Efficient catalysts for the plasma-assisted Dry Reforming of Methane

Marzia Faedda

Physics PhD Workshop, 2 Dec 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 813393

Outline

- My background
- Novel catalysts for plasma-catalytic DRM
- Why plasma + catalysis?
- The catalysts
- The reactor setup
- An eclective work

My background

2012

BSc in Physics

University of Cagliari

2016

MSc in Physics of Advanced Technologies

University of Torino

Thesis: "N-doped carbon-based catalysts for O_2 and CO_2 electrochemical reduction" @IIT & PoliTo

2019

1st October

PhD – PIONEER

Plasma catalysis for CO_2 recycling

Supervisor	Prof. Monika Motak	AGH - UST in Krakow
Co-supervisor	Prof. Paolo Tosi	University of Trento

Project: Novel catalysts for the plasma-assisted

Dry Reforming of Methane(DRM)

Novel catalysts for plasma-catalytic DRM

Dry Reforming of methane

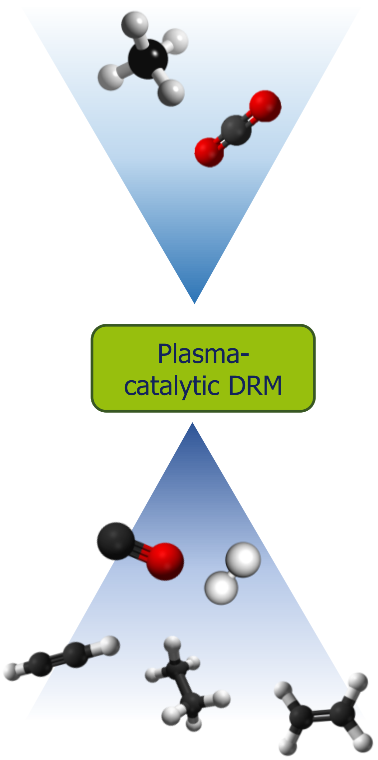
$$\underbrace{CO_2 + CH_4}_{} \rightarrow \underbrace{2H_2 + 2CO}_{} \qquad \underbrace{\Delta H^{\circ}{}_{298K} = +247\ kJ\ mol^{-1}}_{}$$

Two of the most abundant and dangerous greenhouse gases

Synthesis gas ($H_2/CO = 1$)

Highly endothermic reaction

→ High activation temperatures (>600° C) are necessary



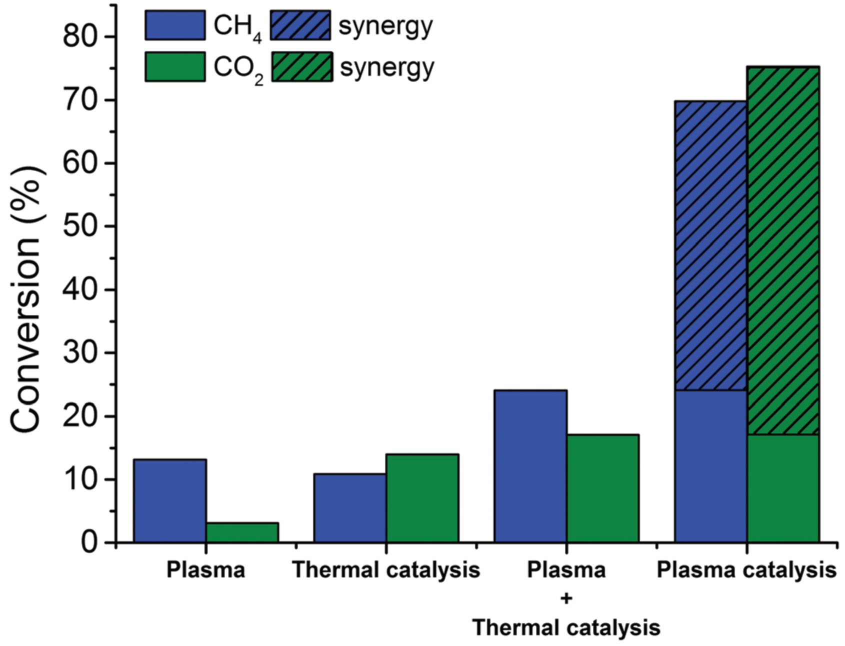
Electrical discharge (NRP plasma) + Catalyst →

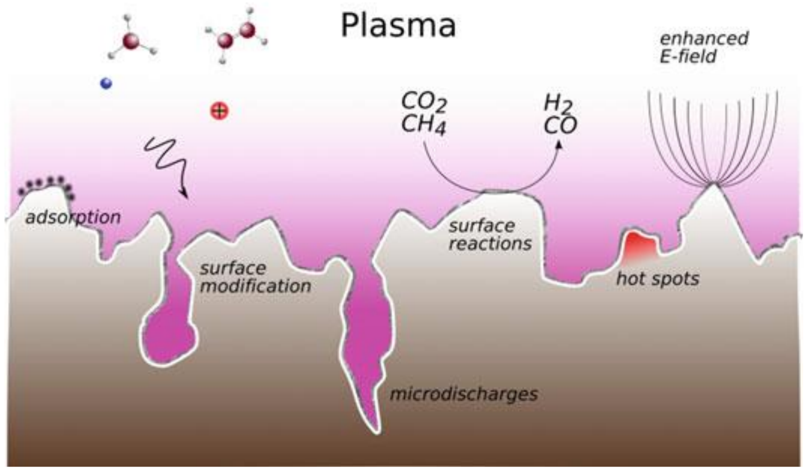
Lower activation energy
Increase energy efficiency
Increase conversion
Control products selectivity

Why plasma + catalysis?

Electrical discharge (NRP plasma) + Catalyst →

Lower activation energy
Increase energy efficiency
Increase conversion
Control products selectivity



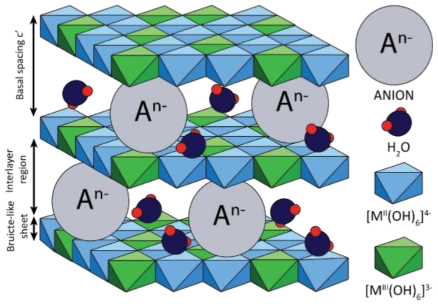


Bogaerts A., Snoeckx R. (2019) Plasma-Based CO2 Conversion. In: Aresta M., Karimi I., Kawi S. (eds) An Economy Based on Carbon Dioxide and Water. Springer, Cham

The catalysts

Ni-based hydrotalcite-derived catalyst

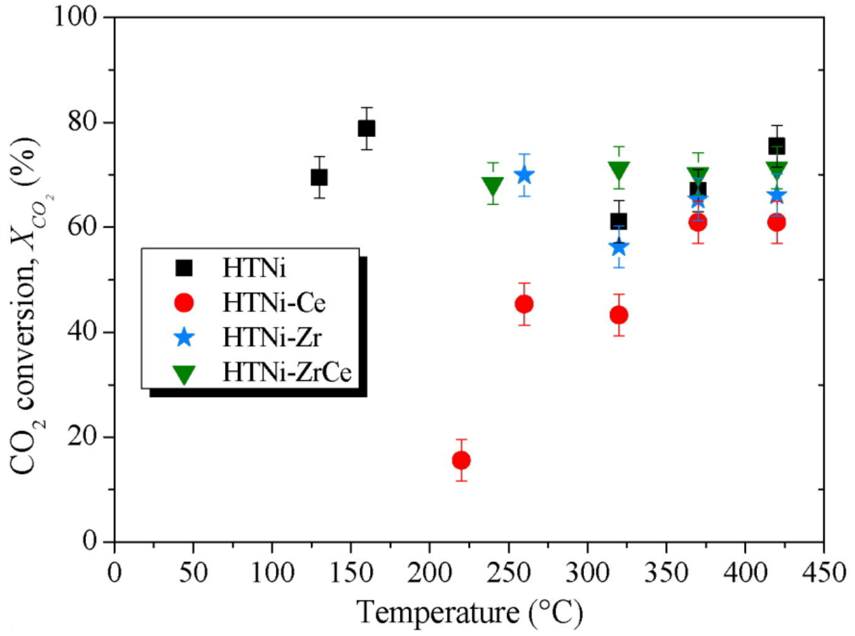
hydrotalcite-like structure



$Mg_6Al_2(OH)_{16}CO_3 \cdot 4H_2O$

Active material: Nickel

Debek 2015 –Low T methanation in a DBD plasma



- their surface basicity allows great CO_2 adsorption capability
- hydrotalcite-derived catalysts have been reported to be highly active and stable in DRM.
- high surface area to volume ratio, high porosity
- low cost
- environment-friendly

[1] *R. Dębek, M. Radlik, M. Motak, M. E. Galvez, W. Turek, P. Da Costa, T. Grzybek, Catalysis Today, Volume 257, Part 1 (2015) 59-65*

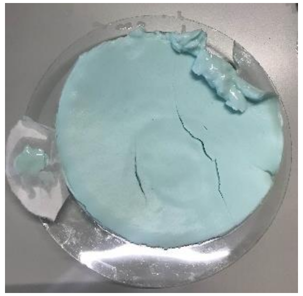
The catalysts

Samples nomenclature

Active metal: Ni	Support : Hydrotalcite
5 wt.%	5NiHT(calc, red,DRM)
10 wt.%	10NiHT(calc, red,DRM)
40 wt.%	40NiHT(calc, red,DRM)

1) Synthesis: co-precipitation method at constant pH and temperature

2) Washing with warm distilled water and filtering

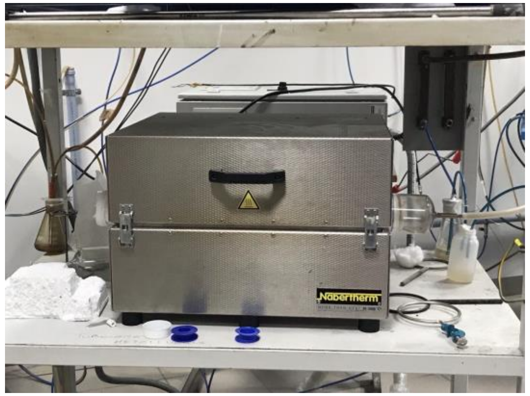


3) Drying overnight at 80° C and grinding into a fine powder

4) Calcination at 550° C for 4 h

Calcined powder

5) Reduction at 900° C for 1 h
5%H/Ar flow
150 sccm
UniTn Materials Eng. Dep.



X-Ray Diffractometry

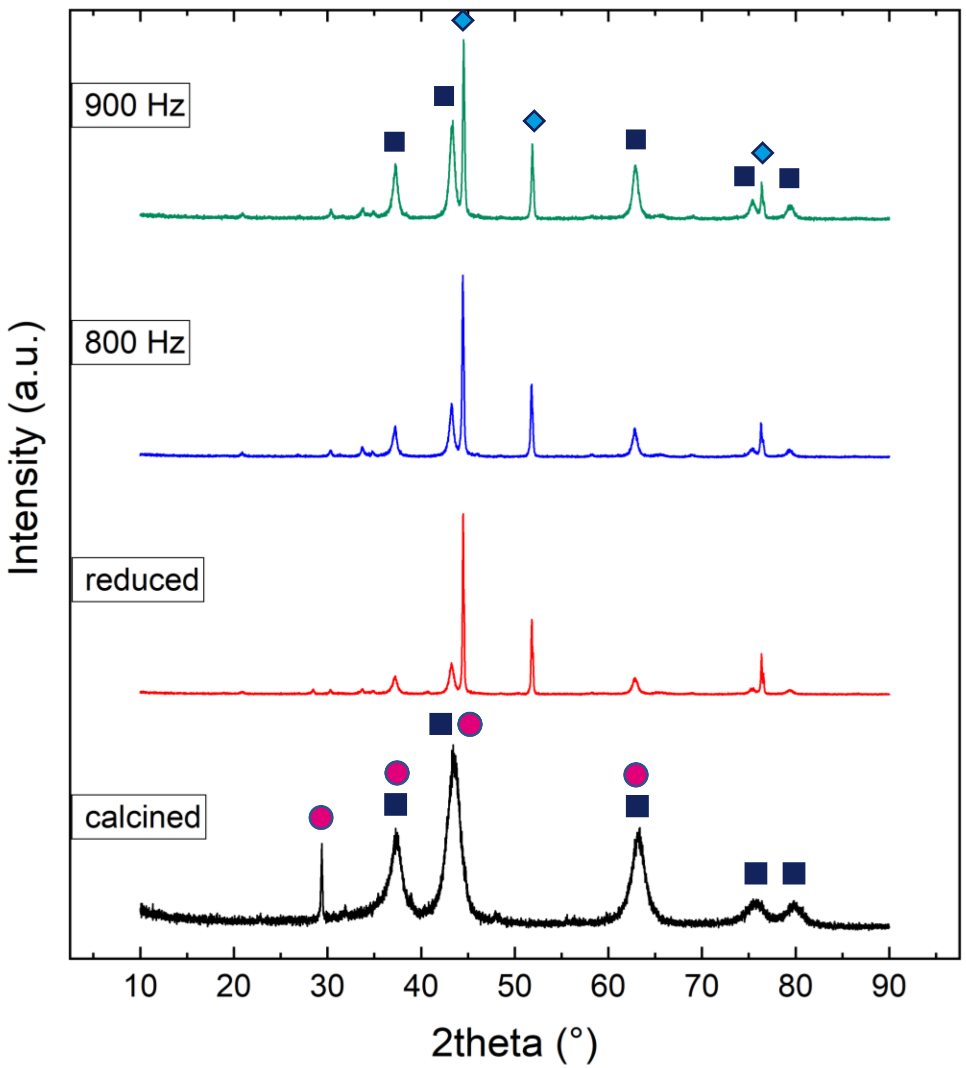
Sample: 40NiHTred

Catalyst crystalline structure after:

- **Preparation steps** (calcination, reduction);
- **DRM reaction**

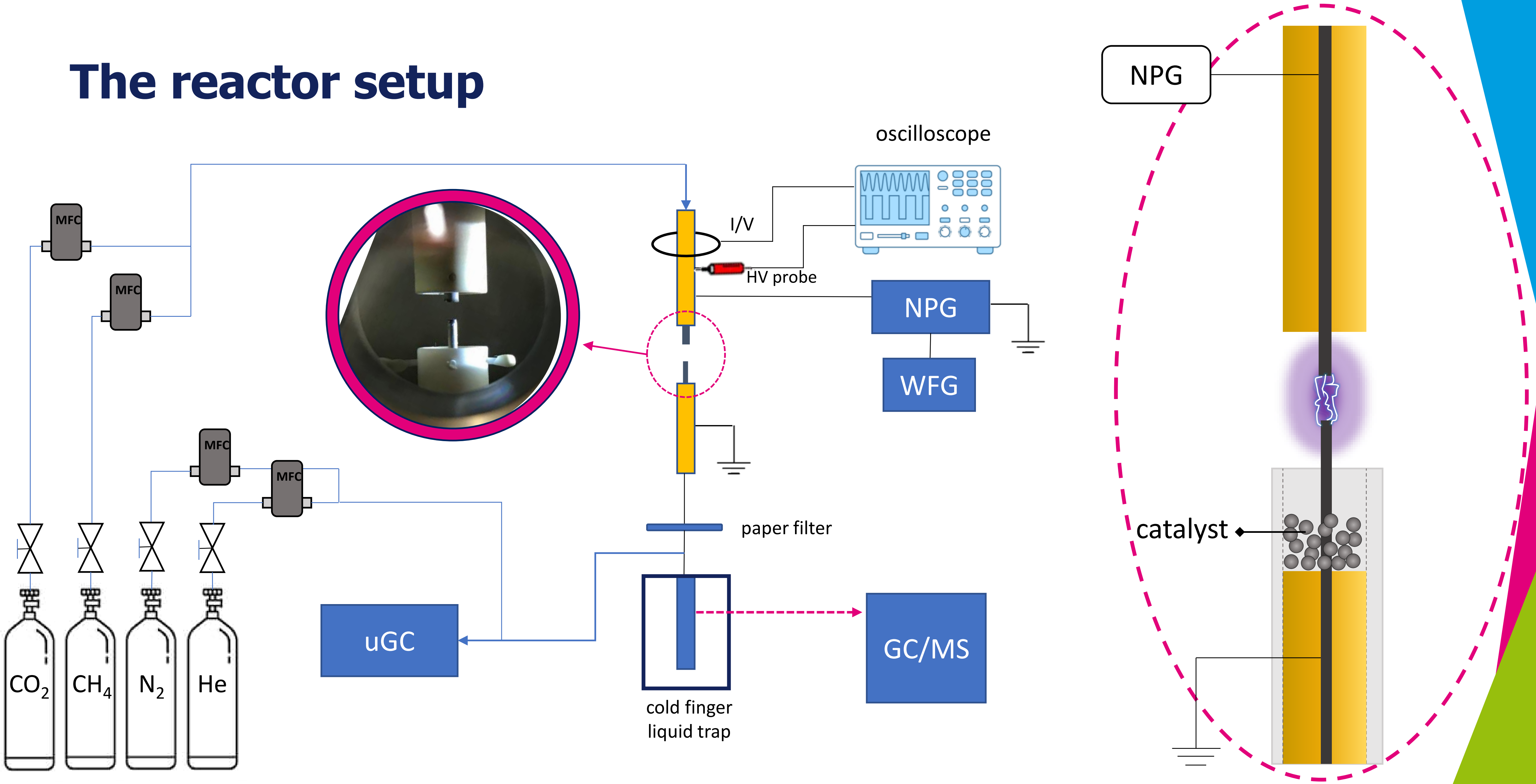
Oxidation of Ni increases with discharge energy.

40NiHT preparation steps and spent catalyst XRD analysis

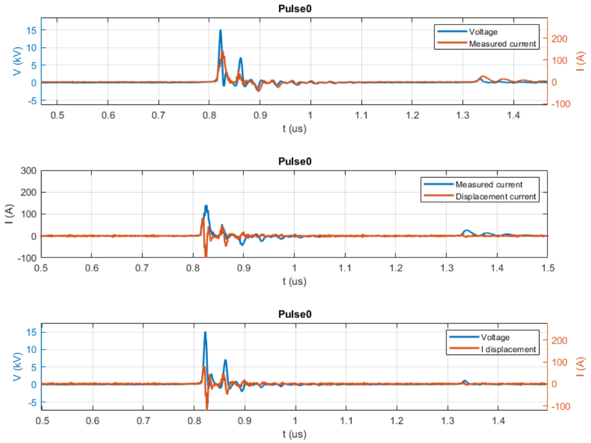


◆ Ni^0, ■ NiO, ● MgO periclase-like structure of mixed oxides

The reactor setup



An eclectic work



vacuum techniques

Setup of plasma discharge

Electrical circuits

Discharge Characteriza-tion

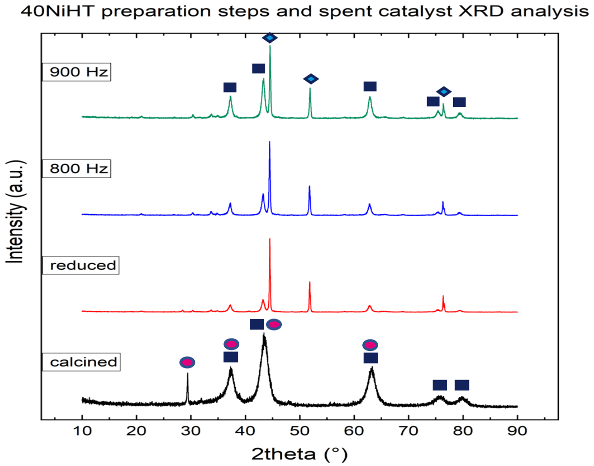
Study of the literature!

Plasma-catalytic DRM

Chemical synthesis of catalysts

Physico-chemical material characterizations (XRD, XPS, TEM..)

DRM reaction with plasma and plasma + catalyst



Contacts

marzia.faedda@unitn.it

Laboratory of Atomic and Molecular Physics | Department of Physics
University of Trento
Via Sommarive 14, 38123
Trento, Italy

PIONEER
PLASMA CATALYSIS CO_2 RECYCLING

IG : @co2pioneer

Website: www.co2pioneer.eu

Thank you for your attention

This project has received funding from the European Union's Horizon H2020 research and innovation programme under the Marie Skłodowska -Curie grant agreement n°813393