Novel Materials for *Energy Storage* and *Conversion*

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Societal Context

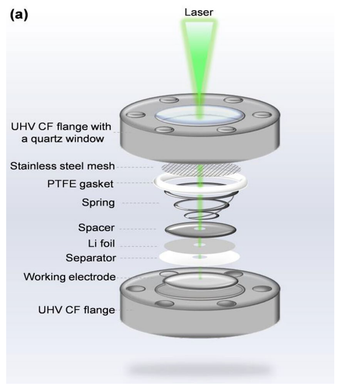
- Electrical Energy Storage & Conversion (EESC) systems are **key** for the development of technologies that are **efficient and sustainable**
- The performance of EESC systems depends on the development of **new materials**/nanostructures with dramatically enhanced ionic/electronic conductivity and catalytic activities
- Advanced EESC systems can enable the deployment of **higher efficiency and greener** methods for chemical conversion and energy storage for applications like **electric vehicles, mobile devices, grid-scale energy storage, and chemical production**

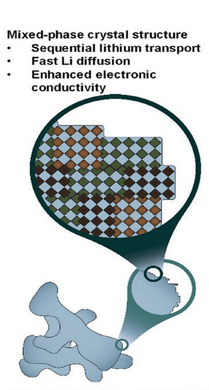
Electrochemical Materials R&D

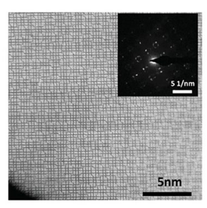
- The discovery of novel materials/nanostructures are at the center of the creation of next-generation energy storage & conversion systems (e.g., **batteries, fuel cells, electrolyzers**) for renewable energy
- The rates and efficiency of many chemical and energy transformation processes are determined by materials (catalysts, electrodes, etc…)

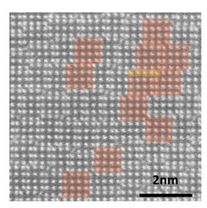
Lithium-ion Batteries

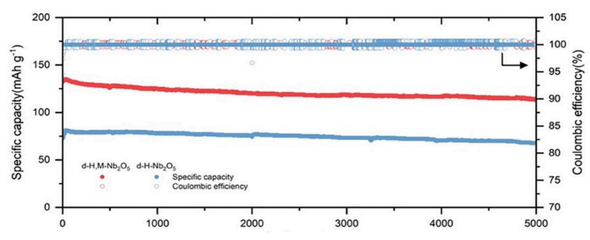
The improvement of lithium-ion batteries requires **development of novel electrode with high capacity and fast charging rate**



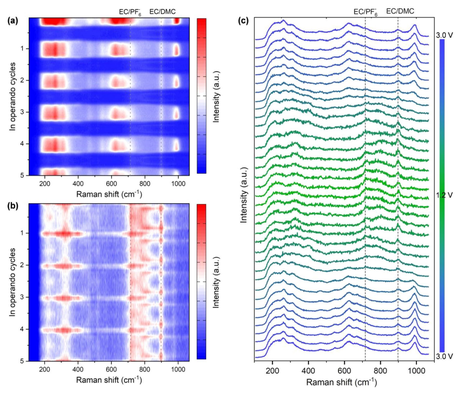








d-H,M-Nb_2O_5 as ultra-fast charging anode for high-power LIBs [2]

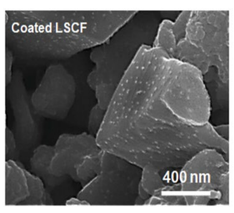


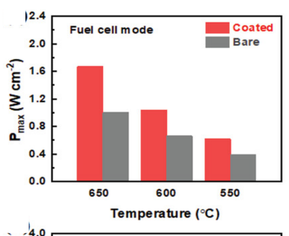
Operando Raman study of (De)lithiation in fast-charging H-Nb_2O_5 [1]

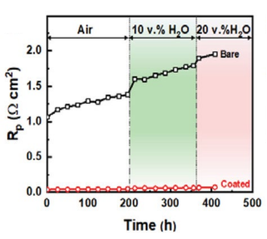
Surface Modification

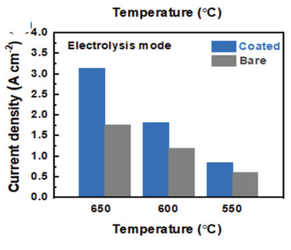
Surface modification enhances the activity and durability of electrode and electrolyte of fuel cells, **enabling low-temperature operation and protection against contamination**

Infiltration



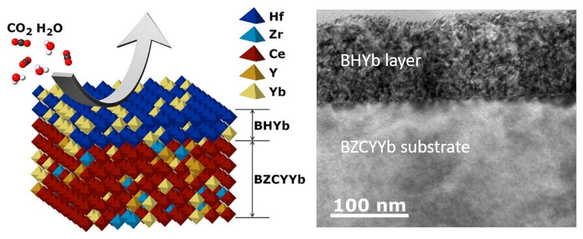


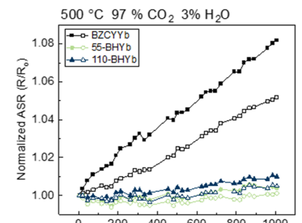




Bifunctional catalyst PBC coated $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) for enhanced ORR/OER activity and durability[3]

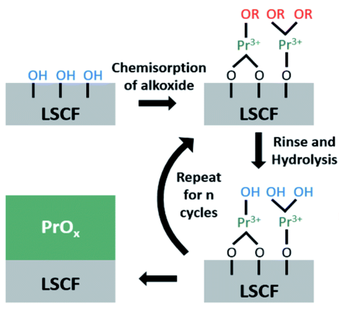
Sputtering

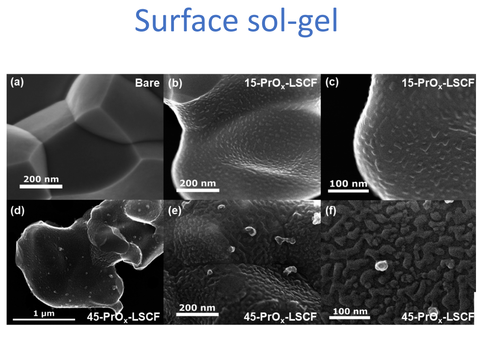


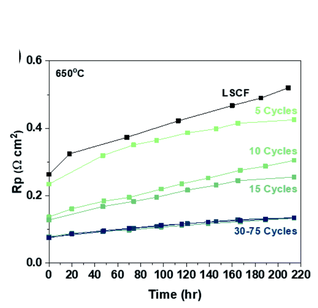


Bi-layer electrolyte with high stability against CO_2[4]

Surface sol-gel



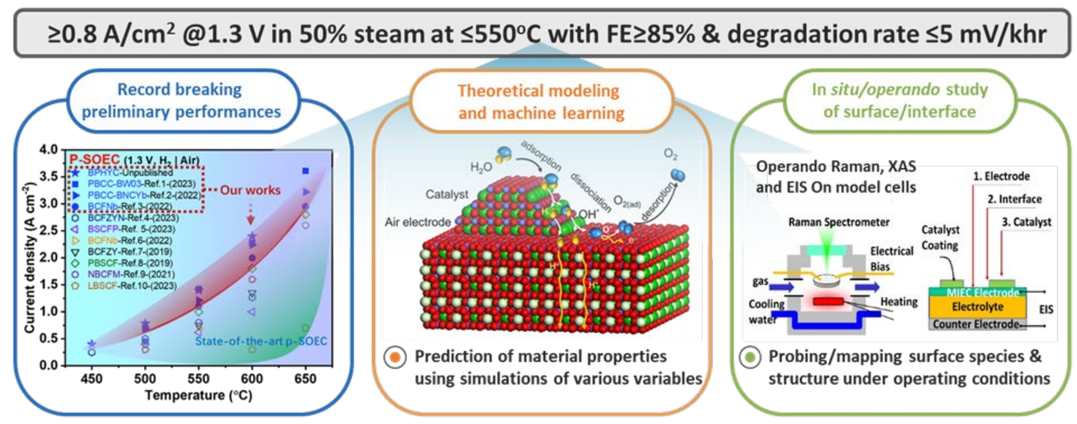


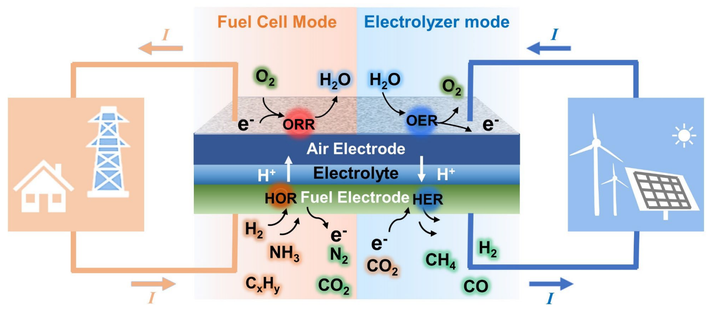


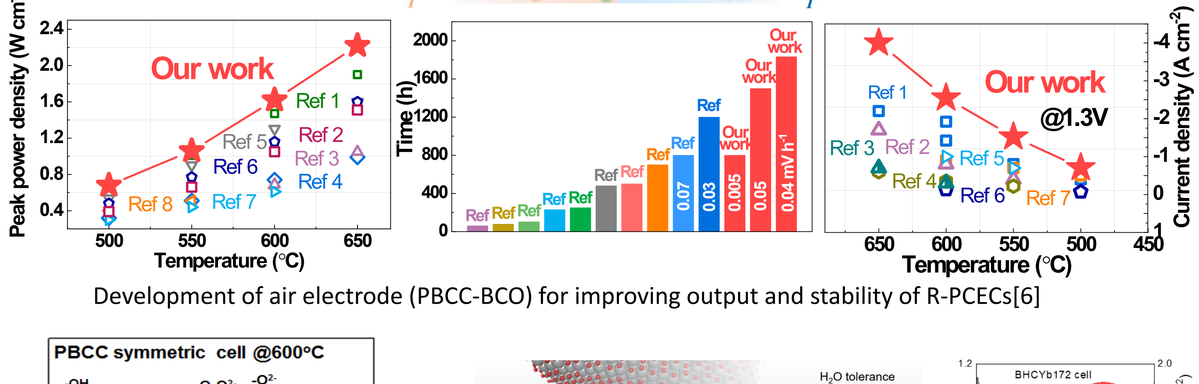
Surface sol-gel coating of PrO_x to LSCF[5]

Reversible Protonic Ceramic Electrochemical Cells

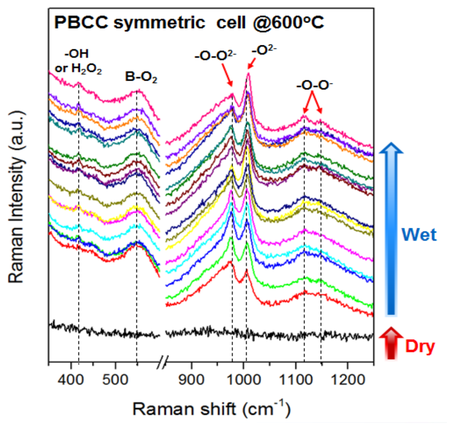
The improvement of R-PCEC technology requires the development of **new electrode and electrolyte materials for enhanced performance and durability**



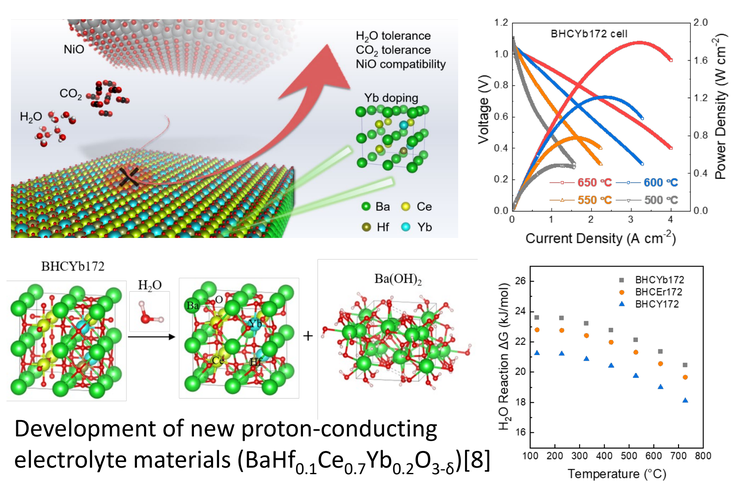




Development of air electrode (PBCC-BCO) for improving output and stability of R-PCECs[6]



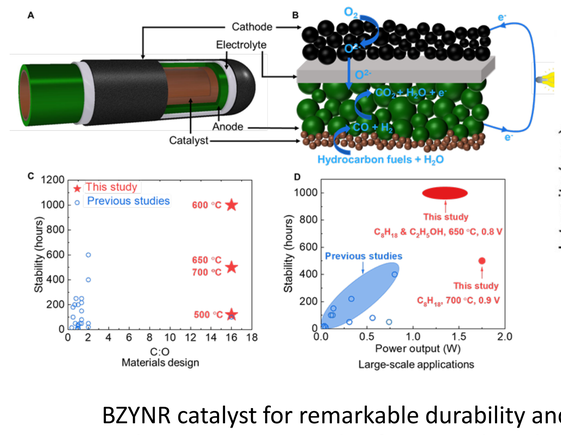
In situ Raman study of ORR on H_2O-induced surface of PBCC cathode[7]

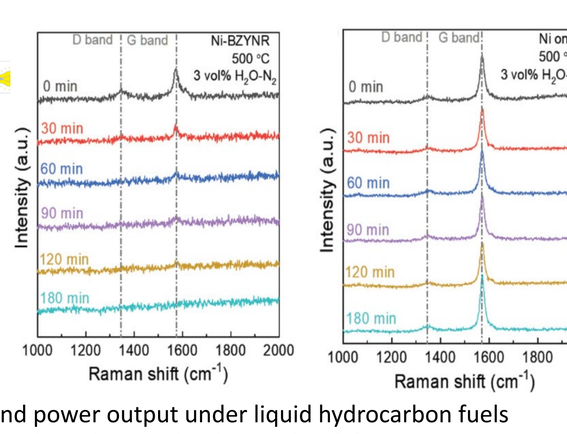


Development of new proton-conducting electrolyte materials ($BaHf_{0.1}Ce_{0.7}Yb_{0.2}O_{3-\delta}$)[8]

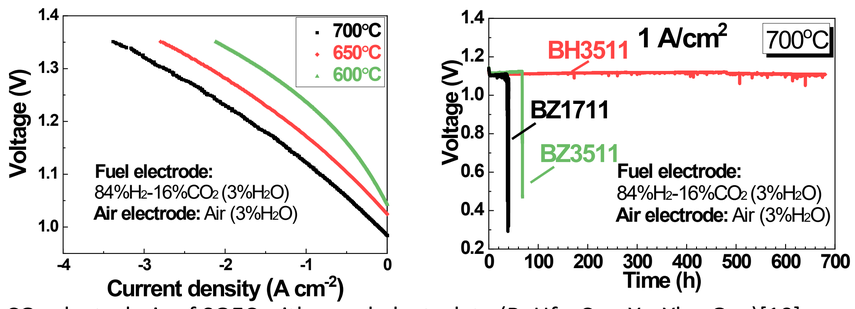
Hydrocarbon-Fueled Fuel Cells and Electrolysis

Development of novel electrolytes and catalysts enables **operation of fuel cells under hydrocarbon fuels with exceptional durability and power output**





BZYNR catalyst for remarkable durability and power output under liquid hydrocarbon fuels and in-situ Raman study of H_2O-mediated carbon cleaning by the catalyst [9]



CO_2 electrolysis of SOEC with novel electrolyte ($BaHf_{0.3}Ce_{0.5}Y_{0.1}Yb_{0.1}O_{3-\delta}$)[10]

References

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