**Engineering of nanomaterials in high temperature solid oxide cells for low carbon energy storage and conversion**

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High temperature solid oxide cell (SOC) technology offers tremendous opportunities in addressing the global climate targets to reach Net-Zero emissions, hence has attracted a great deal of attention in both fundamental research and commercialisation efforts. SOCs are solid-state electrochemical devices, and have the benefits of unparallel high efficiency, low environmental impacts, and wide availability of cheap raw materials, compared to other types of electrochemical devices. On one hand, SOC can work as solid oxide fuel cell (SOFC) to electro-oxidize a wide variety of fuels including H2, CO, CH4 and higher hydrocarbons etc., generating electricity with much lower and concentrated CO2 for capture and utilisation. On the other hand, the same device can reversibly work as solid oxide electrolysis cell (SOEC), splitting H2O, CO2 and/or the mixture to produce green H2, CO and/or syngas, driven by renewable electricity to store the intermittent renewables in the forms of fuels and chemicals. The two-way operations combined with easiness in assembling single cells into stacks for upscaling renders great prosperity in SOC technology.

However, challenges exist due to the high temperature operation, which requires superior thermochemical stability, compatibility with other device components during fabrication and operation, as well as outstanding conductivity and catalytic activity in electrode materials. Nano-structured electrodes has been acknowledged to enlarge the active reaction zone in electrode and provide enhanced catalytic activity, whilst improving materials stability and resistance to impurities. Our research has been focusing on constructing nano-structured SOC electrode through innovative materials design and engineering, structure modification, and materials characterisation including solid-state chemical and electrochemical characterisation. In this talk, I will discuss a few examples of SOC electrode materials, particularly perovskite-type oxide materials that we have been studying, based on nano-construction using different techniques. The materials microstructures, physical properties and electrochemical performance as well as the linkage between them will be explained. Some perspectives of material designing rationale and structural/microstructural engineering will be shared in light of their application in SOC systems.