Platform 3 – Nuclear & Isotope Science

Development of new catalytic materials and systems for low-carbon energy

The SSIF-funded Materials for a Low-Carbon Future (MLCF) programme develops the underpinning material science to drive the development of next generation energy technology in New Zealand and globally. This programme is heavily weighted towards horizon 3 research (generating new ideas) and contributes to the strategic intent of the platform by ultimately delivering environmental and economic benefits for New Zealand. At the heart of the programme is an ion beam modification and characterisation capability that enables rapid prototyping and assessment of new materials and material systems.

Developing new catalytic materials is a core workstream of the programme. Catalytic materials can increase the rate of reactions and reduce the temperature, pressure and energy requirements of chemical reactions for chemical synthesis and energy transformation. This ultimately reduces the cost of energy and products. Some of the best catalytic materials are, however, rare and expensive elements and so a major aim of this research is to reduce the quantities of these elements or replace them with common, low-cost elements.

In 2019, in response to the resurgence of interest in developing a hydrogen economy in New Zealand and globally, the MLCF programme prioritised horizon 3 catalytic research for hydrogen production technologies. This work focussed on fundamental surface properties of the hydrogen evolution catalyst, which are a known major bottleneck in hydrogen electrolyser efficiency. We did this in collaboration with researchers in the United States (Berkeley, California) and Germany (Würzburg University). Work was performed at the Lawrence Berkeley National Laboratory (a U.S. Department of Energy facility), using one of two facilities in the world which can provide a direct visualisation of how particles participate in the surface catalytic reaction. This resulted in a significant publication lead authored by Vedran Jovic titled "Momentum for Catalysis: How Surface Reactions Shape the RuO_2 Flat Surface State". This was published in the American Chemical Society journal *Catalysis* (impact factor 12.5), with one reviewer stating that this research challenges long-standing theories in the field of catalysis.

The major impact of this work has been the development and funding of two new large, GNS-led hydrogen research programmes with greater emphasis on horizon 2 research (developing emerging ideas): from 2020, the Endeavour-funded programme Powering NZ's Green-Hydrogen Economy: Next-generation Electrocatalytic Systems for Energy Production and Storage ($8.45M over five years); and from 2021, the SSIF-funded Aotearoa: Green Hydrogen Technology programme ($9.2M over seven years) under the Advanced Energy Technology platform, in collaboration with a confidential industry partner. Overall, an initial SSIF investment of $0.4M in hydrogen research in MLCF has grown into more than $20M of SSIF- and Endeavour-funded hydrogen research at GNS Science and its partners. Importantly, it has also created a centre for hydrogen research that has brought together key research and industry stakeholders and which is underpinning New Zealand's progress towards a hydrogen economy. The established stakeholder group includes Callaghan Innovation, MBIE, MacDiarmid Institute, Meridian Energy, Energy Estates, Contact Energy, Hot Lime Labs, First Gas, Hiringa Energy, New Zealand Hydrogen Council, Channel Infrastructure (formerly Refining NZ), Ballance Agri-Nutrients, Halcyon Power, Gallagher Fuel Systems, Chiyoda Corporation, Hydrogenics, Z Energy, Fabrum and BP New Zealand. Leveraging both MLCF- and Endeavour-funded research, a new spin-off company, b.spkl, has been created to progress early-stage commercialisation of GNS' new method and prototype for manufacturing the catalyst coated membranes (CCMs) used in green hydrogen production. This breakthrough technology is expected to significantly reduce both the cost of producing CCMs and the amount of critical metals required (e.g., platinum).