



UNIVERSIDAD  
DE MÁLAGA



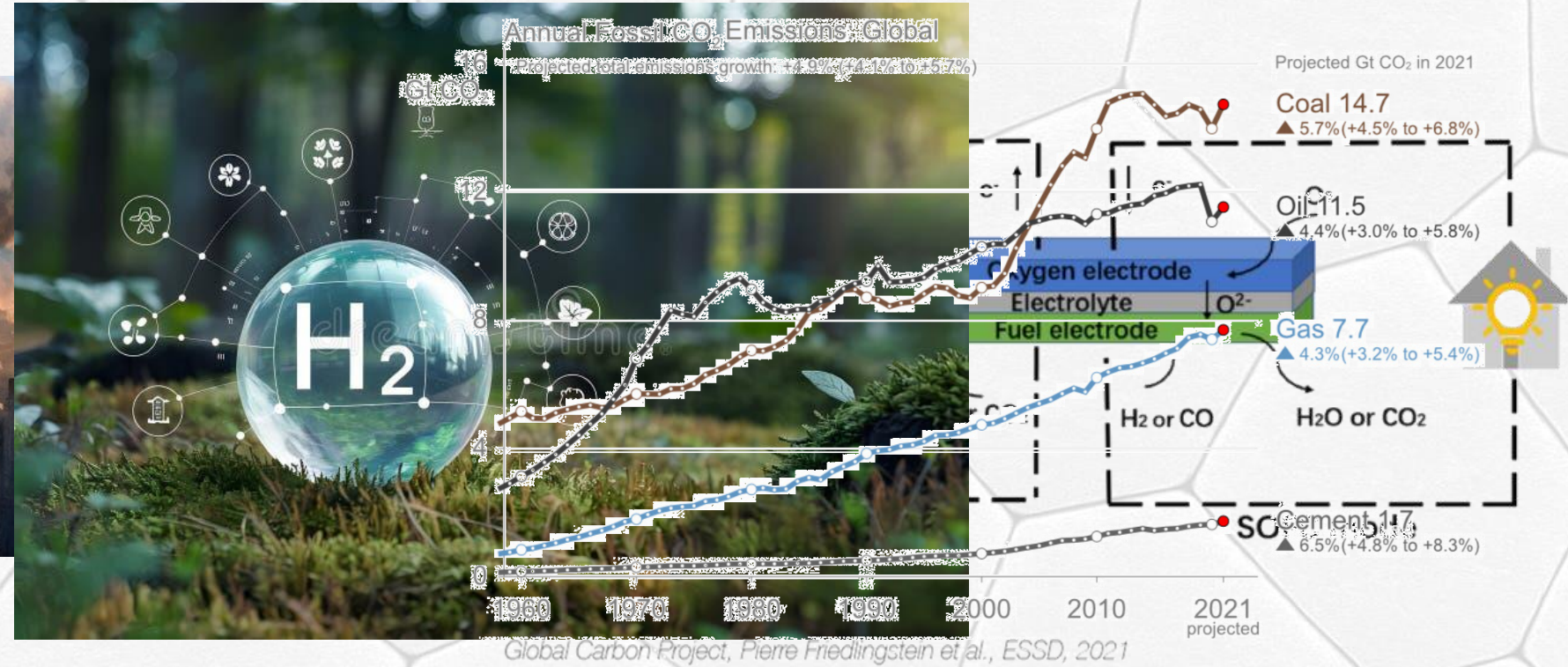
# Electrochemical evaluation of Re-doped $\text{SrFeO}_{3-\delta}$ electrodes for SOFCs

Abraham Sánchez-Caballero, MA García-Plaza, José M. Porras-Vázquez,  
Lucía dos Santos-Gómez, Javier Zamudio-García, David Marrero-López

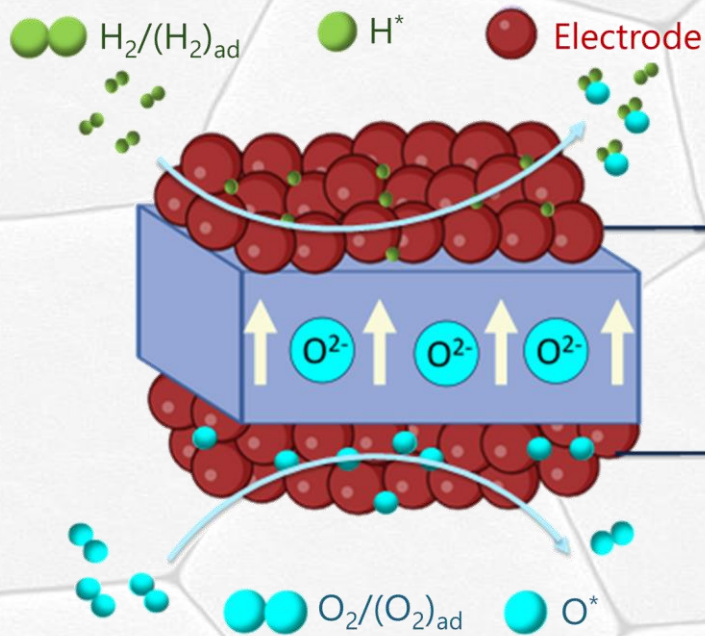
abraham11sc@uma.es

Dpto. Química Inorgánica, Cristalografía y Mineralogía  
Dpto. Física Aplicada I

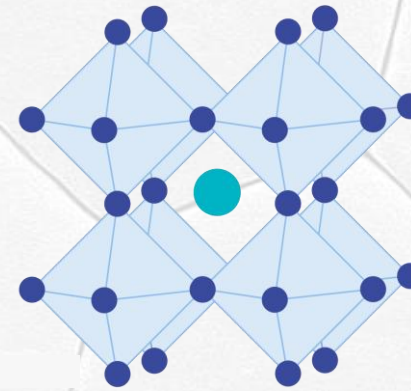
# INTRODUCTION



## Symmetrical SOCs (SSOCs)



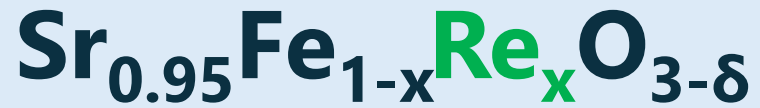
- One-stage electrode assembly
- Electrode-electrolyte compatibility
- **Electrode regeneration!**



Perovskite

Most studied materials  
such as SSOFC

- $\text{La}(\text{Cr},\text{Mn})\text{O}_3$
- $\text{SrTiO}_3$
- $(\text{La},\text{Sr})\text{FeO}_3$
- $\text{PrBa}(\text{Fe},\text{Mn})_2\text{O}_{5+\delta}$



$x = 0.05, 0.1, 0.2, 0.3$



## Why Re?



Synthesize the materials by the freeze-drying precursor method.

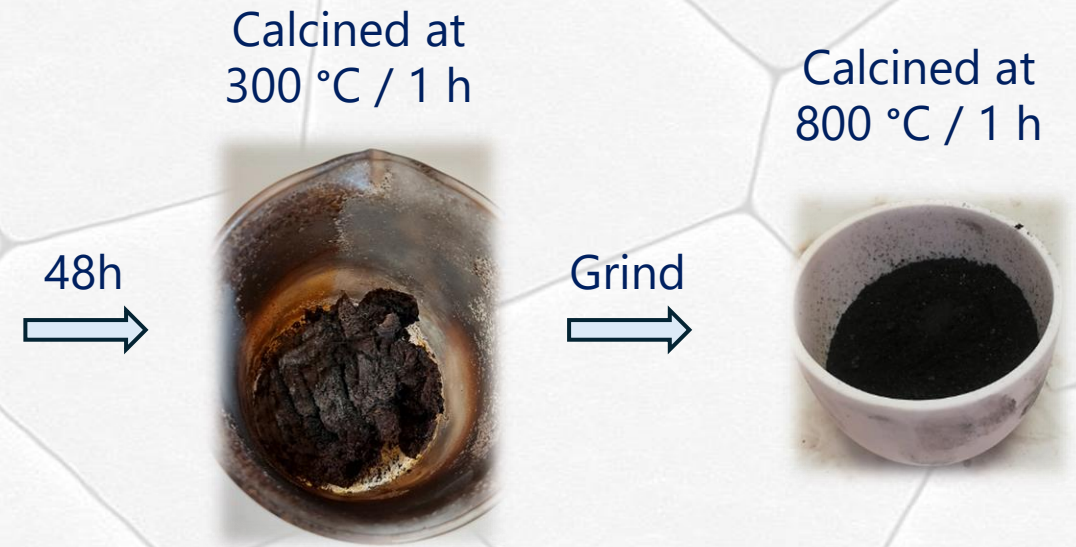
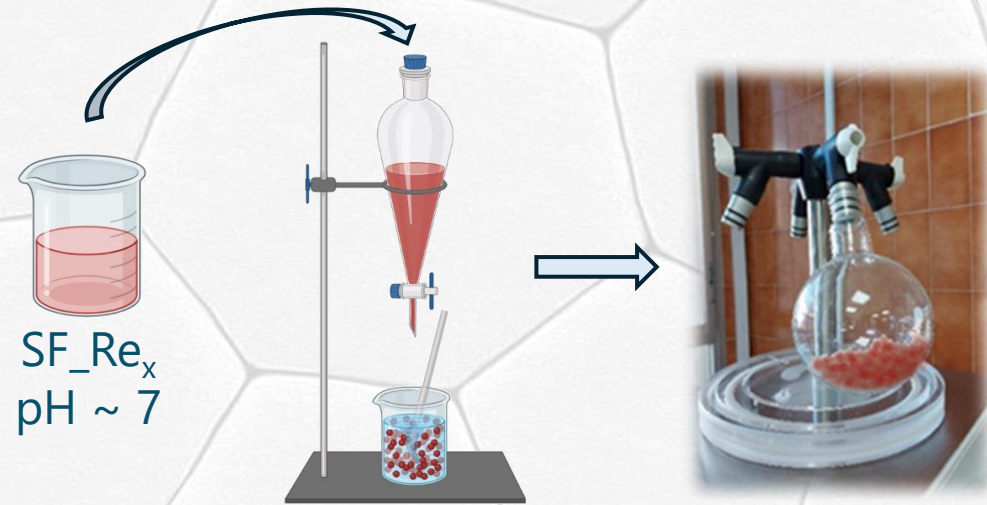


To investigate the reversible exsolution of Re nanoparticles from SrFeO<sub>3</sub>-based perovskites under redox conditions.



To evaluate the material's electrochemical performance as both anode and cathode in symmetrical SOFC and SOEC configurations.

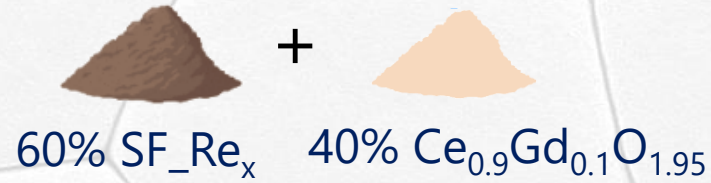
## Experimental procedure



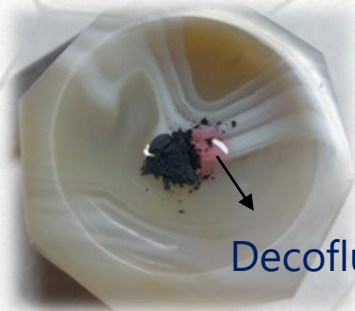
Structural Characterization (XRD, DTA, TEC, XPS, SEM, TEM)

Electrode preparation for electrochemical characterization

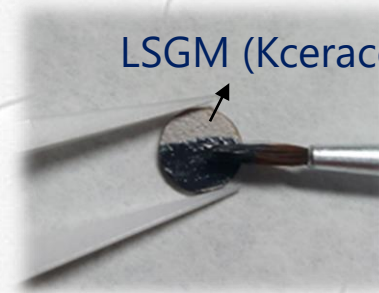
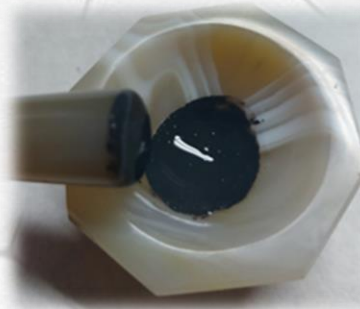
## Electrode preparation



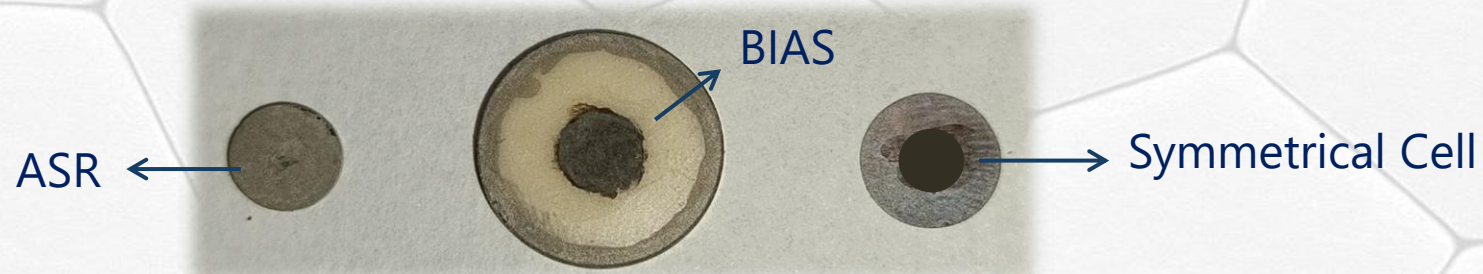
Ball milling in acetone for 90 min



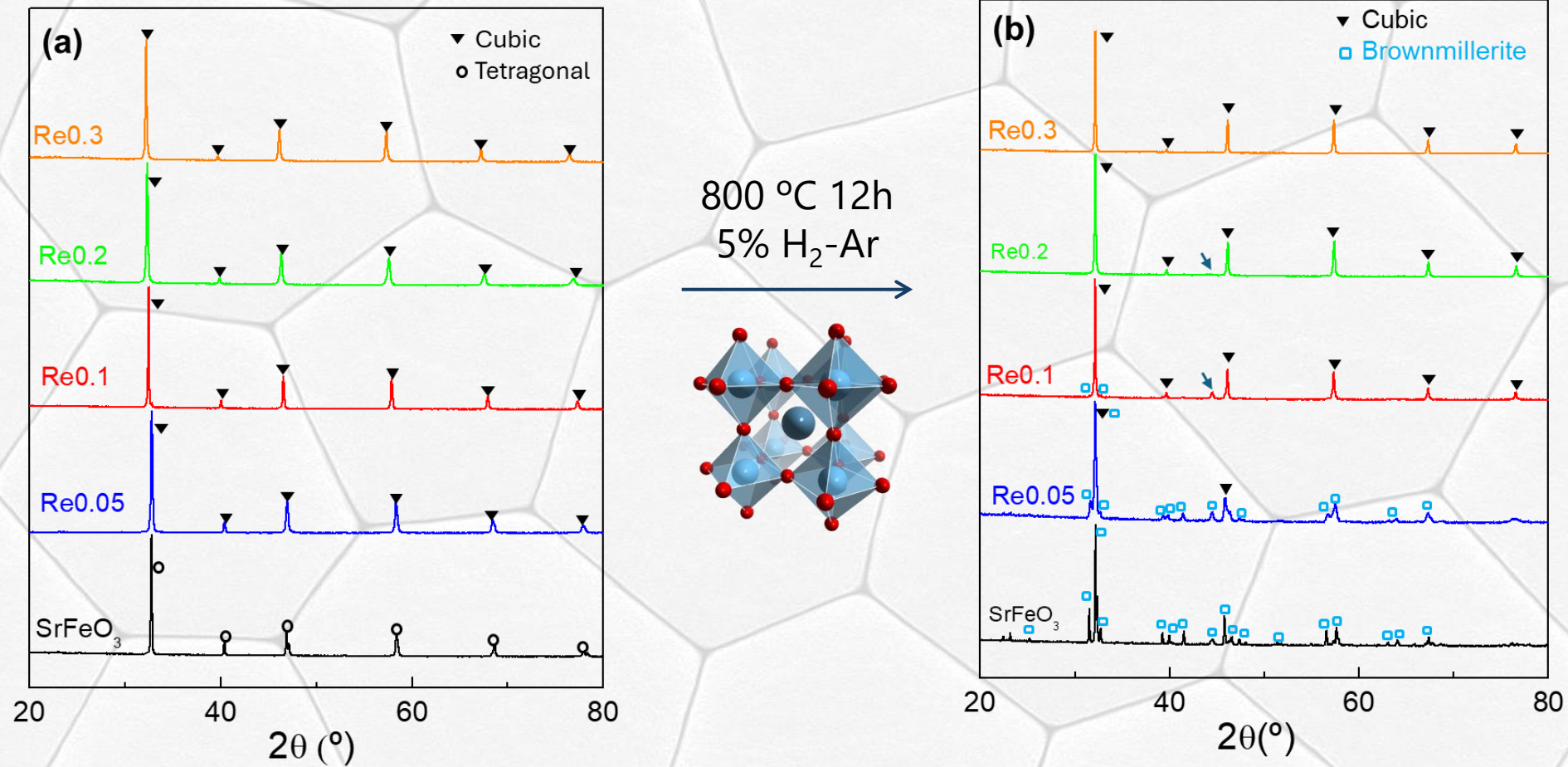
Decoflux™



LSGM (Kceracell 99.9 %)

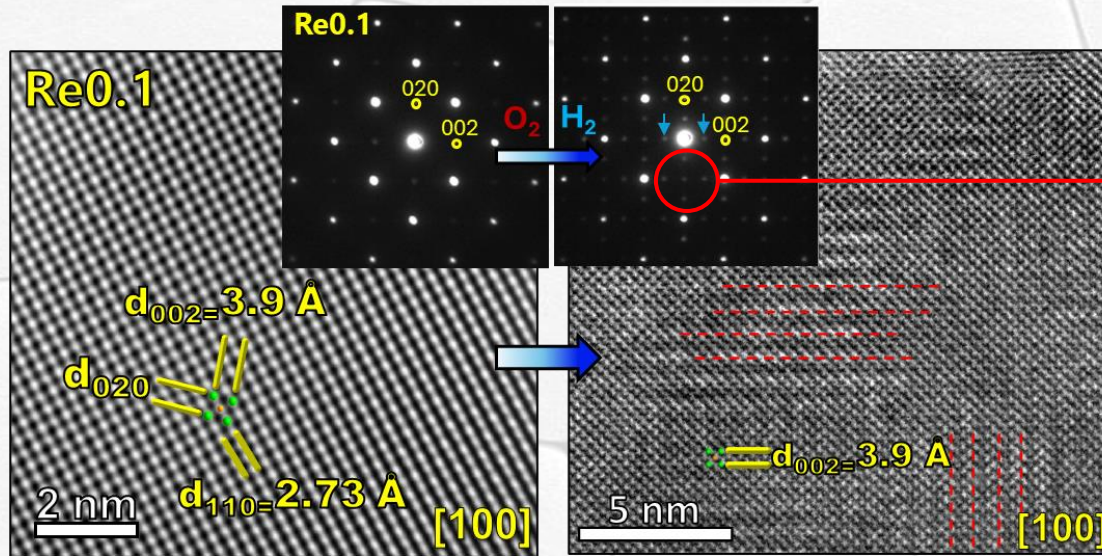


## Structural Characterization

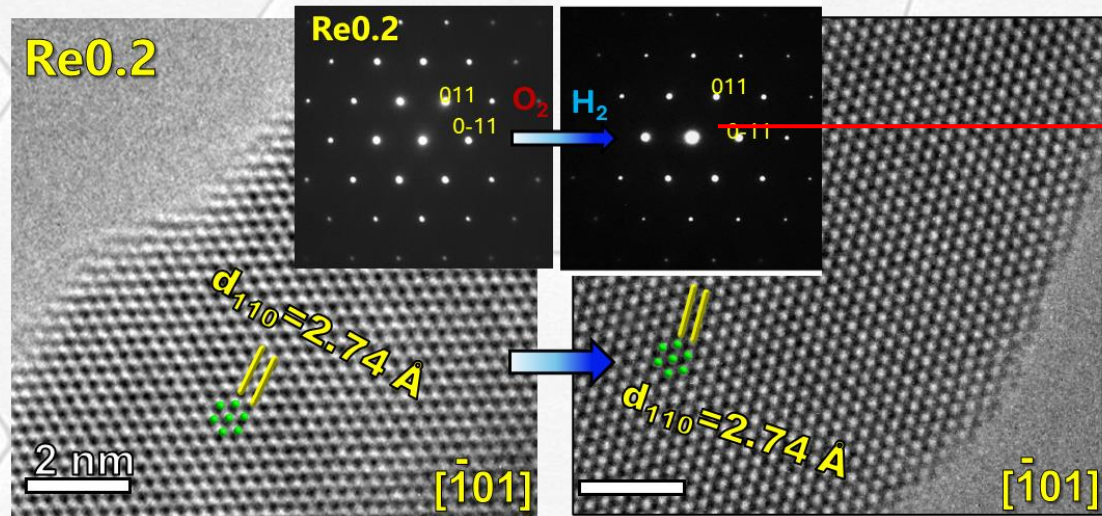


X-ray diffraction patterns of  $\text{Sr}_{0.95}\text{Fe}_{1-x}\text{Re}_x\text{O}_{3-\delta}$ , ( $x = 0, 0.05, 0.1, 0.2, 0.3$ ) series calcined at 1100 °C for 1h in air (a) and reduced at 800°C in hydrogen (b)

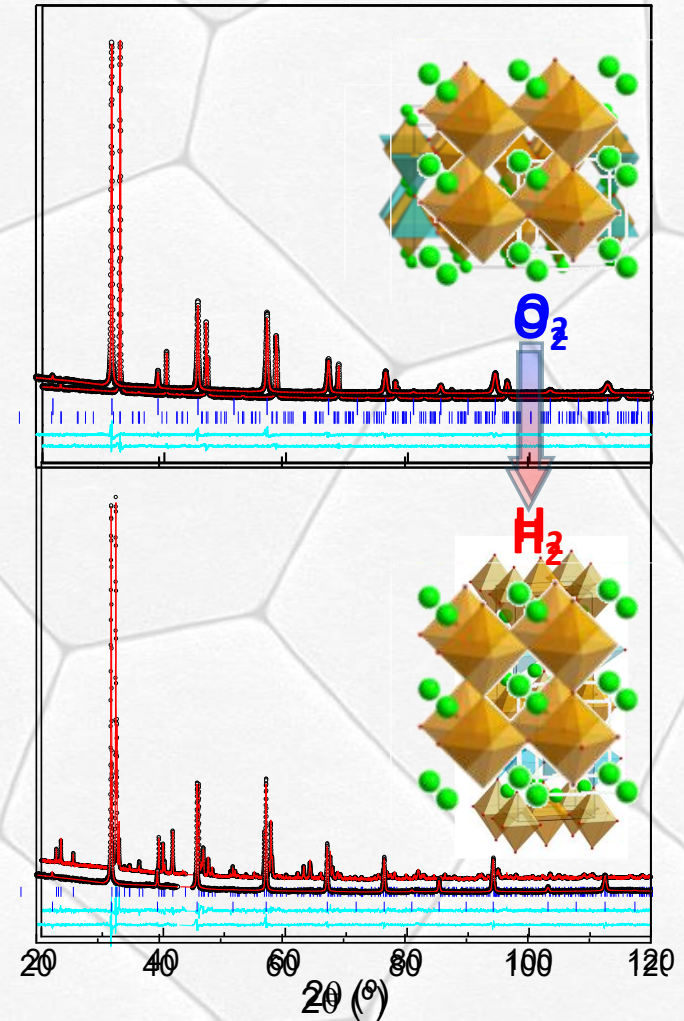
## TEM Characterization



Reflections corresponding to microtwining for phase transition!

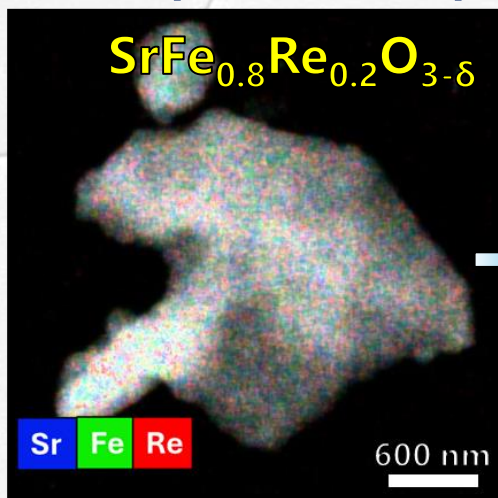


¡Stabilize the cubic structure!

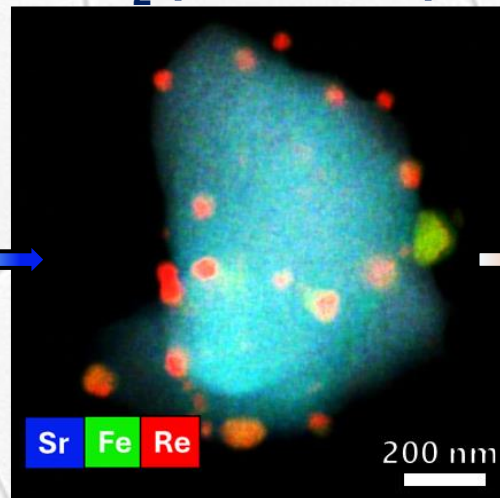


## EDS and XPS Analysis

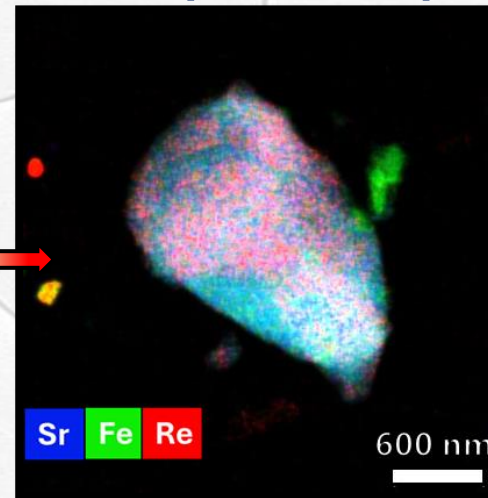
Air (1100 °C 1h)



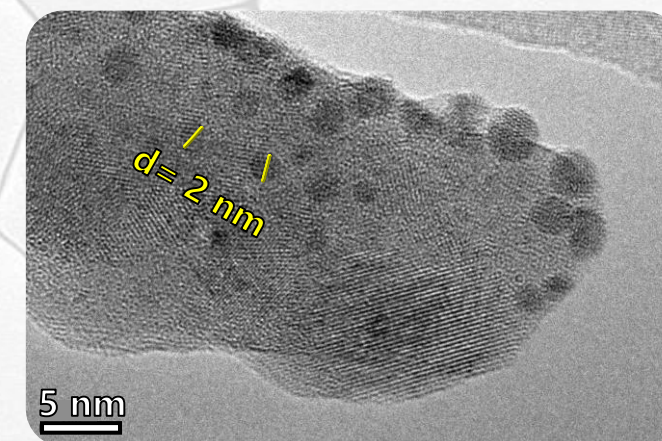
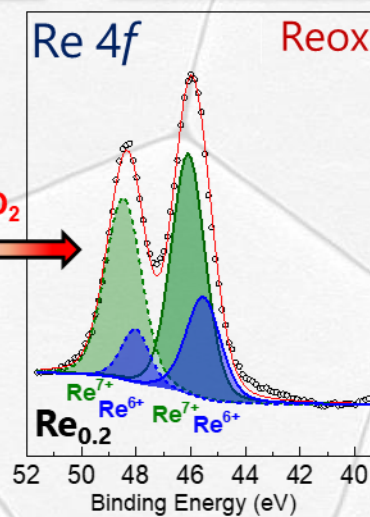
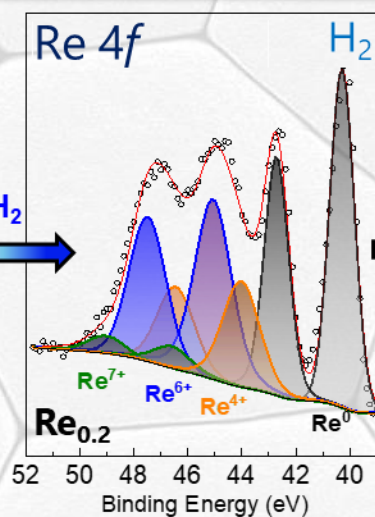
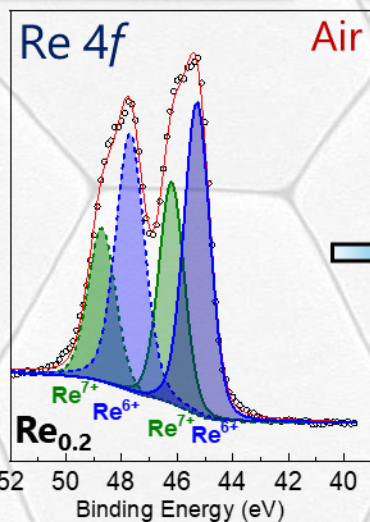
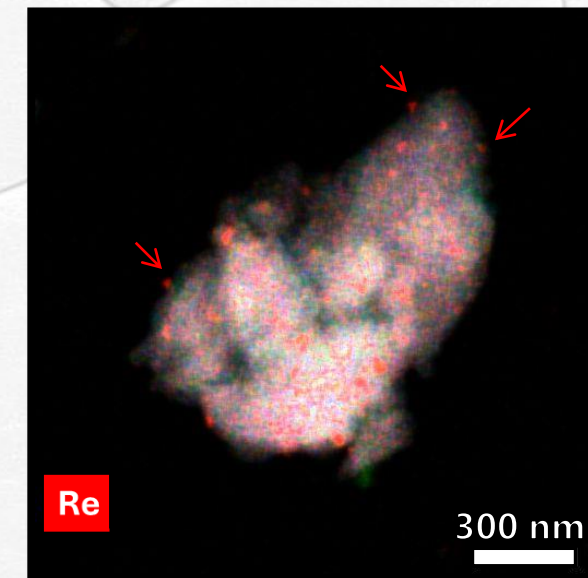
H<sub>2</sub> (800 °C 6h)



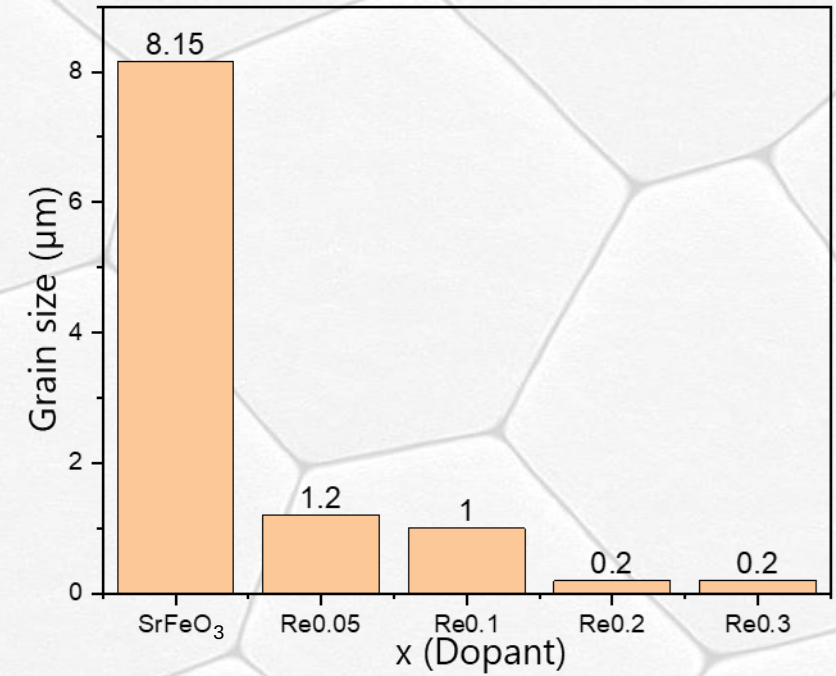
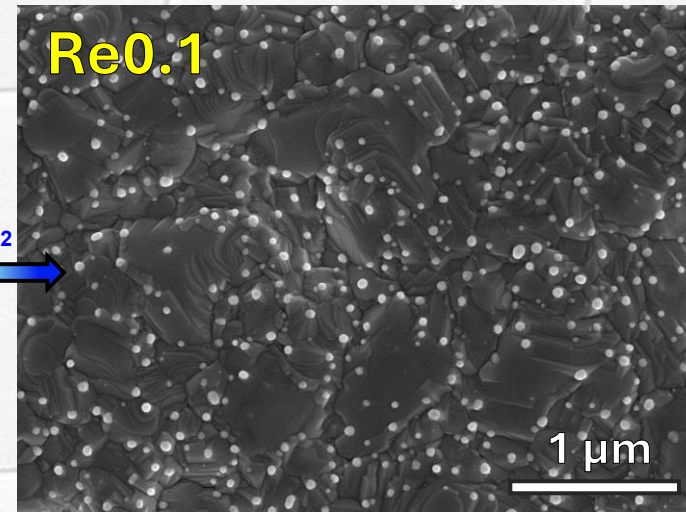
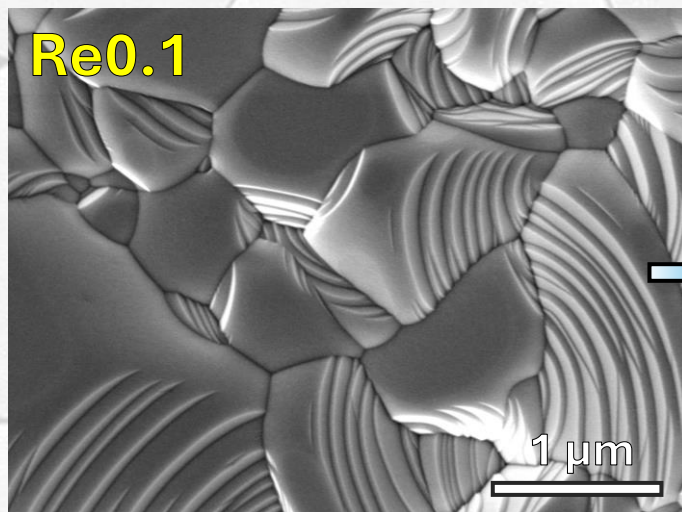
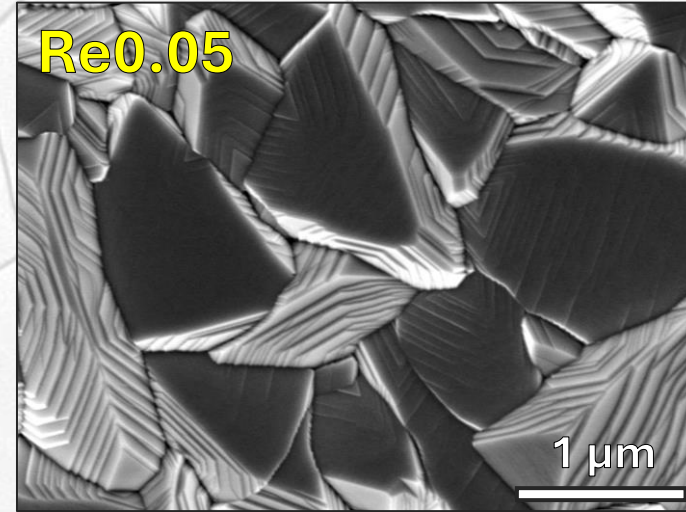
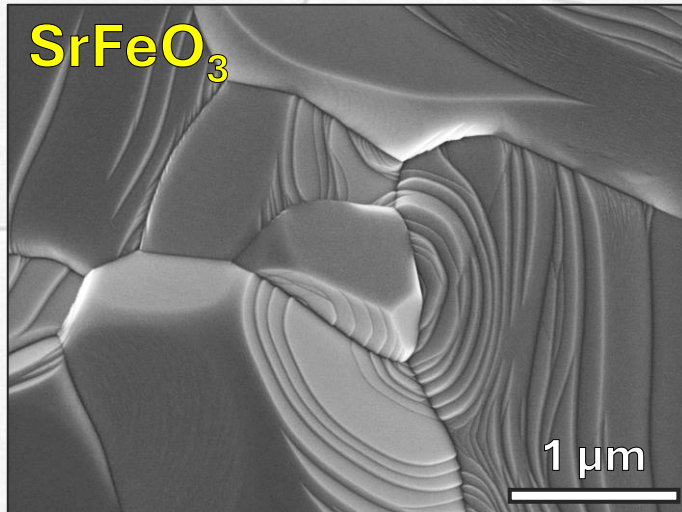
Air (800 °C 1h)



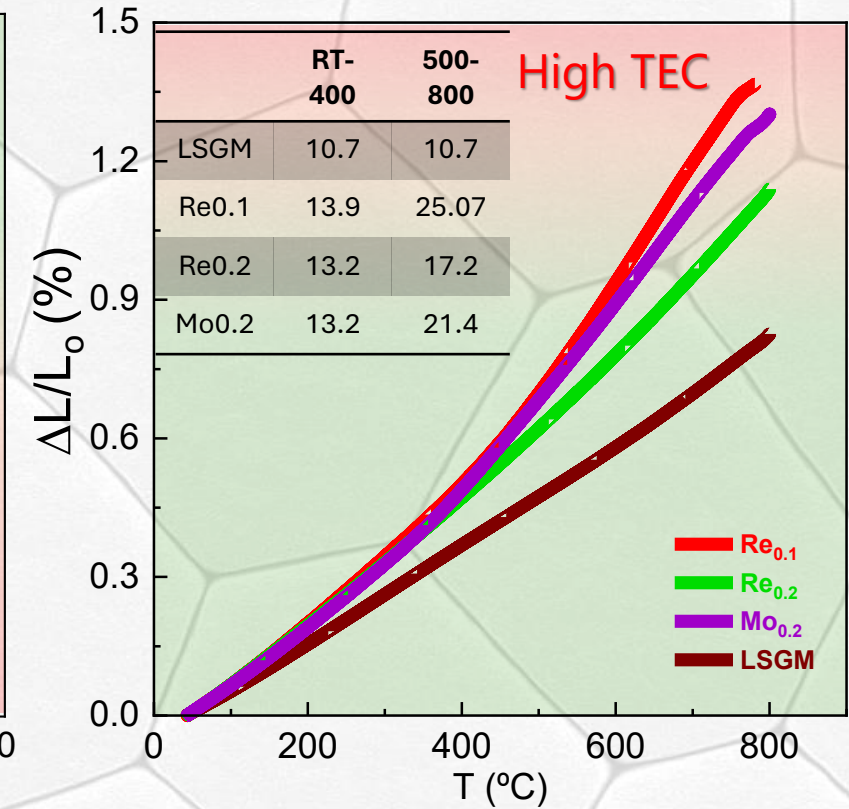
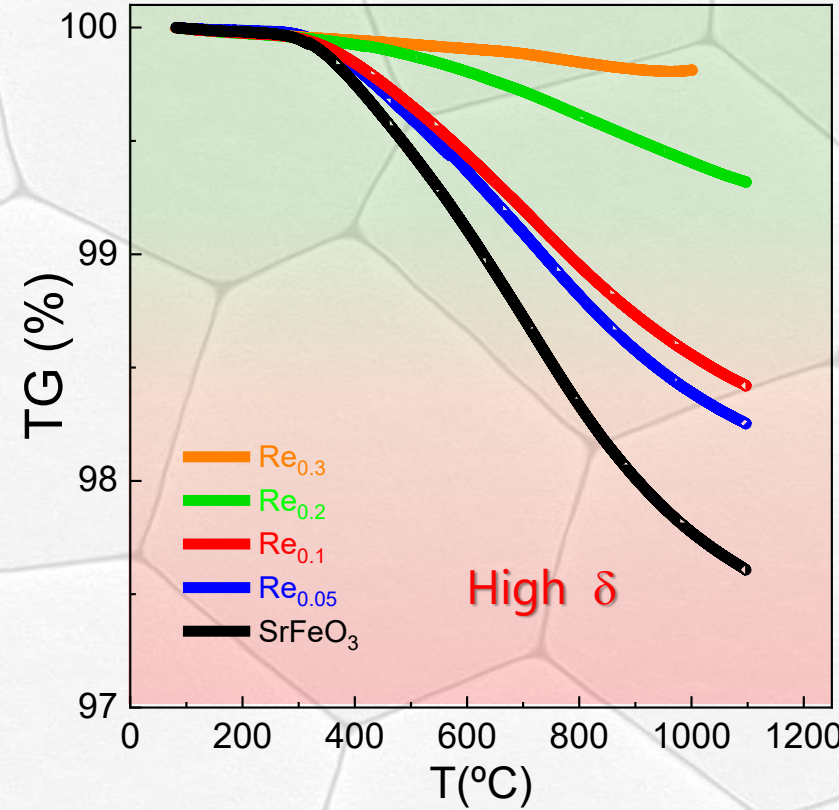
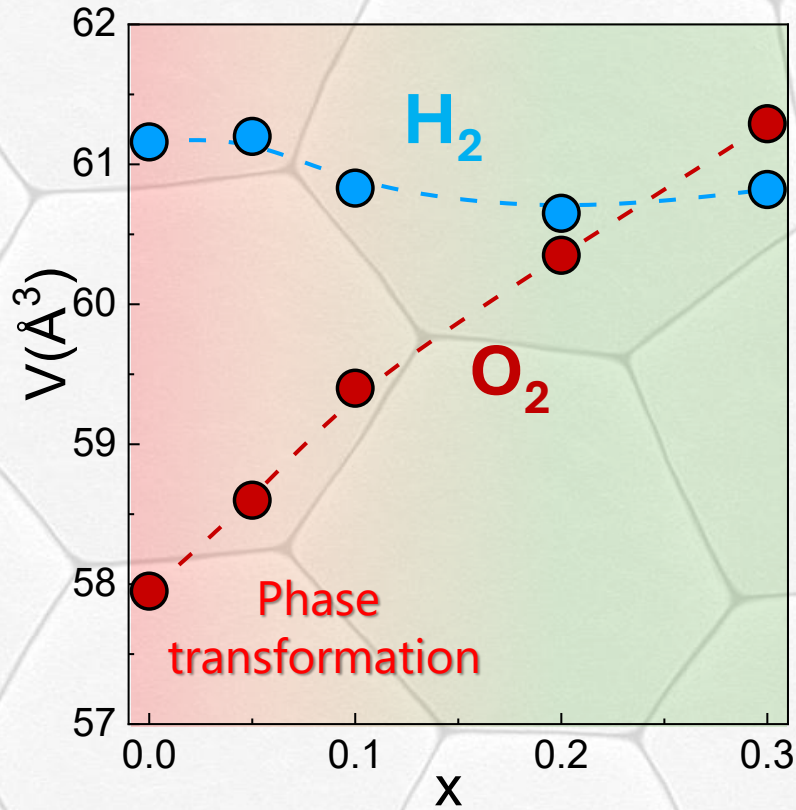
H<sub>2</sub> (600 °C 6h)



## SEM Analysis

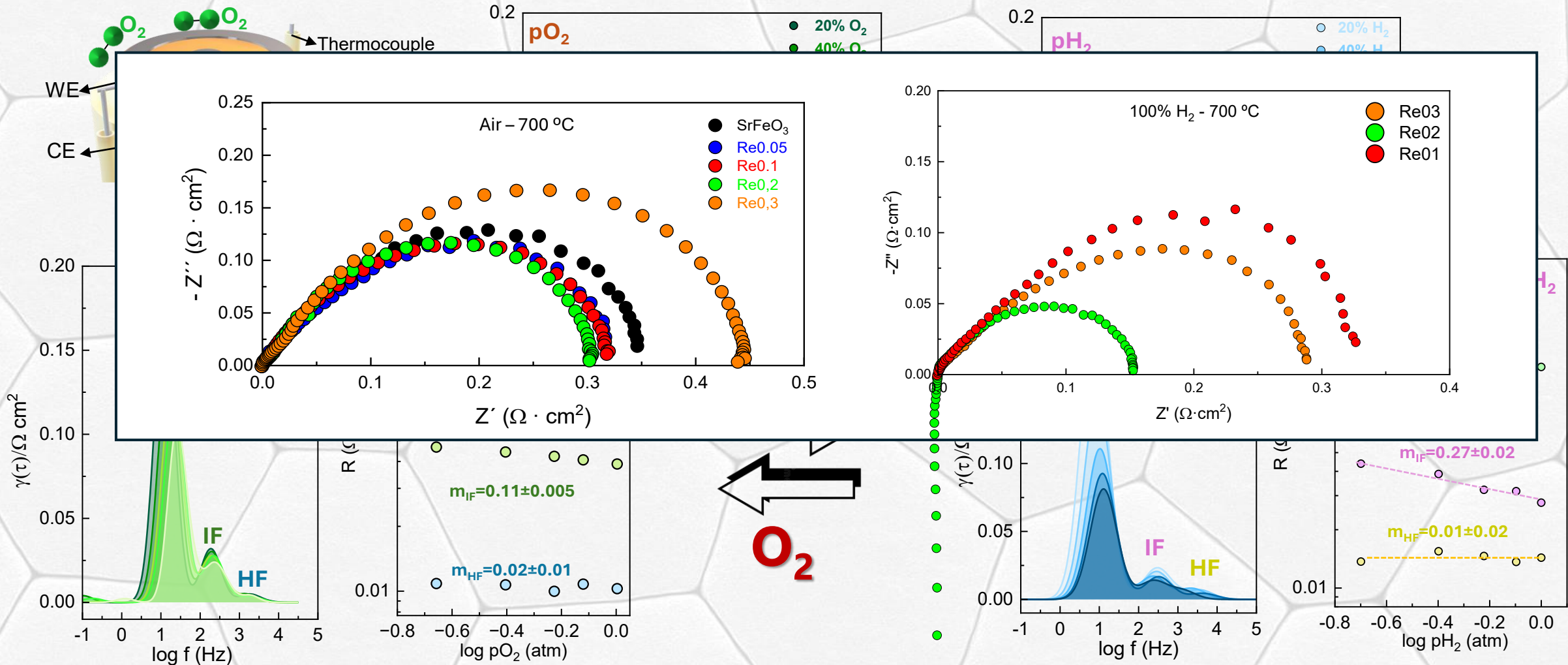


## TEC and TG



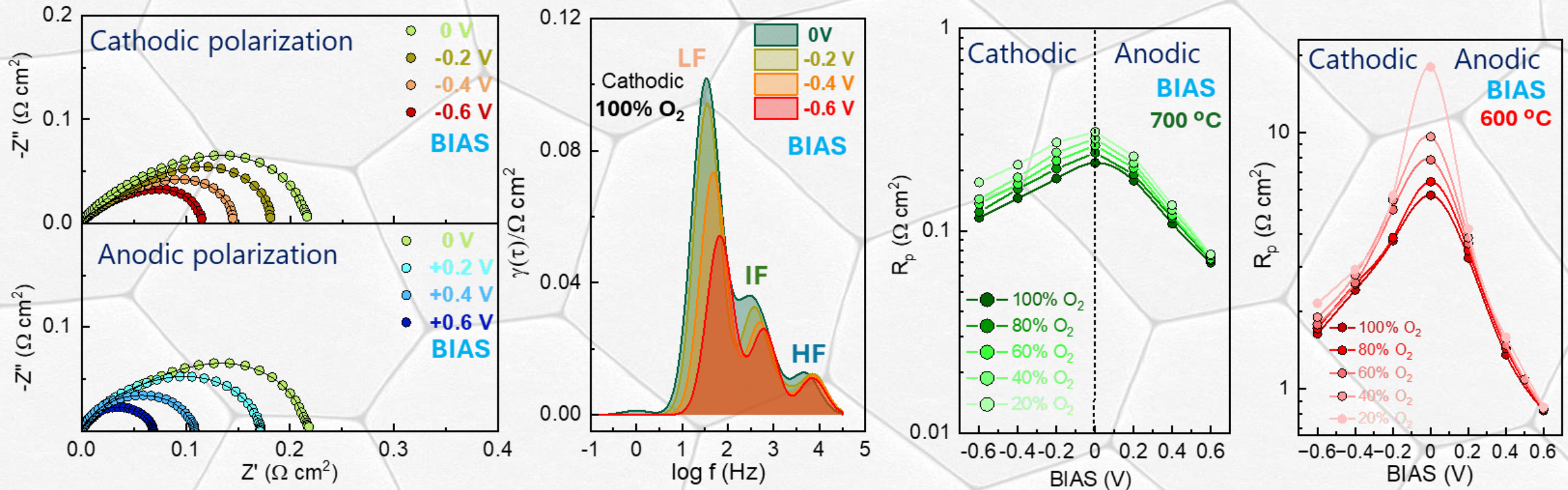
## Electrochemical characterization

→ BIAS study of Re0.2 ( $O_2$  and  $H_2$  at different atmosphere, %)



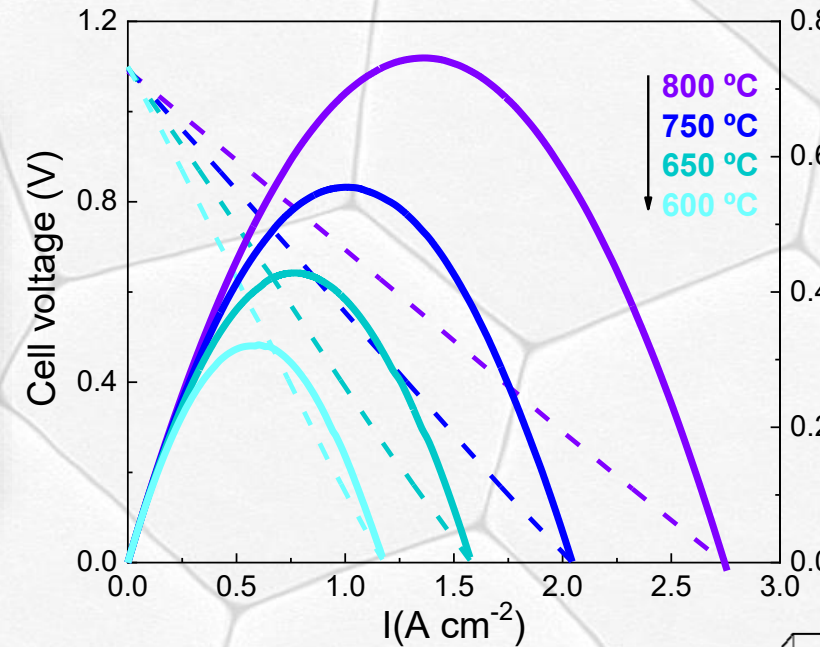
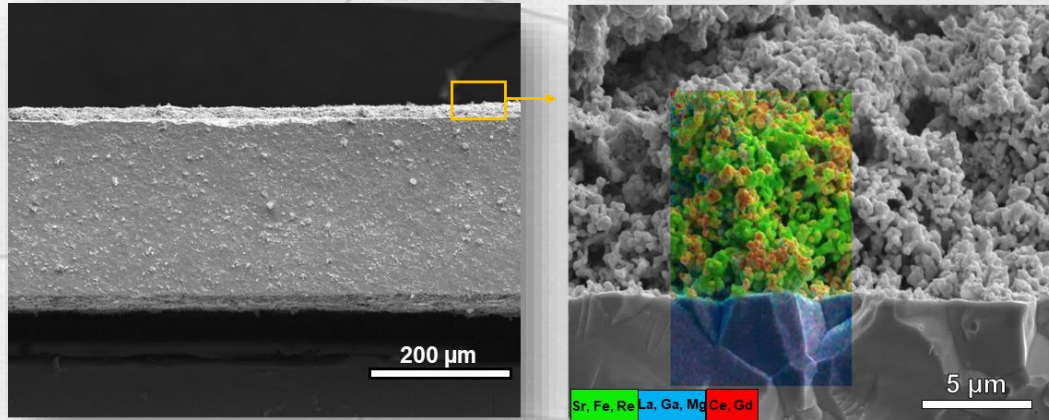
## Electrochemical characterization

→ BIAS study ( $O_2$  and  $H_2$  at different atmosphere, %)

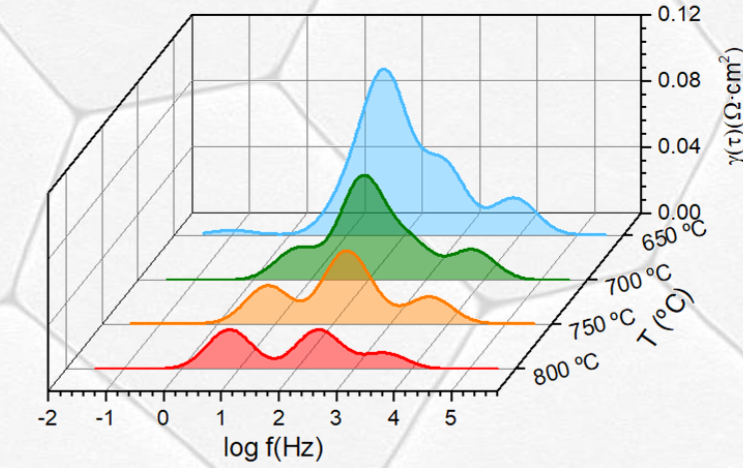
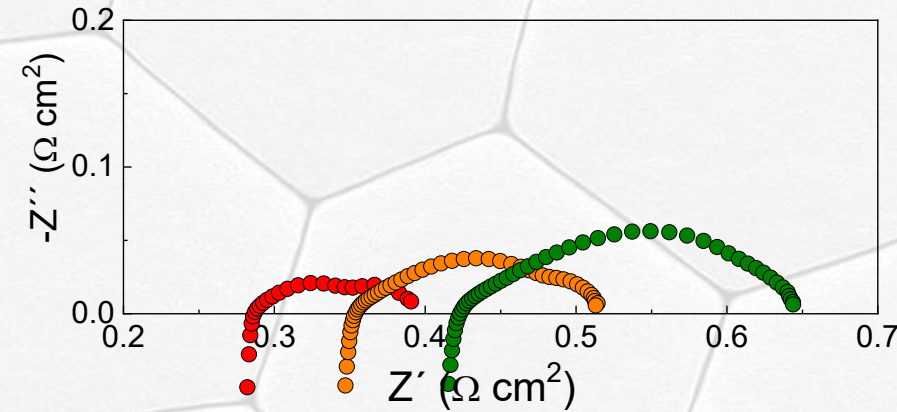
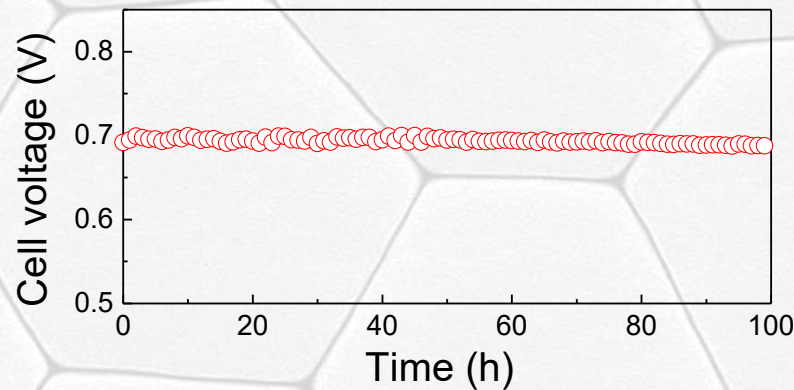


Bias-dependent polarization and DRT profiles reveal multiple electrochemical processes, modulated by oxygen content and temperature

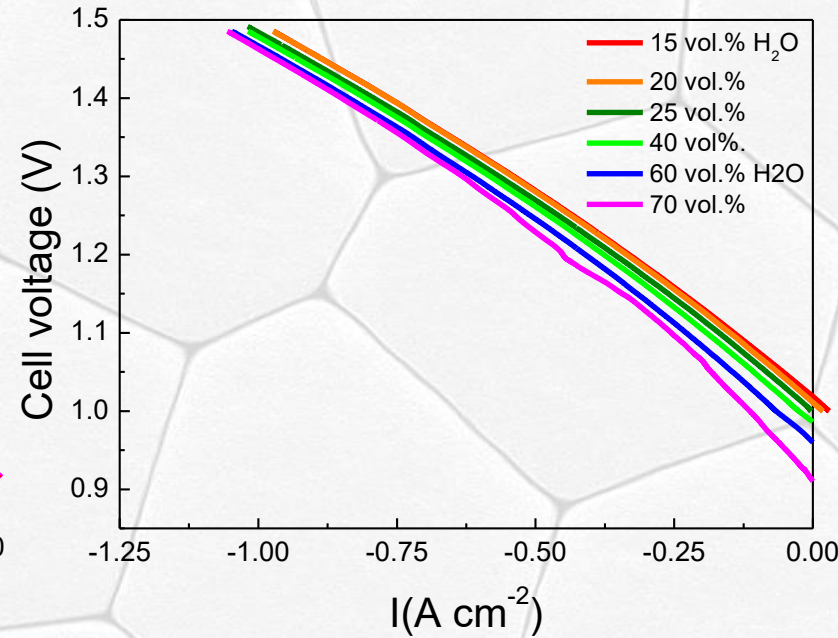
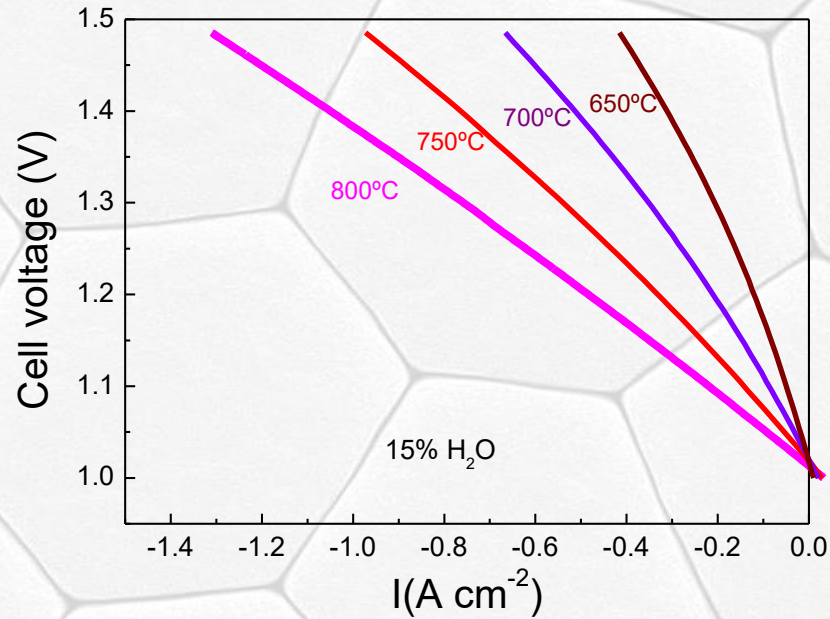
## Fuel Cell



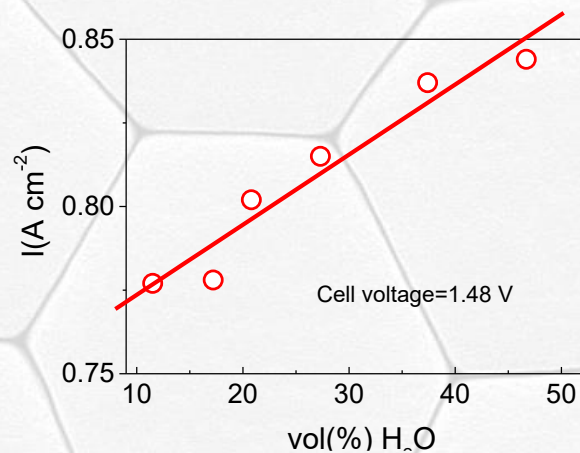
**750 mW cm<sup>-2</sup>  
at 800 °C**



## Electrolyzer



**1.3 A cm<sup>2</sup> at 1.5 V**  
in a gas mixture containing H<sub>2</sub>  
with 15 vol. % H<sub>2</sub>O



Hydrogen production increases with steam concentration under 1.48 V, demonstrating the electrode's activity and stability in SOEC mode.

# CONCLUSIONS

---



- New symmetrical electrodes are investigated ( $\text{Sr}_{0.95}\text{Fe}_{1-x}\text{Re}_x\text{O}_{3-\delta}$  ( $0 < x < 0.3$ ))
- In air atmosphere, the rhenium doping stabilize the cubic symmetry
- The lowest  $R_p$  values in  $\text{H}_2$  are obtained for  $\text{Re}_{0.2}$ :  $0.15 \Omega \text{ cm}^2$  at  $700 \text{ }^\circ\text{C}$
- The rate-limiting steps for the oxygen reduction reaction are attributed to charge transfer on the electrode surface, and hydrogen oxidation reaction are attributed
- TG and dilatometric analysis confirm that the increase of Re-content in  $\text{SrFeO}_3$  minimizes both oxygen lattice release and thermal expansion.
- A manufactured symmetrical SOC generated a power output of  $0.75 \text{ W cm}^{-2}$  at  $800 \text{ }^\circ\text{C}$  in SOFC mode and  $1.3 \text{ A cm}^2$  at  $1.5\text{V}$  in SOEC mode.



UNIVERSIDAD  
DE MÁLAGA



# Thank you for your attention!

## Electrochemical evaluation of Re-doped $\text{SrFeO}_{3-\delta}$ electrodes for SOFCs



Abraham Sánchez Caballero

abraham11sc@uma.es



Dpto. Química Inorgánica, Cristalografía y Mineralogía  
Dpto. Física Aplicada I

TED2021-129836B-I00  
PID2021-126009OB-I00