Kinetics and Material Analysis for Solar Fuel Production via Metal Oxides

Florida Energy Systems Consortium

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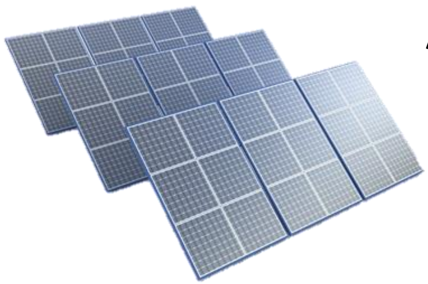
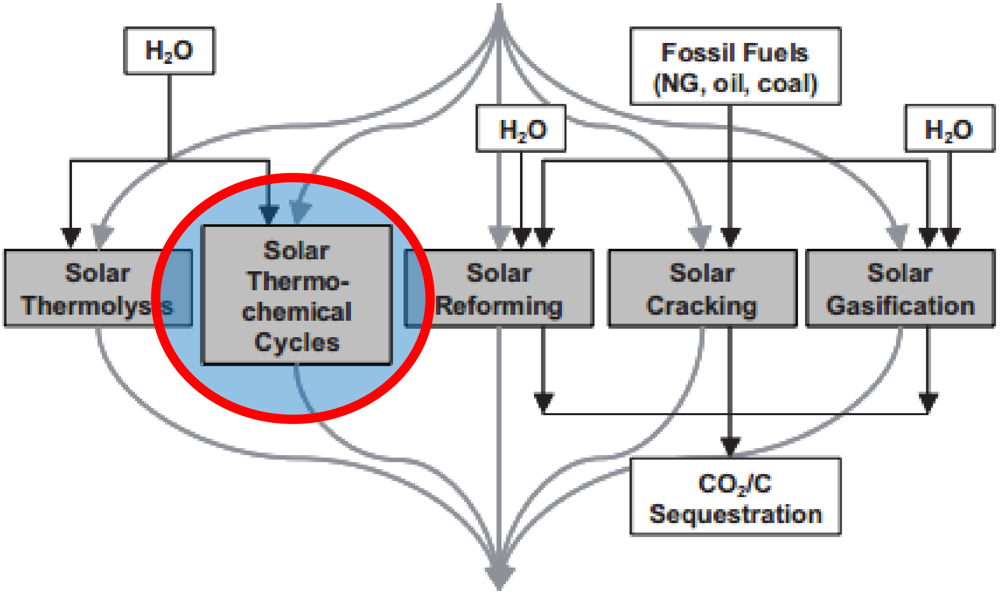
Solar Energy Pathways

Photovoltaic



Photochemical

Thermochemical: Concentrated Solar Power



Solar Fuels

Solar Thermochemical Cycles

- Use inputs of concentrated solar thermal energy, water and/or CO_2 alongside intermediate reactive materials
- Capable of producing chemical fuel in a regenerative process by subjecting intermediate reactive materials to redox reactions

Material	Oxidation Step	Thermal Reduction Step	
Iron	$3FeO + H_2O \rightarrow Fe_3O_4 + H_2$	$Fe_3O_4 \rightarrow 3FeO + \frac{1}{2}O_2$	**Stoichiometric**
Ceria	$\delta H_2O + CeO_{2-\delta} \rightarrow CeO_2 + \delta H_2$	$CeO_2 \rightarrow CeO_{2-\delta} + \frac{\delta}{2}O_2$	**Non-stoichiometric: $0.35 > \delta > 0.01$**

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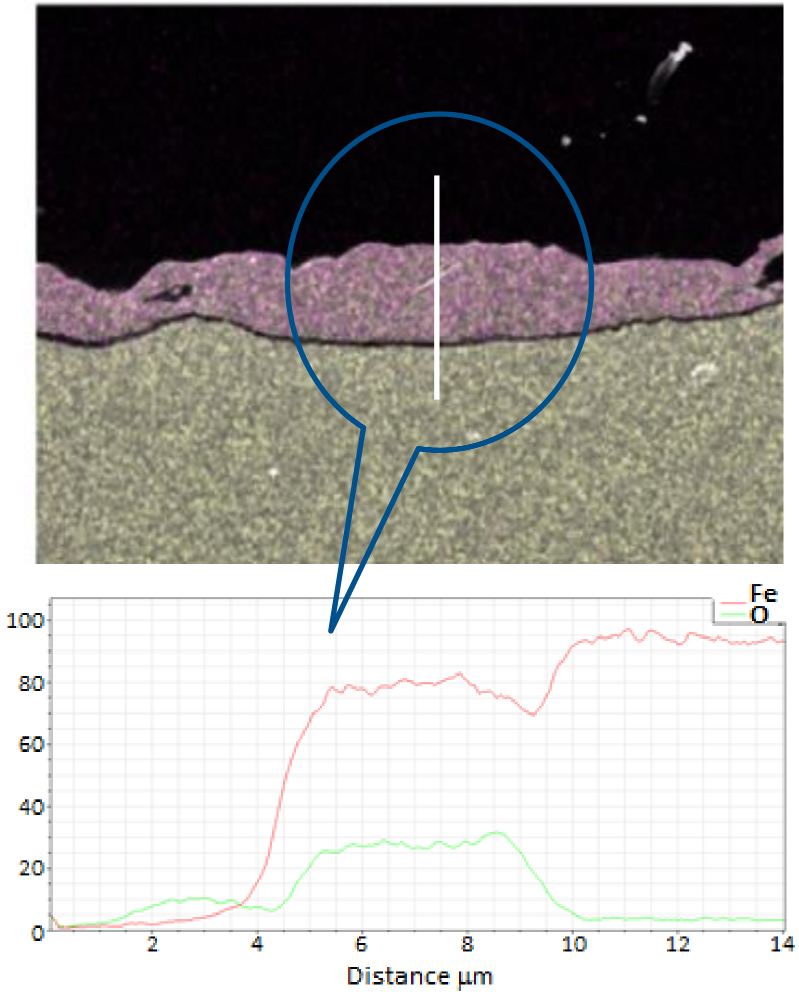
Oxide Layer Analysis – Mechanisms?

- Use SEM and EDS images to visualize the oxide layer
- SEM provides topographical information of the material & EDS provides elemental composition across oxide layer
- Fe/O gradients supports Cabrera-Mott model of oxidation kinetics
- Non-stoichiometric oxygen depletion at outer surface following reduction



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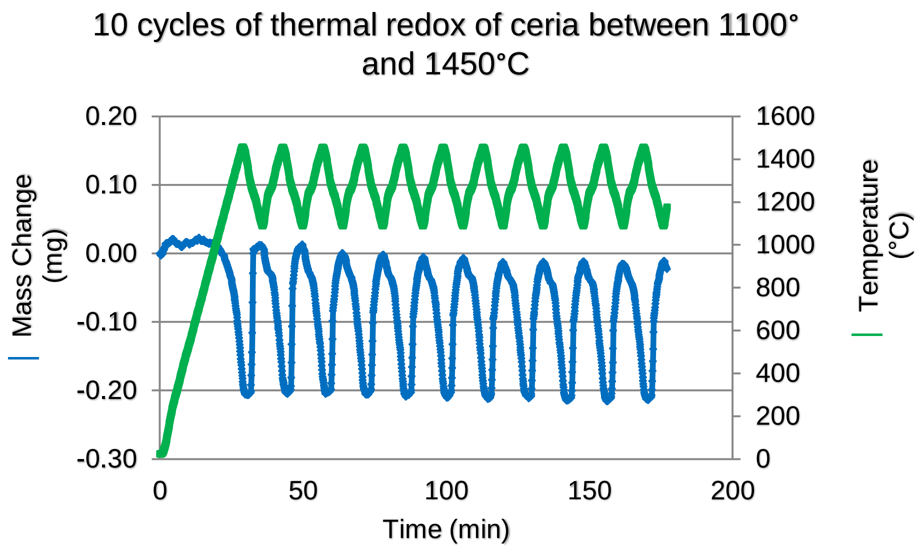
Material Reactivity – Ceria Stability?

- Thermogravimeter (TG) uses a sensitive balance to record mass change of sample in a reactive environment
- Extent of ceria reactivity (δ) can be assessed: Strong *f*(T,P)
- Multiple cycles provide data for repeatability and reactive stability: 2,000 cycles to date



- Future directions: Currently exploring process efficiency on 10 kW pilot reactor using solar simulator at UF Energy Park

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