A.D. 1308
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DIPARTIMENTO
DI FISICA E GEOLOGIA

NiPS Laboratory
Noise in Physical Systems

Microtecnologie e nanomateriali per la microgenerazione e l'accumulo di energia

Piano Triennale della Ricerca e Terza Missione (2021-2023)

10/01/2021

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Sommario

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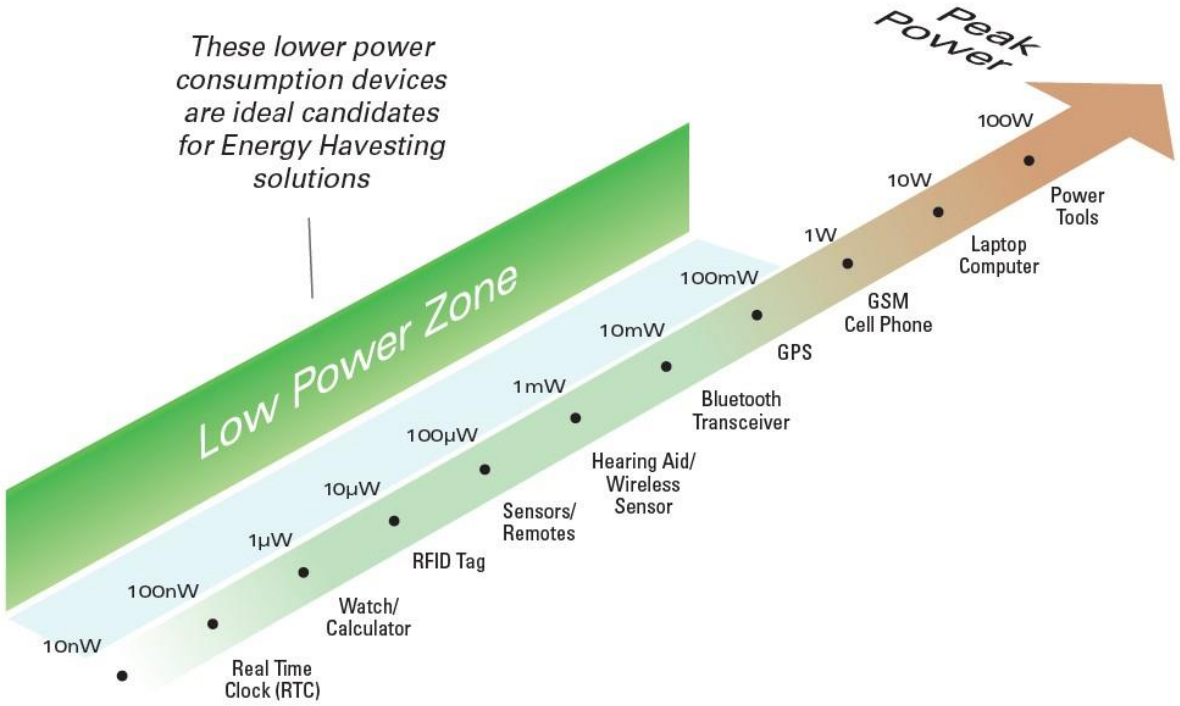
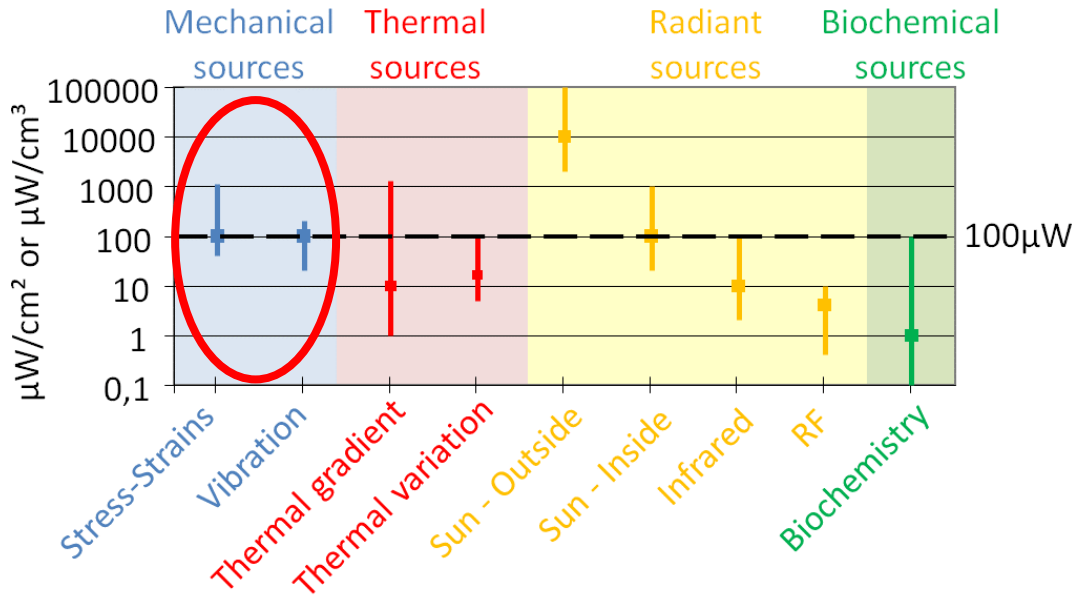
  - Photoconversion of CO2 through solar energy

Introduzione all'energy harvesting

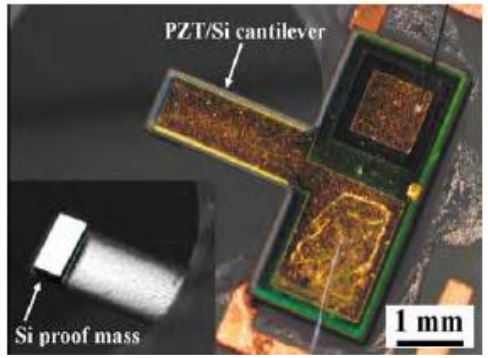




S. Boisseau et al. 2012

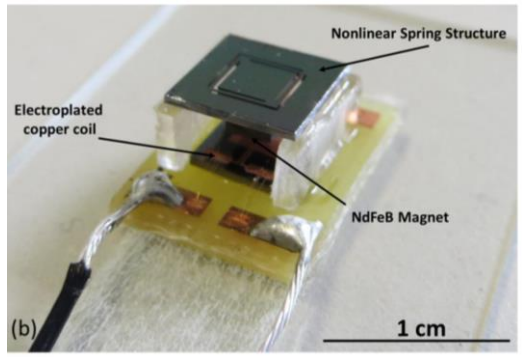
Sistemi di energy harvesting: MEMS/NEMS

Piezoelectric



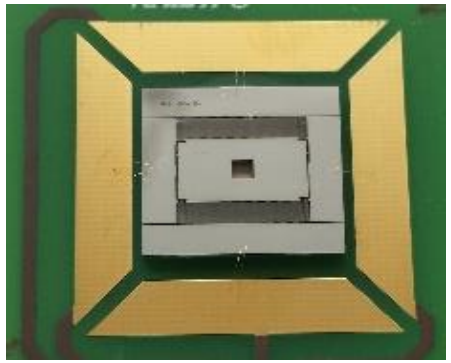
D. Briand, EPFL 2010

Magnetic induction



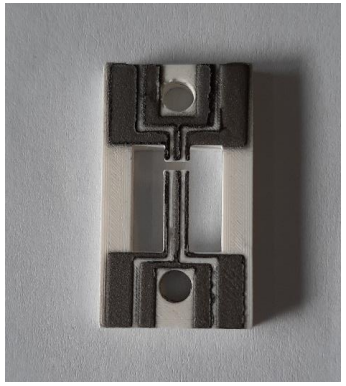
Mallick D. and Roy S., 2015

Electrostatic



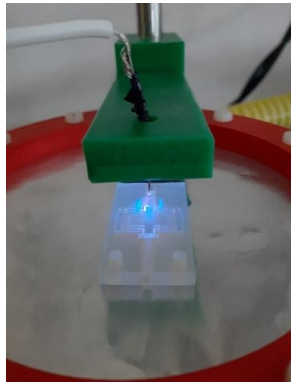
Cottone F., Basset P. 2013

3D printed generators



Electrostatic bi-stable energy harvester

Interdigitated capacitive sensor with PCL/copper nanotube charged filament

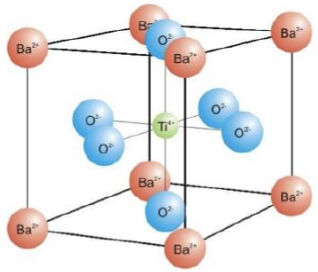


Corona discharge for electrets production

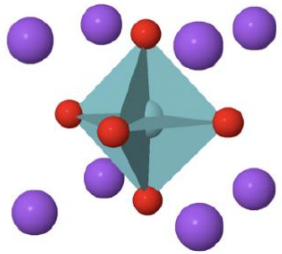
F. Cottone

Sistemi di energy harvesting: materiali

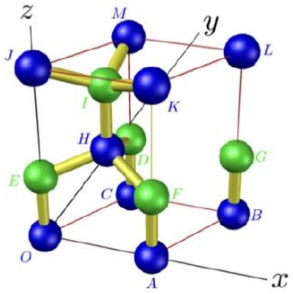
- Studio di materiali **piezoelettrici micro/nano strutturati** per **energy harvesting:**



Perovskiti
$BaTiO_3$

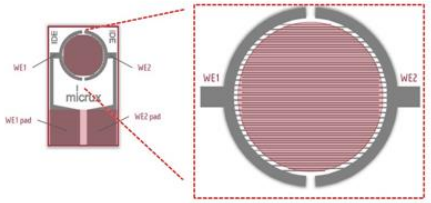


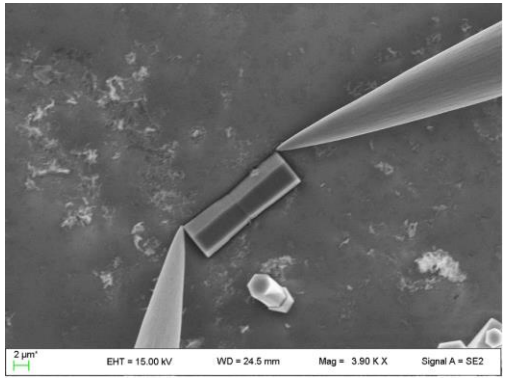
Wurzite
ZnO



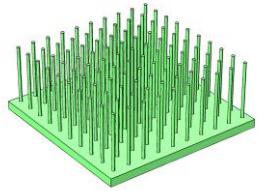
$KNaNbO_3$

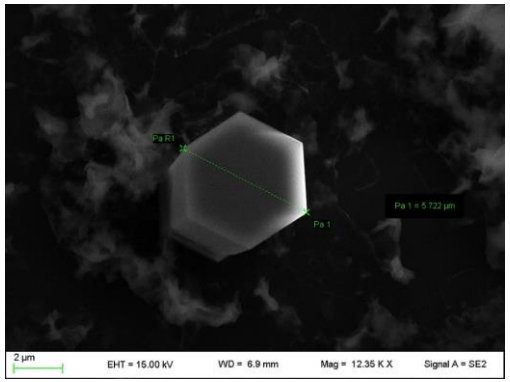
- Biocompatibili
- Performance
- Basso costo
- micro e nano strutture





ZnO forest

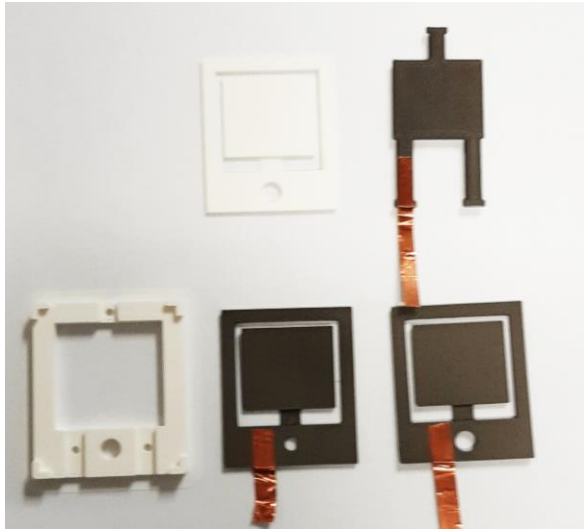


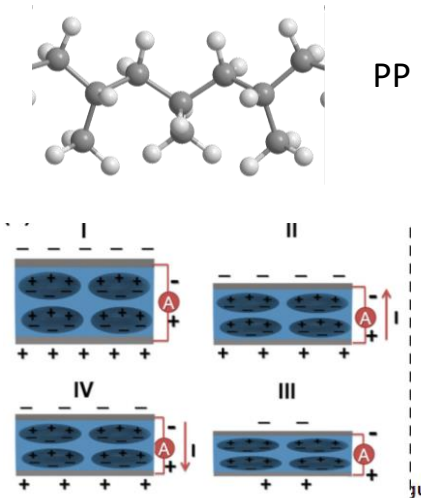


Sistemi di energy harvesting: materiali

- Studio di materiali **elettrostatici** ad **elettreti** per **energy harvesting:**

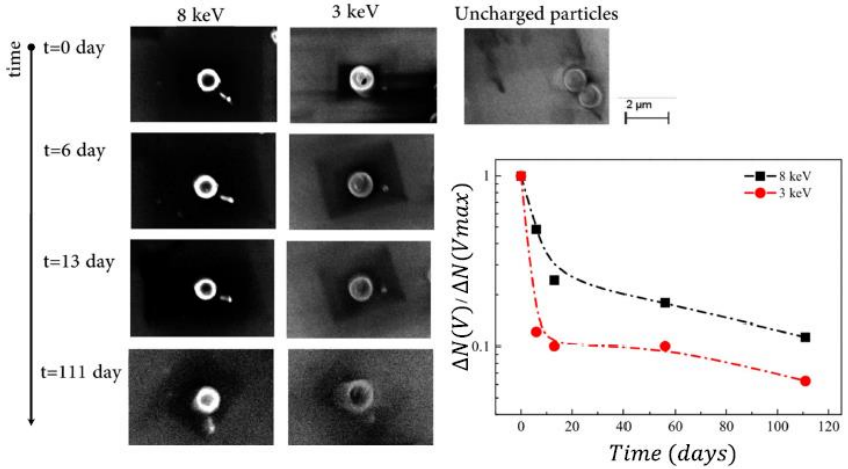
3D printed electrets: **PLA, Polipropilene (PP), PET, TPU**

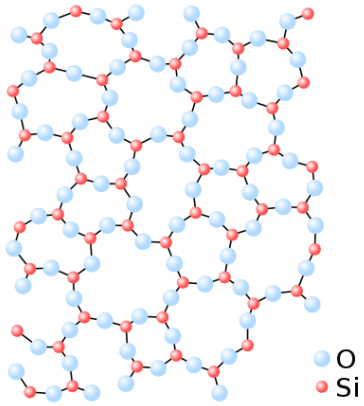




PP

Fused Silica **SiO2** - Micro/Nano Particelle





ure 7. Images from the in-lens detector of the charged (first line, 8 keV and second line, 3 keV) and control particles (third line) at different times from the charging. In the graph: time behaviour of the emitted electrons difference between a charged and a non-charged particle.

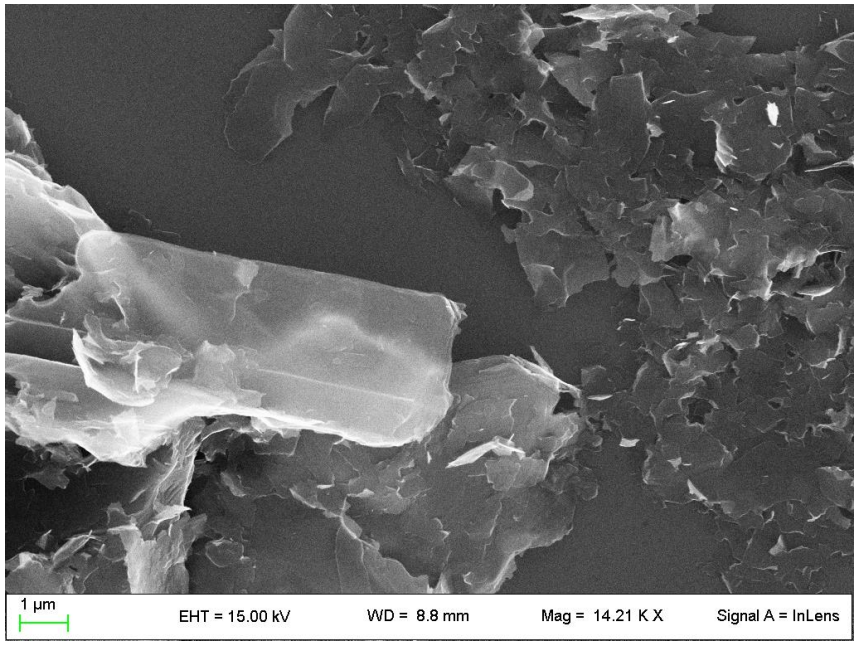
Elettreti con polimeri cellulari stampati 3D

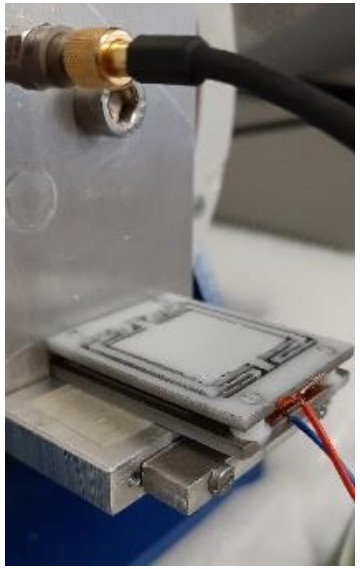
Bonacci, F., Di Michele, A., Caponi, S., Cottone, F., & Mattarelli, M. (2018). https://doi.org/10.1088/1361-665X/aaca55

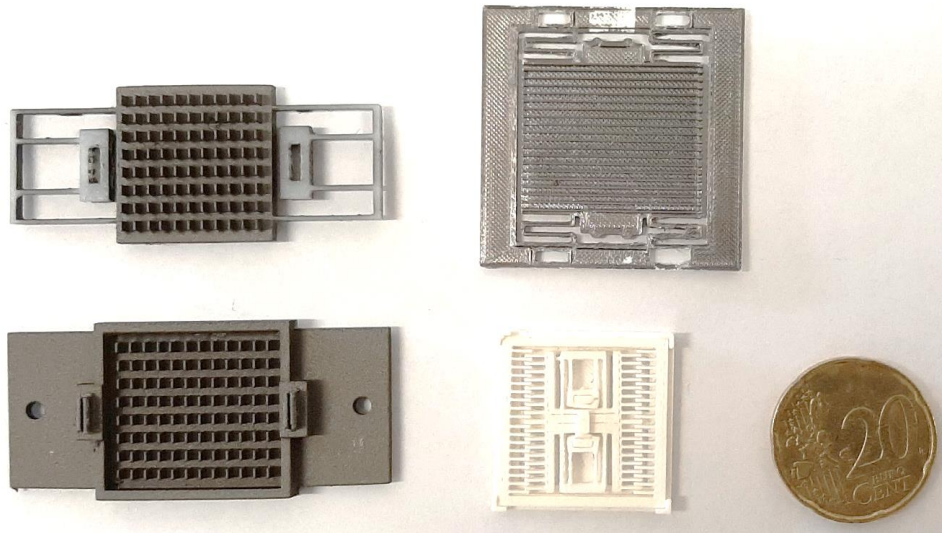
Sistemi di energy harvesting: integrazione

- Micro generatori elettrostatici **stampati in 3D** con **Nickel/grafene**

Sintesi del graphene: partendo da polvere micrometrica pura al 99% di grafite seguente **esfoliazione** da solvente DMSO (dimetilsolfossido) in ultrasuoni (generatore con sonda da 750W), successivamente filtrato e lavato.







3D printed in-plane electrostatic energy harvester

3D printed Interdigitated capacitive harvester

Progetti in partenza e collaborazioni

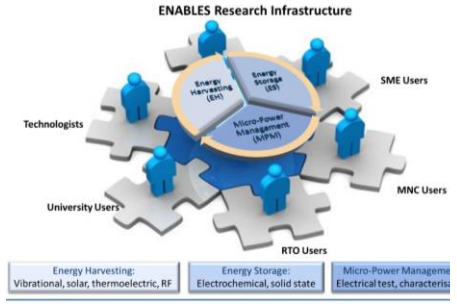
PROGETTI FINANZIATI CON BORSE PON - TRIENNIO 2022 - 2025

- Dottorato 2022 – 2025 – **Gabriele Perna** – Titolo: Materiali piezoelettrici innovativi micro- e nano- strutturati per applicazioni di energy harvesting – Tutors: I. Neri, C. Francesco
- RTDA 2022 – 2021 – **Giacomo Clementi** – Titolo: Biogreen - Energy harvesting da sistemi di cellule – Tutor: Prof. Gammaitoni
- RTDA 2022 – 2021 – Progetto **BETASMART** – UNIPG/UNIPD – Tutor: Prof. Mengoni, Prof. Cottone

PROGETTI EUROPEI EnABLES 1 e 2 (2022).

WISEPOWER

ESIEE PARIS



Tyndall National Institute (IRL)
Role: Access Provider (EH-Vibrational, EH-Thermoelectric, ES, MPM, SI)

CEA-Leti (F)
Role: Access Provider (ES)

CEA-Liten (F)
Role: Access Provider (EH-Thermoelectric)

Fraunhofer – Institute for Integrated Circuits (D)
Role: Access Provider (EH-Vibrational & Thermoelectric, MPM, SI)

Fraunhofer – Institute for Microelectronic Circuits and Systems (D)
Role: Access Provider (EH-Solar, EH-RF)

imec Nederland (NL)
Role: Access Provider (EH-RF, MPM, SI)

Karlsruher Institut für Technologie (D)
Role: Knowledge Hub (ES)

Politecnico di Torino (I)
Role: Knowledge Hub (ES)

Università di Bologna (I)
Role: Knowledge Hub (MPM)

NiPS Laboratory, Università degli Studi di Perugia (I)
Role: Knowledge Hub (EH-Vibrational)

University of Southampton (UK)
Role: Knowledge Hub (EH-Vibrational)

Conclusioni

- La ricerca sui **materiali** per **energy harvesting**: piezoelettrici, ferroelettrici ed elettreti anche integrati con **grafene** in micro-generatori offre molte opportunità di sviluppo, sia in termini di competenze e **ricerca di base**, sia a livello di **trasferimento tecnologico**.

- La ricerca e lo sviluppo di **dispositivi di energy harvesting** (anche stampati in 3D) e integrati con **grafene** sono una promettente alternativa **low-cost** ai sistemi MEMS basati su silicio.

- La prospettiva di un **ecosistema dell'innovazione** - sulla sintesi/fabbricazione di **nanomateriali**, **micro** e **nano dispositivi** rappresenta un importante opportunità per il nostro dipartimento, il territorio e per on impatto su l'industria **territoriale** e **nazionale**.

Ambito/i del PTSR interessato/i: Ambito 5: **Nanoscienze**, Ambito 6: **Energy harvesting e ICT**

Azioni collaborative di Ateneo coinvolte: Azione 4 (Digitale. Industria e Spazio), WP 4.2: Nanoscienze e nanotecnologie; Azione 5 (Clima, energia), WP 5.1: Infrastrutture, sistemi energetici e produttivi a basso impatto ambientale

Parte – 2 Accumulo di energia

Sintesi e caratterizzazione di materiali nanostrutturati per accumulo di energia

- Catalizzatori metallici nanostrutturati per la produzione di green Hydrogen

L'**Hydrogen Economy** è basata sull'idea di utilizzare l'H_2 come trasportatore di energia.

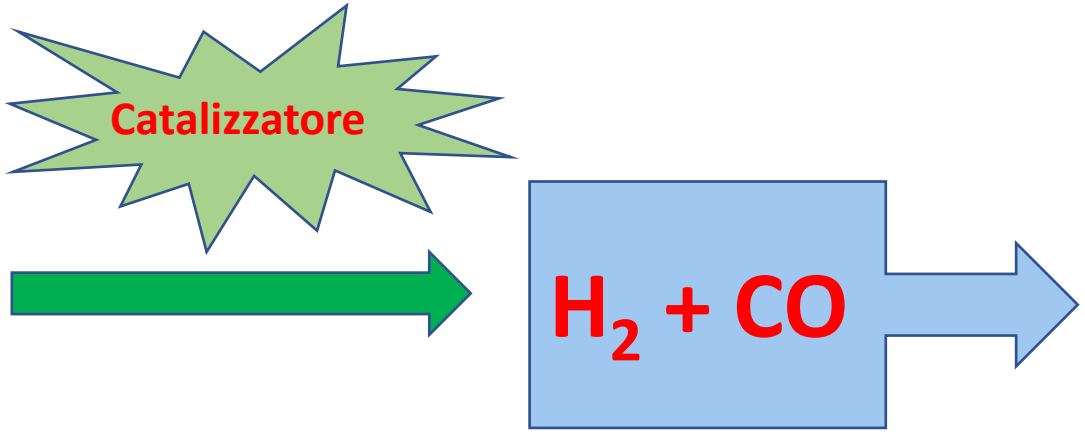
L'idrogeno non è un combustibile ma un vettore di energia.

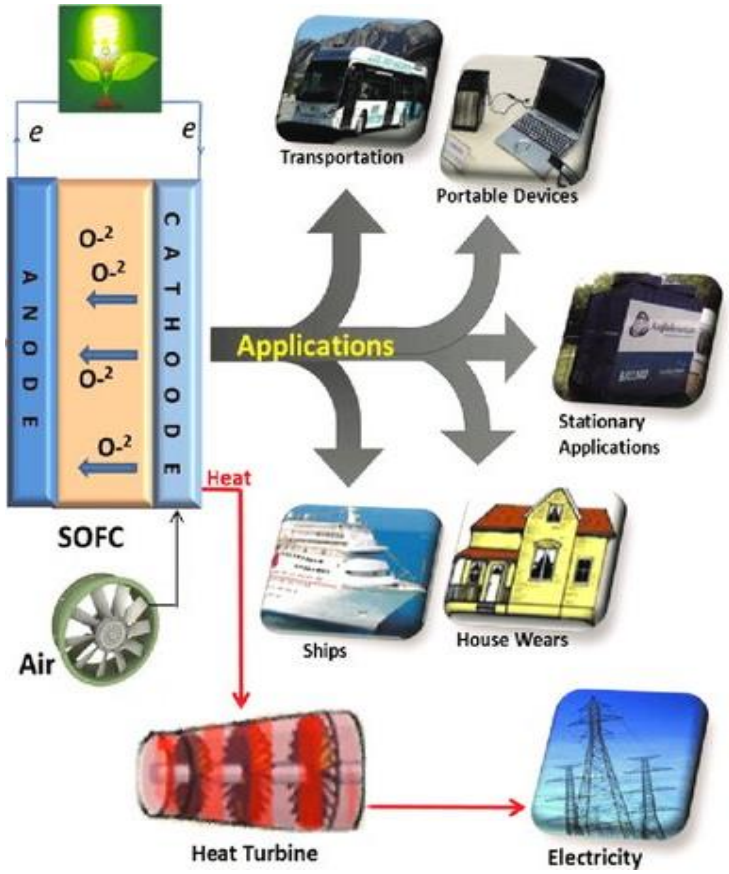
La biomassa può essere convertita in idrogeno come vettore energetico, per essere sfruttato come combustibile pulito (praticamente nessuna emissione distribuita) e convertito in modo efficiente nelle celle a combustibile

Etanolo

Glicerolo

$CO_2 + CH_4$

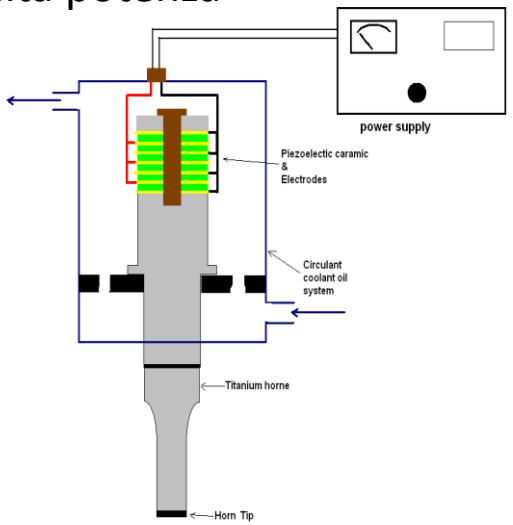




Renewable and Sustainable Energy Reviews 53:450–461

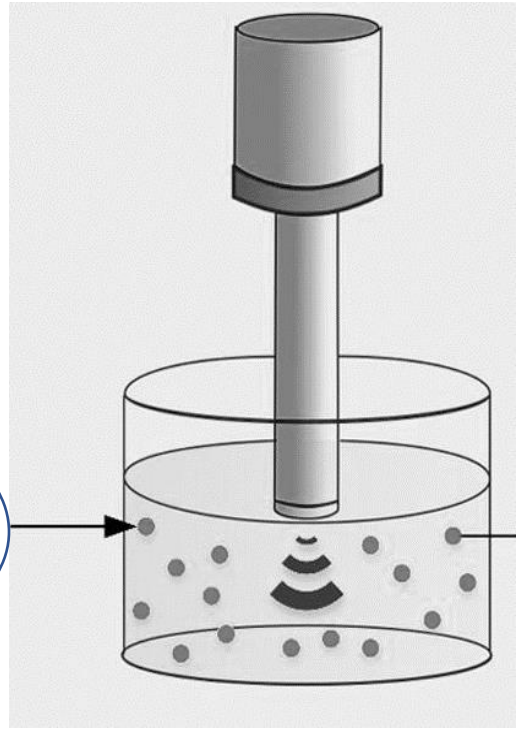
Sintesi e caratterizzazione di Catalizzatori metallici nanostrutturati mediante cavitazione acustica

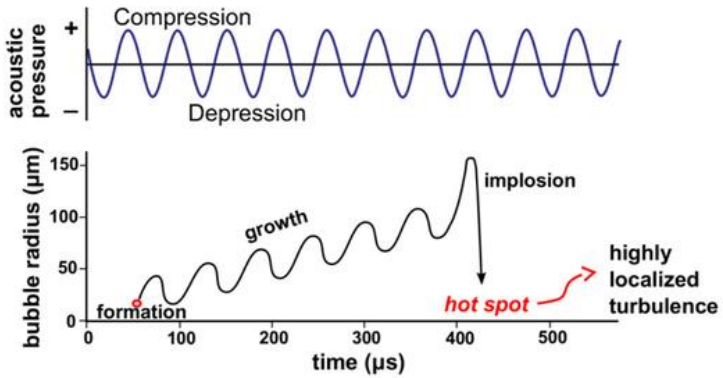
Generatore di Ultrasuoni ad alta potenza



~100 W/cm²

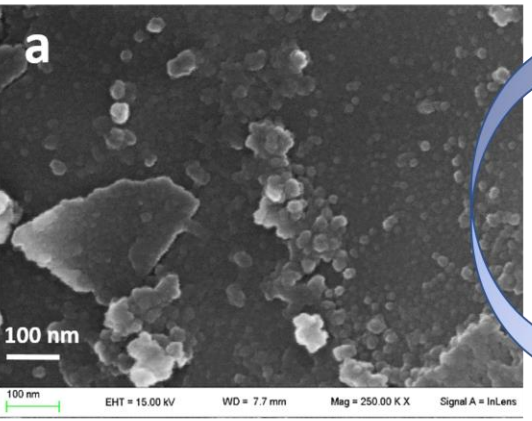
Nanoparticelle metalliche





Suslick, K. S. "Sonochemistry", Science, 1990, 247,1439-45

Dry Reforming



$CH_4 + CO_2$

$H_2 + CO$

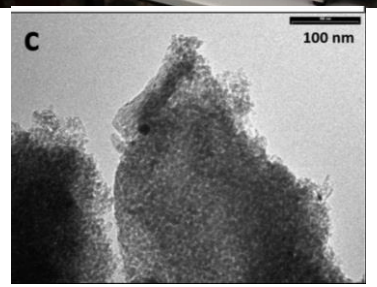
Coke formation:

$CH_4 \rightleftharpoons C + 2H_2$

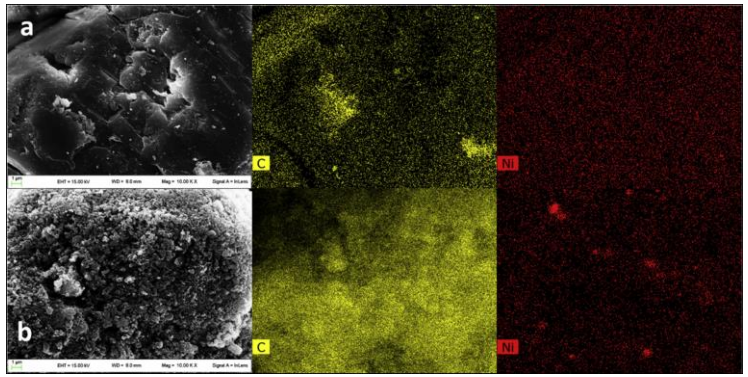
$2CO \rightleftharpoons C + CO_2$

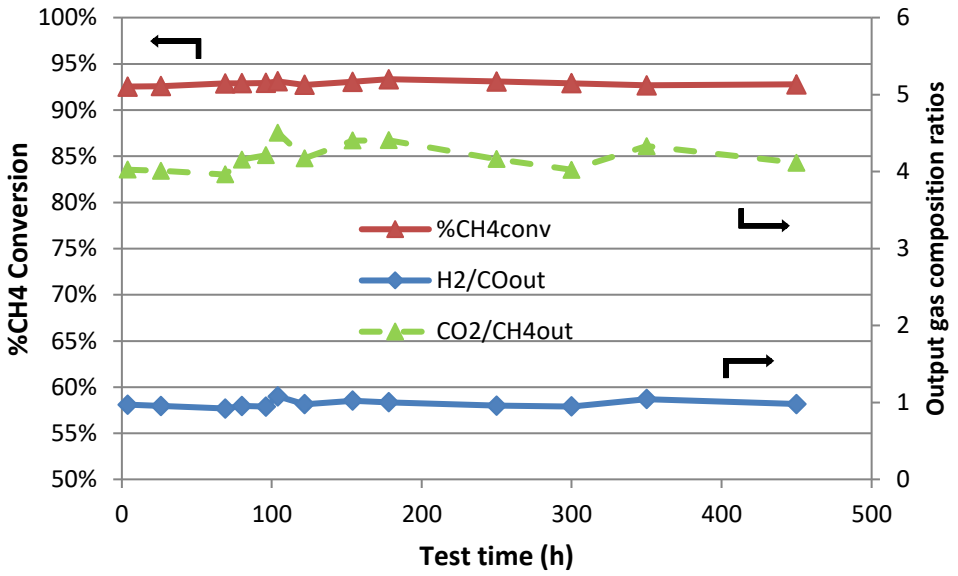
$CO_2 + 2H_2 \rightleftharpoons C + 2H_2O$

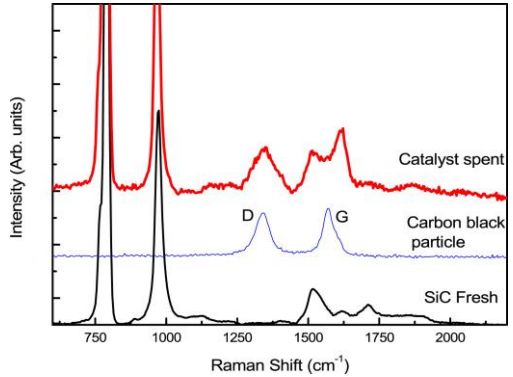
$CO + H_2 \rightleftharpoons C + H_2O$



15%Ni 6%ZrO_2 3%CaO /Al_2O_3



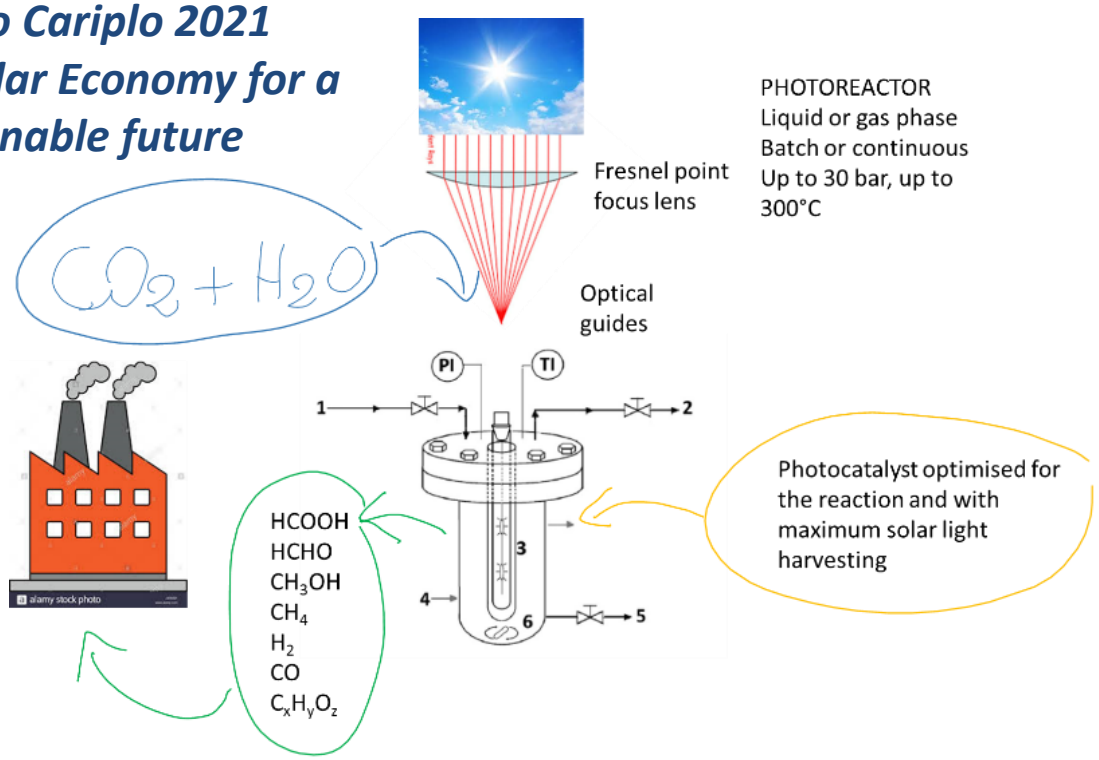




Barelli, Di Michele et al. Int. J. Hydrogen Energy 44, 16582-93, 2019

Photoconversion of CO2 through solar energy

Bando Cariplo 2021
Circular Economy for a sustainable future



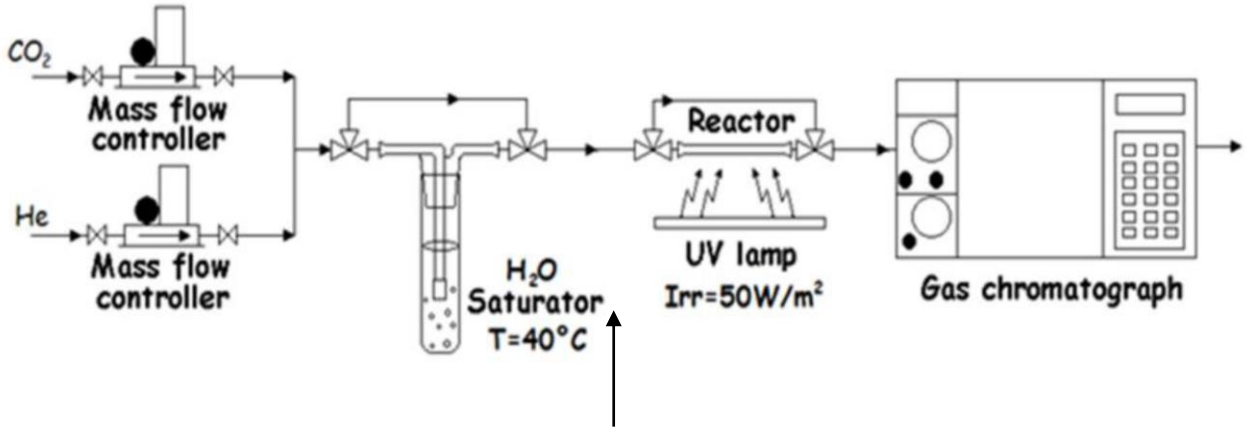
regenerated fuel

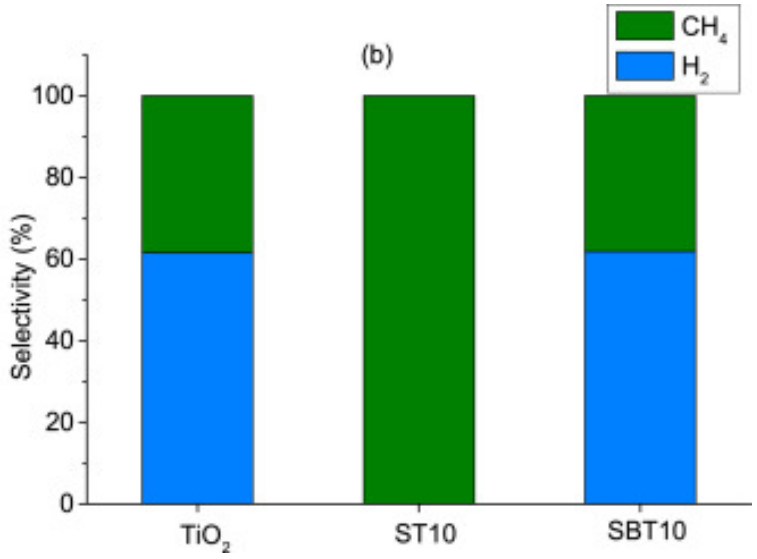
Objectives:

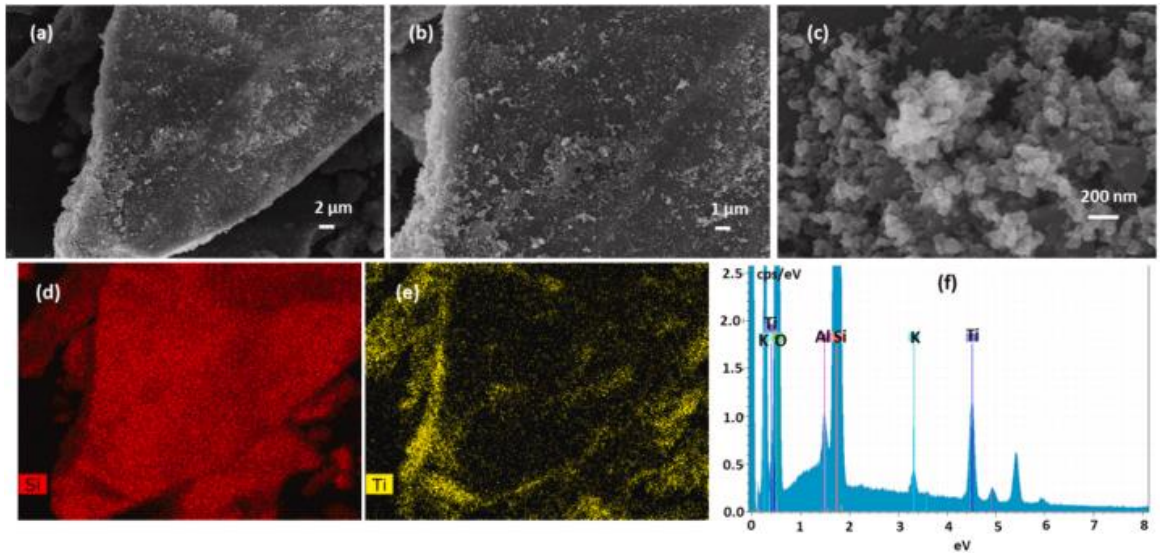
i) regenerate valuable chemical compounds in a fully circular approach;

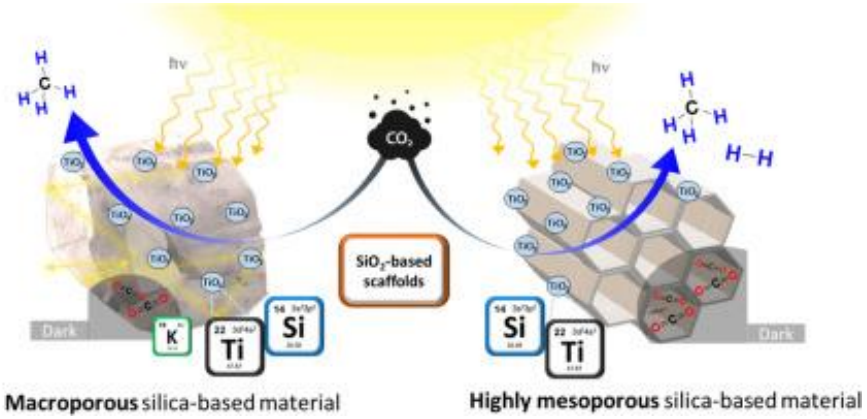
ii) convert CO_2 (one of the most concerning greenhouse gases, negatively affecting EU economy for carbon-related taxes);

iii) store solar energy





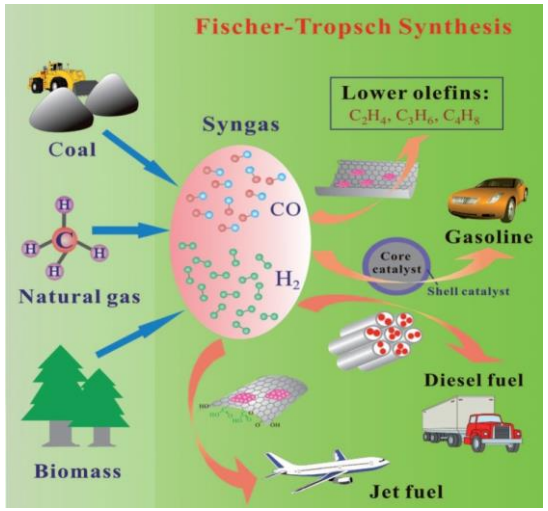




Catalysts

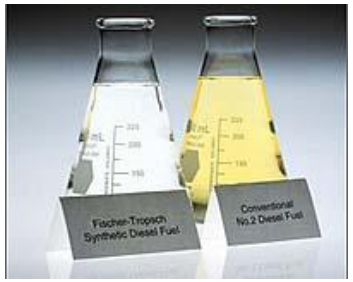
D. Zanardo, G.Forghieri, S. Tieuli, E. Ghedini, F. Menegazzo, A. Di Michele, G. Cruciani, M. Signoretto, Effects of SiO2-based scaffolds in TiO2 photocatalyzed CO2 reduction, Catalysis Today, *in Press*

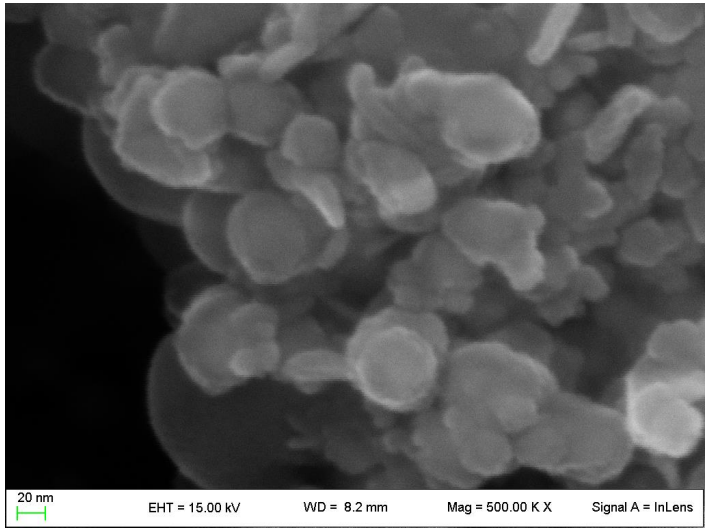
Fischer-Tropsch Process

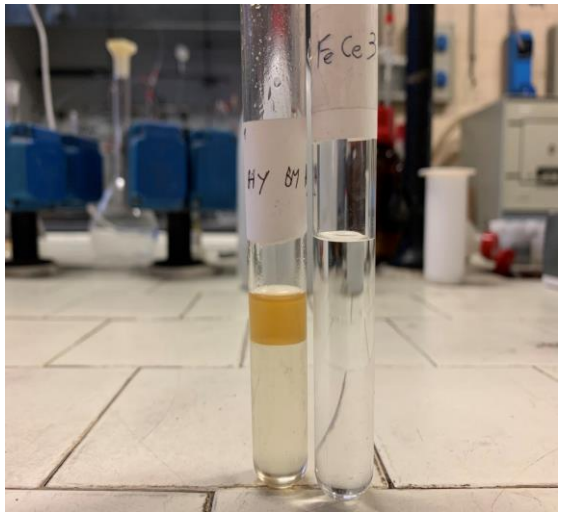


❖La FT è la conversione del cosiddetto gas di sintesi, composto principalmente da monossido di carbonio e idrogeno, in idrocarburi attraverso l'influenza di temperature elevate e pressioni normali o elevate, in presenza di un catalizzatore.

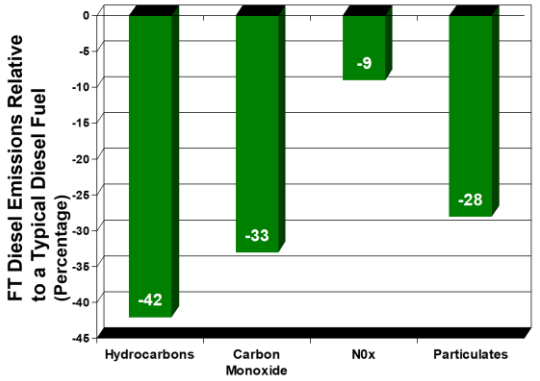
$$CO + 2H_2 \rightarrow -CH_2- + H_2O$$







- **No composti solforati**
- **No aromatici**



Q. Zhang, J. Kang, Y. Wang ChemCatChem 2010, 2, 1030 – 1058

Prof. Michela Signoretto
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Dr. Elena Ghedini

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Prof. Carlo Pirola

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Dr.ssa Cristina Diamantini
Dr. Giacomo Clementi
Dr. Gabriele Perna
Dr.ssa Silvia Caponi (cnr)

Prof. Linda Barelli
Prof. Gianni Bidini
Prof. Paola Sassi
Prof. Morena Nocchetti
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