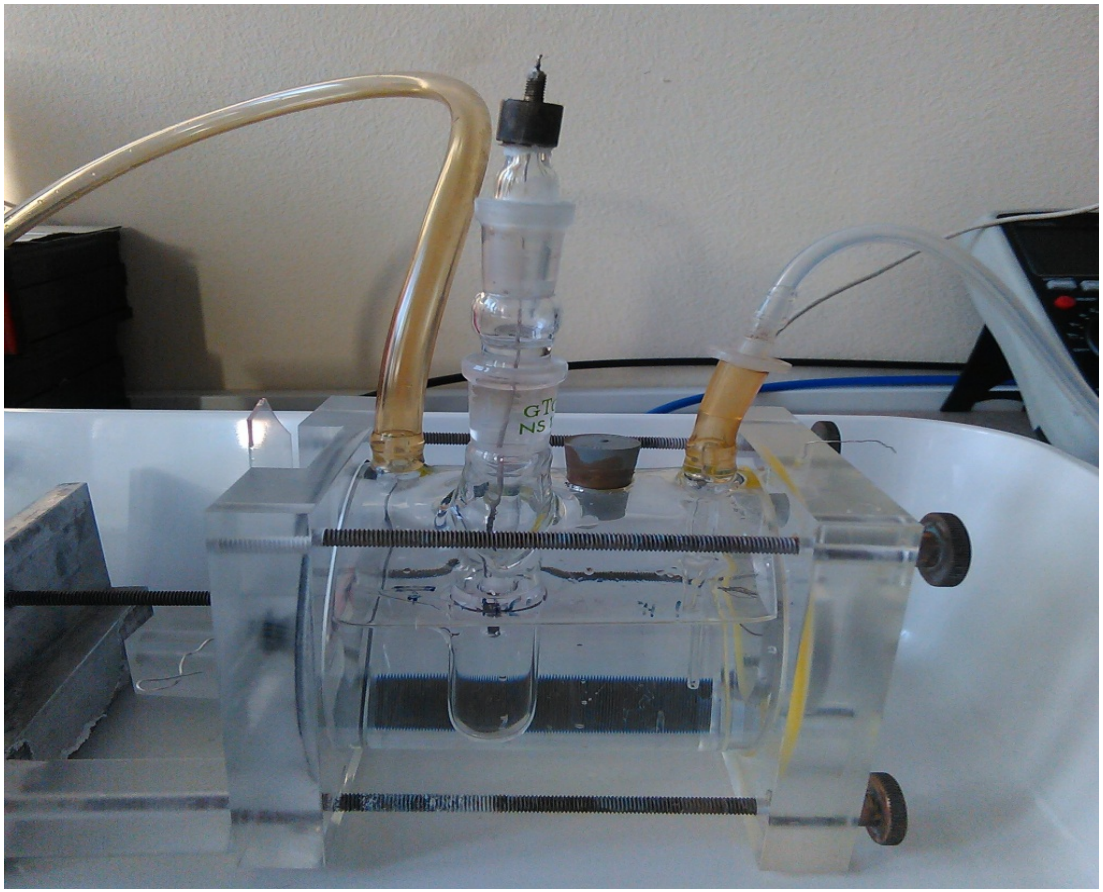
SURFACE ANALYSIS - XPS





XPS of 4f spectra of magnetron sputtered catalysts

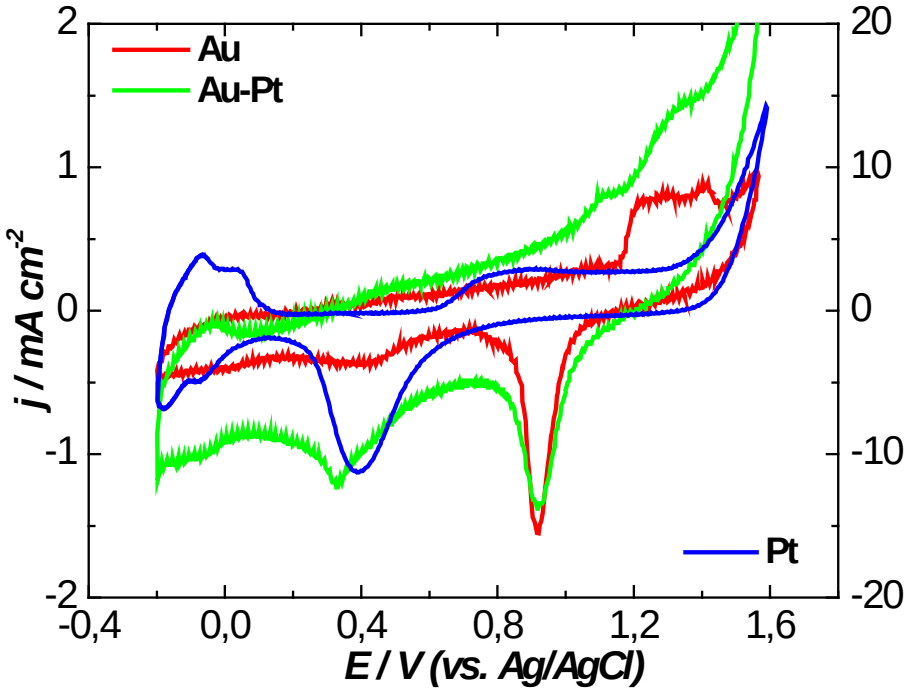
EXPERIMENTAL

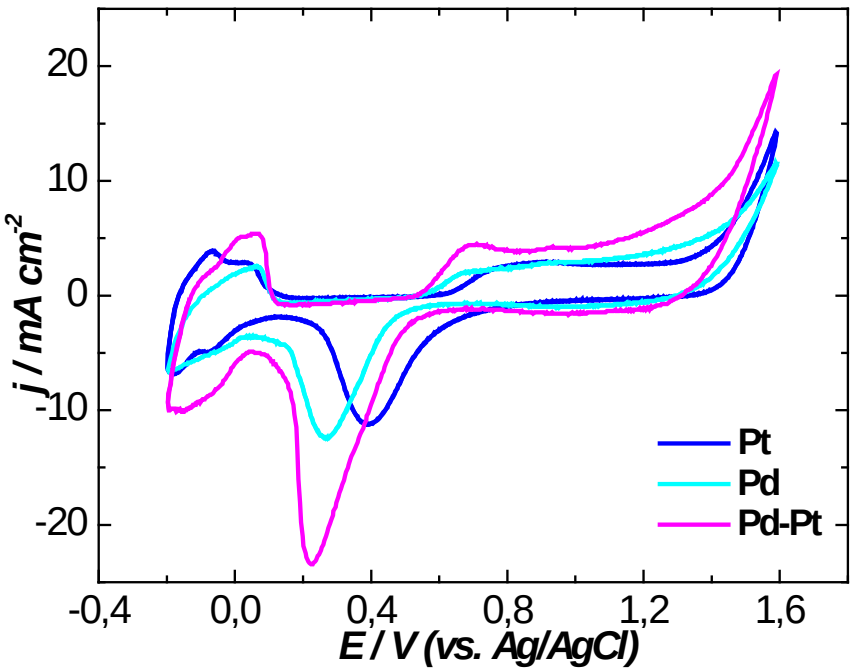


- **Electrolyte** - 0.5 H_2SO_4
- **Electrochemical Cell** – Standard three electrode
- ✓*Reference Electrode (E_{rf})*- ***Ag/AgCl***
- ✓*Counter Electrode(E_C)*- ***Pt-wire***
- ✓*Working Electrode(E_W)*- ***Sputtered films***
- ***S_{Ew} = 0.5 cm $^{-2}$***

Three-electrode electrochemical cell

ELECTROCHEMICAL TESTS

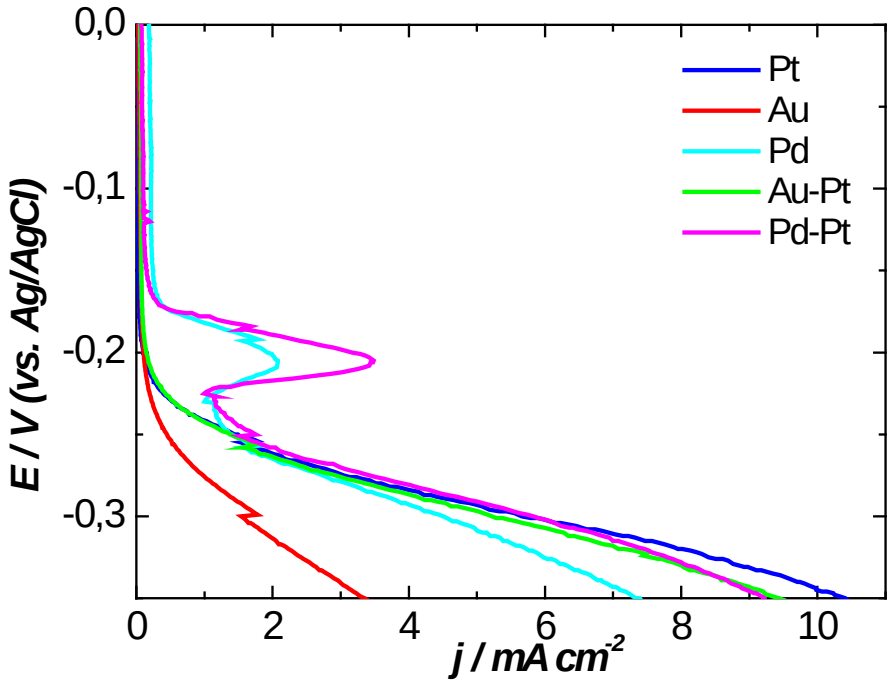




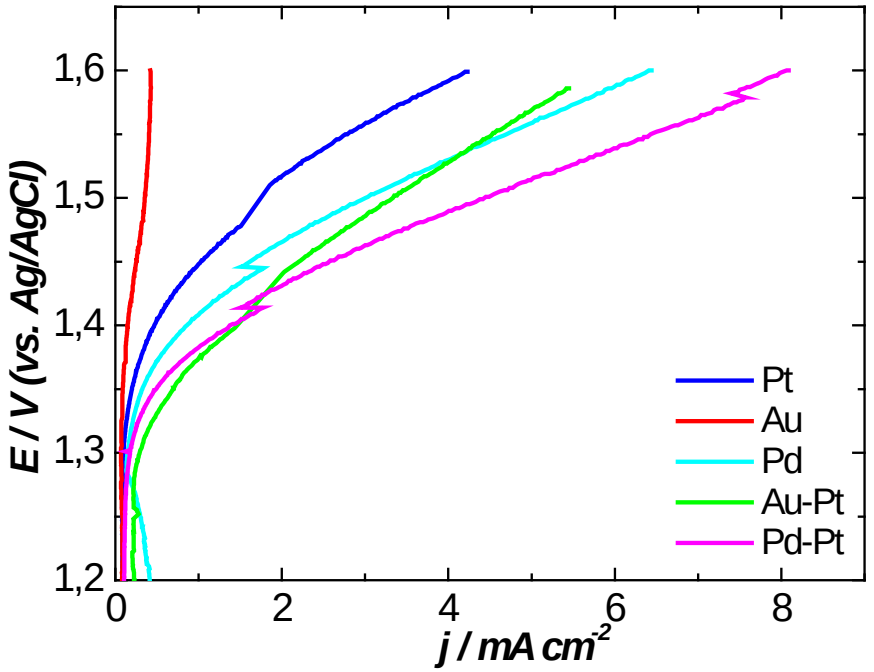
Cyclic voltammograms of the sputtered catalysts in 0.5M H_2SO_4; potential range -0,2 to 1,4 V; scan rate 100 mV s^{-1}

ELECTROCHEMICAL TESTS

HER



OER



Cathodic and anodic potentiodinamic polarisation curves in 0.5 M H_2SO_4, scan rate 1 mV s^{-1}

CONCLUSIONS AND OUTLOOK

- The method of magnetron sputtering is a precise technique for deposition of multilayered catalysts with controlled thickness and tailored synergetic effects between the components
- Ti/Au/Pt is more efficient catalyst toward HER and could behave as a bi-functional oxygen electrode catalyst enhancing remarkably both ORR and OER compared to pure Pt
- The observed synergism between Au and Pt is related with the registered shift in the 4f Au BE, resulting from electronic interactions between the thin Pt top layer and the underlying Au
- How exactly the BE shift affects the mechanism of the proceeding electrode reactions needs to be cleared in the ongoing research
- The Pd-Pt facilitates stronger both HER and OER compared to the pure metals and could be potential bi-functional oxygen catalyst too
- The possibility to enhance the observed synergetic effects by optimization of the layers order, number, and thickness should be also explored
- The effects have to be verified in real PEM Hydrogen Energy Systems (FC and WE)

THANK YOU FOR YOUR ATTENTION

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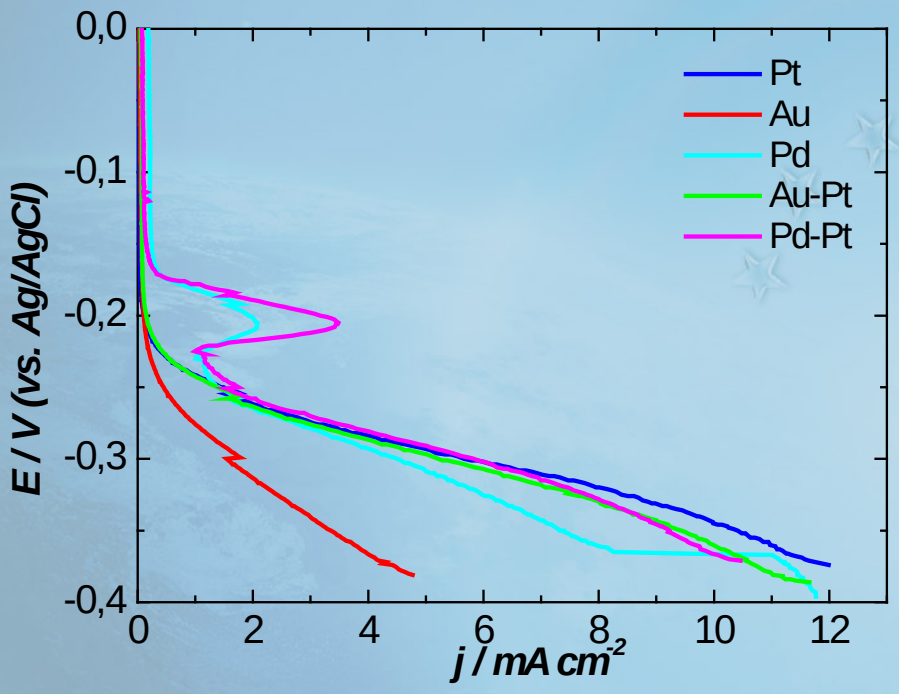
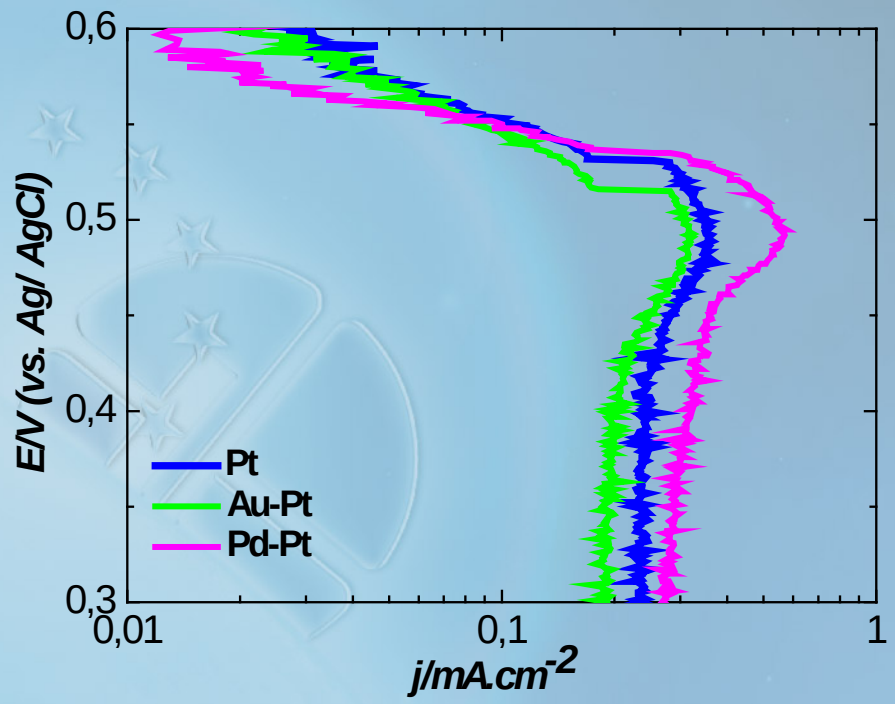
ELECTROCHEMICAL TESTS





Cathodic potentiodinamic polarisation curves in 0.5 M H_2SO_4, scan rate 1 mV s^{-1}