New materials, architectures and manufacturing processes for Solid Oxide Cells

The objective of the topic is to propose the next generation of cells and stacks for the various SOC related applications, including new materials, architectures and associated manufacturing processes. It should consider several operating modes, SOE and rSOC modes being mandatory and co-SOE or any other operating modes optional.

The potential proposal should focus on the development of new concepts of cells (electrodes, interfaces, architectures) in terms of innovative materials and related production processes for their integration into stacks, targeting the following improvements without compromising the other targets included in the MAWP:

- Improvement of cell/stack long-term stability and reliability while maintaining their performance for SOE, co-SOE or rSOC operation, potentially for pressurized operation or at lower operating temperatures. To this respect particular attention should be given to the development of manufacturing processes able to control microstructural properties of electrodes and interfaces;
- Allowing, thermal and load cycling as required for the aforementioned applications; in particular the possibility of recovery or self-healing options as well as increased resilience strategies should be considered;
- Decreasing the use of high cost and critical raw materials (CRM), promoting environmentally friendly processes: smart use of raw materials, e.g. aqueous solutions rather than organic based solvents, use of non-toxic organic additives, zero or low amount of wastes in the process, recycling and/or based on eco-designed manufacturing processes, reducing the energy intensity of the whole process;
- Selecting at least 10 concepts, materials, and the related processes suitably controlling their microstructure able to cope with future industrial needs (e.g. should be industrially scalable for mass production, at low cost, compatible with the size requested for stacks). The new materials that can be considered in the project should have already proven a performance and stability not lower than 70% of the reference state of the art materials in at least one relevant testing conditions (SOE/rSOC/Co-SOE operation).

The potential project should address:

- Validation of the developments on cells with > 50 cm^2 of active area and at short stack scale (≥ 5 cells) considering a stack design already available;
- Durability improvement, demonstrated with tests above 2,000h for single cells, above 1,000h for short-stacks in conditions representative of the application;
- For the most promising solutions developed in the present project, a long-term durability test at stack level above 5,000h should be performed;
- An environmental assessment of the proposed cell designs as compared to the state-of-the-art cell design. This assessment should be carried out according to the requirements in the FC-HyGuide guidance document (http://www.fc-hyguide.eu/guidance-document.html).

The project should rely mainly on existing test-infrastructure, while additional support in test infrastructure could only cover new operating modes. Investment in new test facilities needs to be justified by additional requirements for specific operating mode, not covered by the conventional equipment. The advanced characterisations and analyses, as well as the modelling activities, if needed, should also be performed between partners having the appropriate background and knowledge in the field.

Modelling activities could be performed to support the understanding of the link between performance, durability and microstructures and guide the improvements proposed. Those activities should be based on previously elaborated models by FCH 2 JU supported projects such as Endurance, Sophia, Eco, Pro-SOFC or other similar work.

It is expected that the technology starts at TRL2 and reaches TRL4 at the end of the project.

The consortium should include at least three cell or stack manufacturers involved in SOE, co-SOE or rSOC developments as well as research institutions and academic groups working in these field(s).

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu, which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B ""Collaboration with JRC – Rolling Plan 2019""), in order to benchmark performance of components and allow for comparison across different projects.

The maximum FCH 2 JU contribution that may be requested is EUR 5 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

A maximum of 1 project may be funded under this topic.

Expected duration: 3 years.

Solid Oxide Cells (SOC) have historically been developed for the conversion of gas into power, known as Solid Oxide Fuel Cell (SOFC). In the context of the energy transition with more intermittent renewable energy sources and efforts to decarbonise entire industry sectors such as steel and the chemical industry, Solid Oxide Cells see potential applications in a much wider scope. The same base set of materials can cover Solid Oxide Electrolysers (SOE) for hydrogen production or for the production of syngas (co-electrolysis of steam and CO2, co-SOE), or for renewable energies storage (reversible electrolysis/fuel cell mode, rSOC), and further operating modes are envisioned in the context of sector coupling in the energy field.

Today's set of materials has been optimised for the historically longest-standing application, the SOFC. The additional use modes challenge the current material and microstructural sets, opening the door for new materials and processes not commonly applied in the SOC industry. The challenge is to address a large scope of materials, appropriate microstructures and manufacturing processes for SOC and to integrate them into stacks to reach an optimum (trade-off) in terms of performance, durability, reliability and cost.

The project should provide the industry with a choice of materials and the related manufacturing processes to be implemented into the next generation of SOC cells and stacks, in order to improve the performance, durability and cost of cells and stacks and to make them ready to be scaled up to industrial production. The main impact would be then that industrial partners will have identified and validated most promising next generation materials, processes and components for their products.

In order to achieve this, the project should achieve the following performances:

- Current densities above 0.75 A/cm^2 in electrolysis mode, for the three usages (SOE, co-SOE, rSOC modes);
- With a corresponding ASR value of 0.5 $Ohm.cm^2$ or below 750°C in electrolysis mode, for the three usages (SOE, co-SOE, rSOC modes);
- Degradation rate below (voltage increase for a given current density) 1%/1,000h in SOE, co-SOE or rSOC mode, for a level of performance similar as the one achieved with state-of-the-art cells, measured for durations above 2000h at single cell level, and above 1000h in stack environment;
- Stability upon SOFC/SOE cycling for rSOC mode: similar as compared to individual SOFC or SOE modes, that is to say degradation rate upon SOFC/SOE cycling of 1%/1,000h or below in each mode;

- Stability upon load cycling: similar as compared to steady state operation, that is to say degradation rate upon load cycling of 1%/1,000h or below;
- Stability upon thermal cycling: 50 cycles performed in representative stack environment with less than 0.2 mV lost per cycle, in the operating mode selected;
- Cell manufacturing cost acceptable as compared to standard cells considering the improvements achieved;
- Reduction by at least 25% of use of toxic organics or materials as compared to reference processes;
- For cells developments: cells with > 50cm2 of active area and validated at the short-stack scale (≥ 5 cells) in industrial stack design environment.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

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