

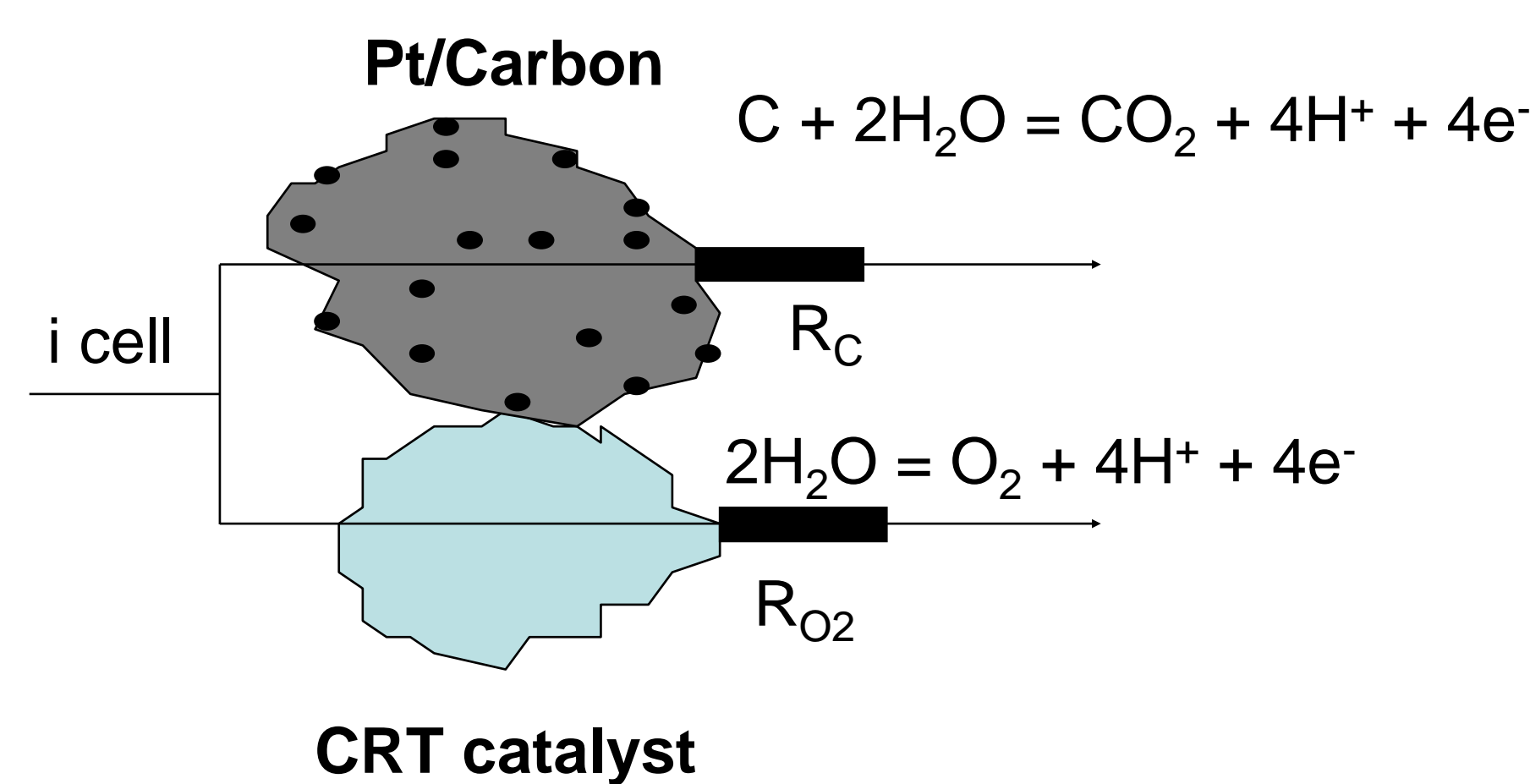
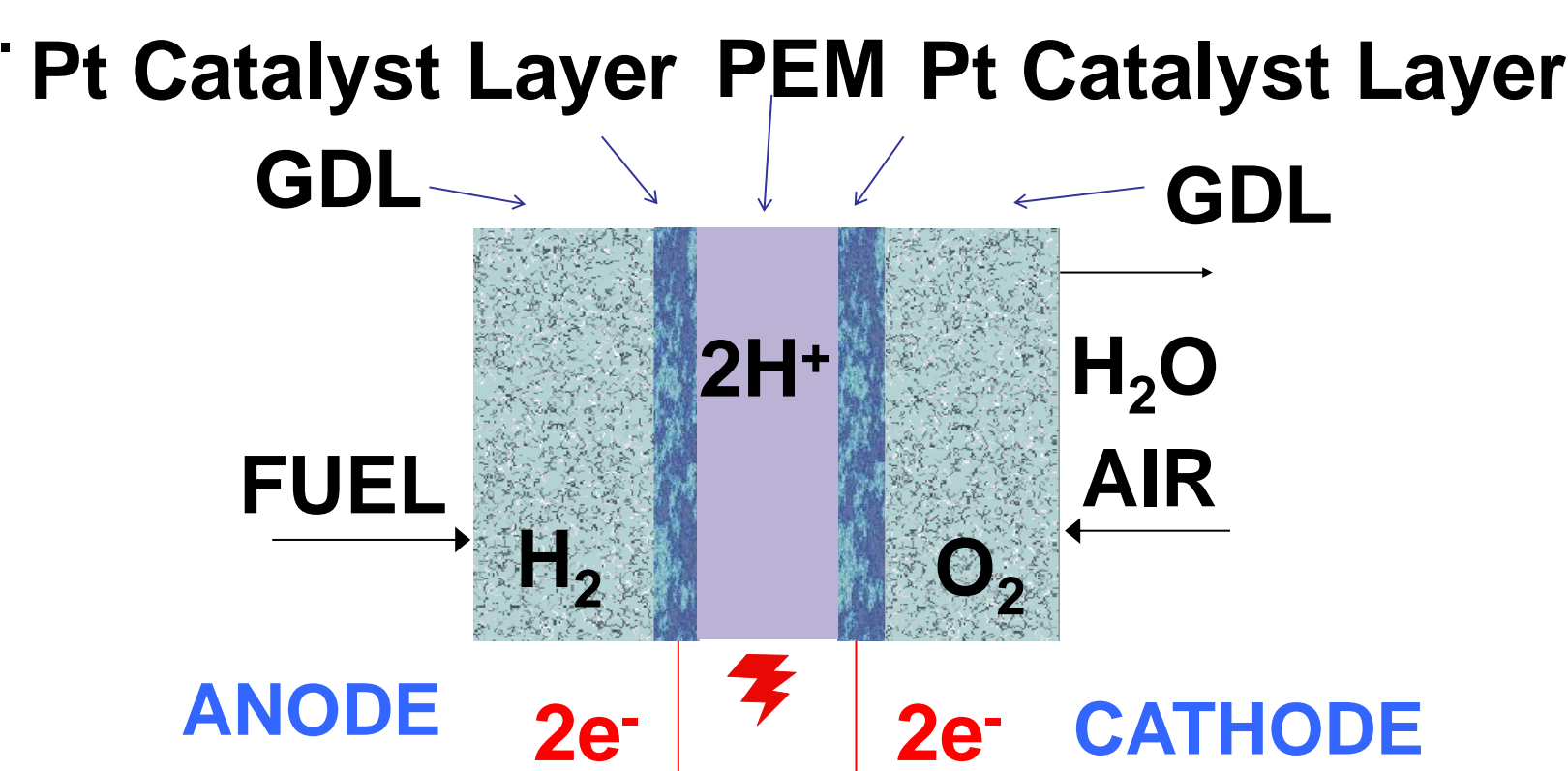
Non-Carbon Supports for Fuel Cell and Electrolyser Applications

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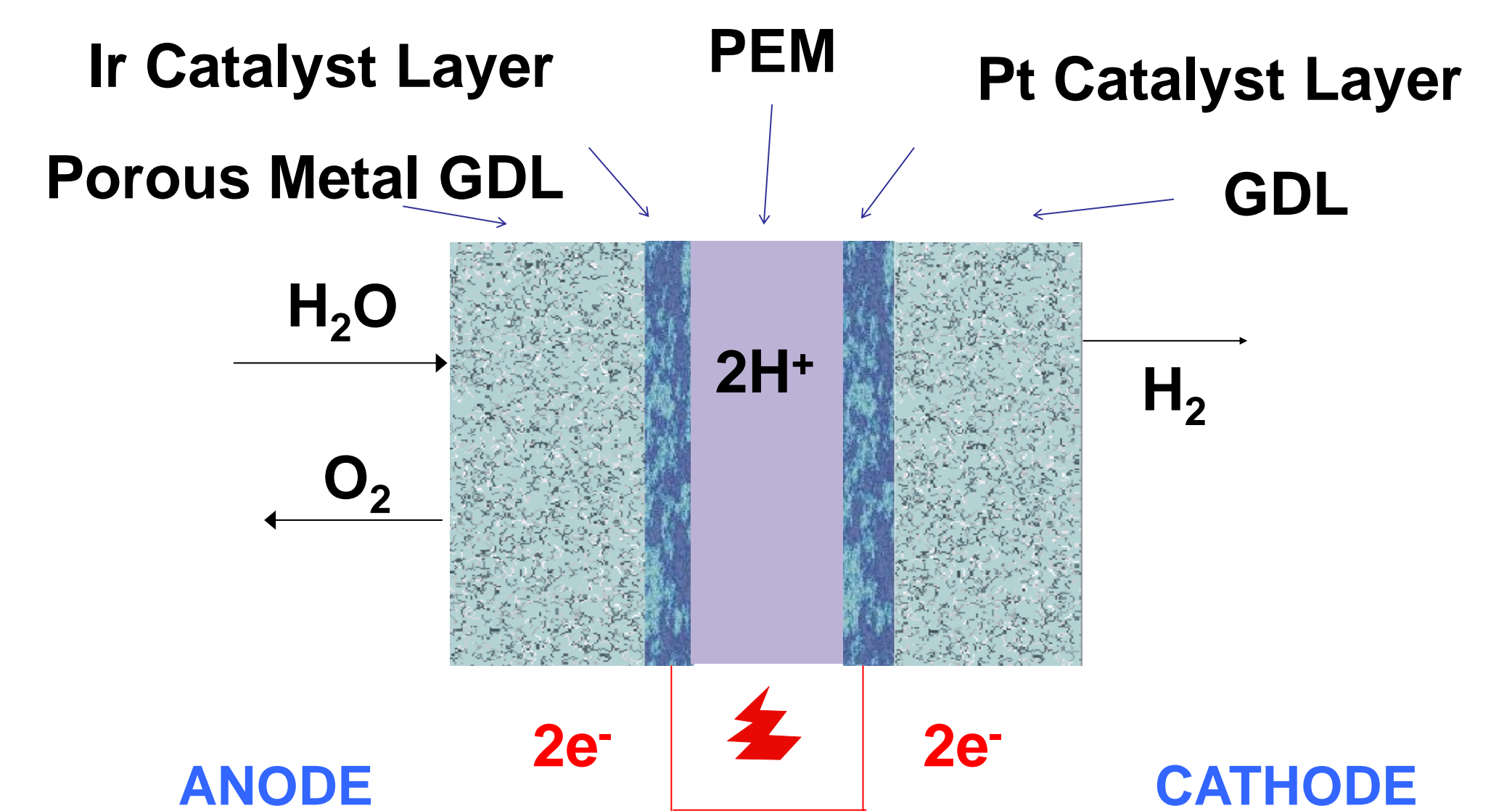
Introduction

In PEM fuel cells there has been a move from unsupported Pt black to carbon supported PGM nanoparticles. Carbon black provides high surface areas to stabilise the catalyst particles and porosity to the electrode layers while being intrinsically electrically conductive and relatively stable at potentials <1.2V vs RHE.



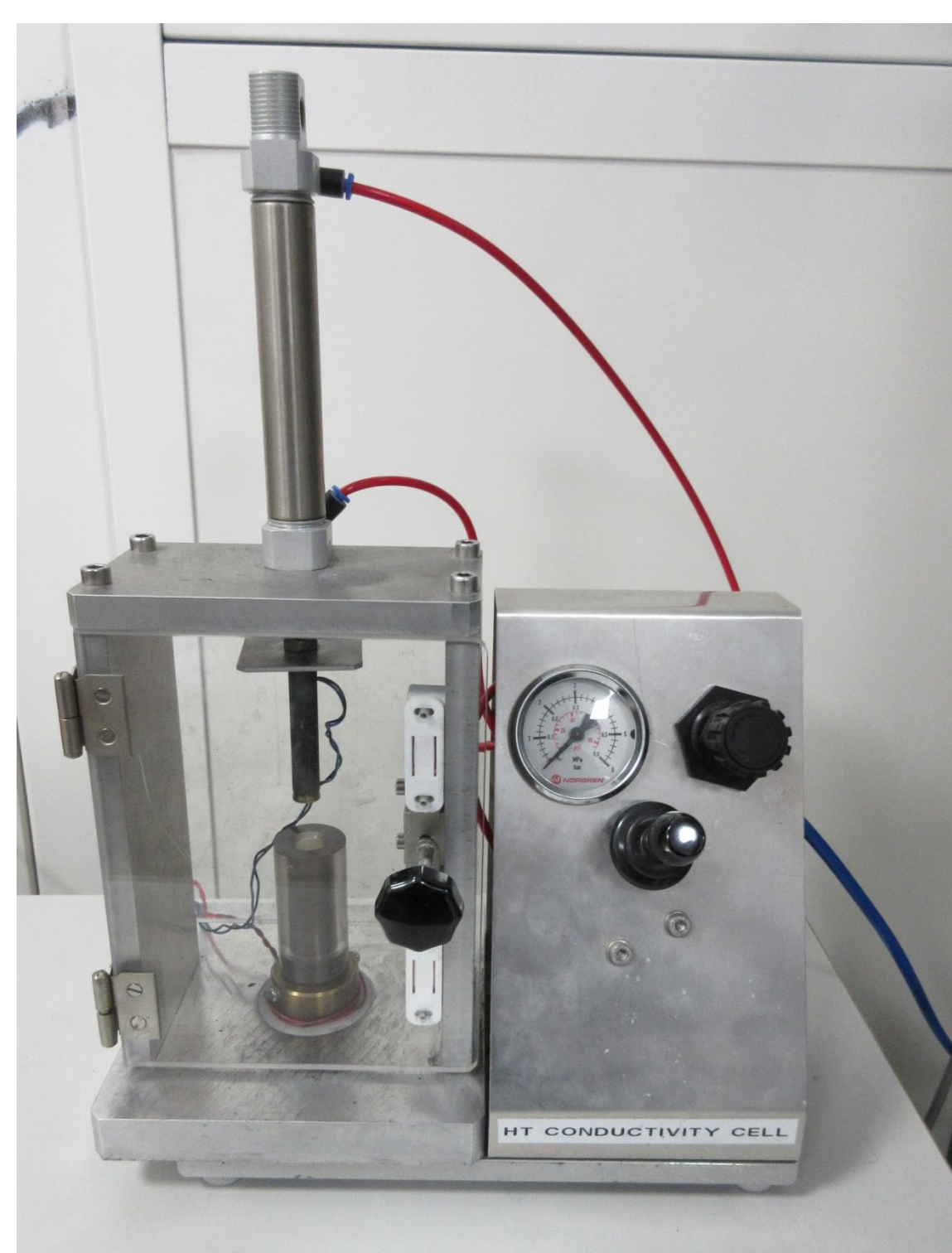
During fuel starvation and start-stop events high potentials can occur leading to rapid support oxidation and loss as CO₂. This can be mitigated by adding a cell reversal tolerant catalyst able to catalyse oxygen evolution from water to provide an alternate oxidation reaction to CO₂ formation.

For PEM electrolyser anodes, high potentials >1.6V vs RHE are used in standard operation and thus highly corrosion resistant supports are needed.

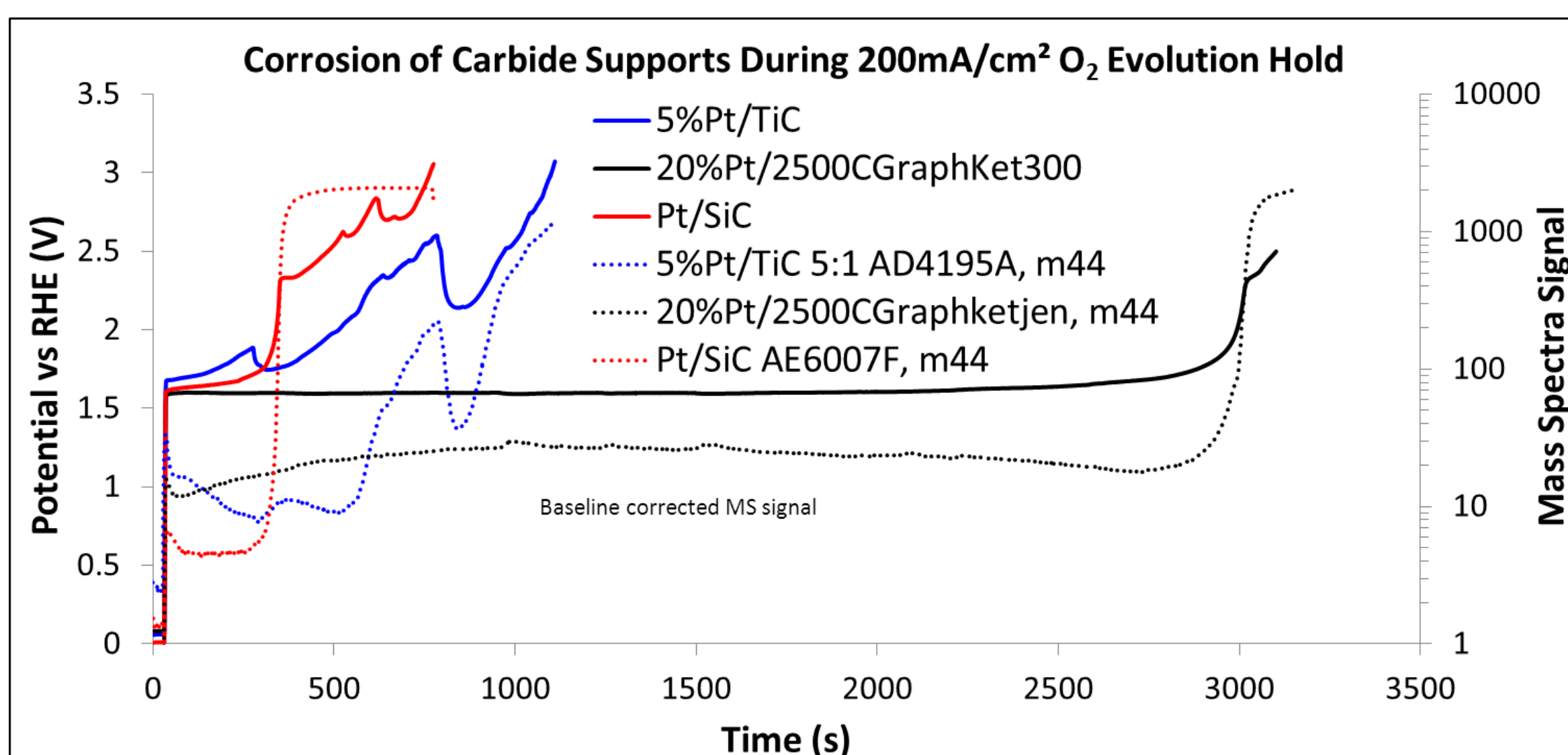


Conductivity Measurements

Powder samples are added to a cylinder and compressed, using a piston, between two Au plated electrodes (1 cm² area, one on the piston and one at the bottom of the cylinder) at 2 bar pressure. The thickness of the resulting pellets was measured and the conductivity could be derived from the resistivity measured from the slope of change in voltage with applied current using an Autolab potentiostat.



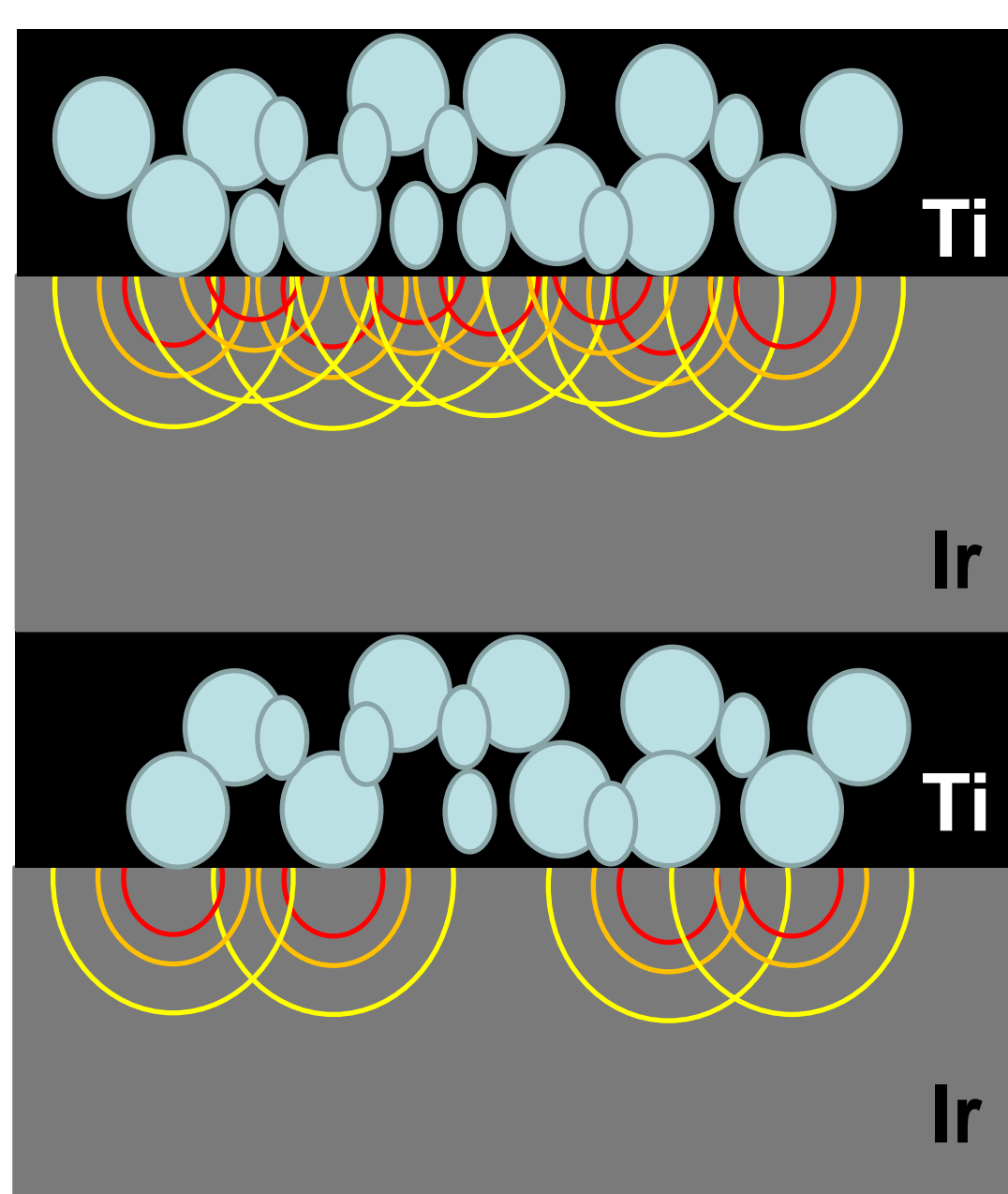
Carbides



Carbide materials can have high surface area and conductivity but corrosion testing under simulated starvation conditions gives rapid CO₂ evolution and loss of oxygen evolution activity in layer.

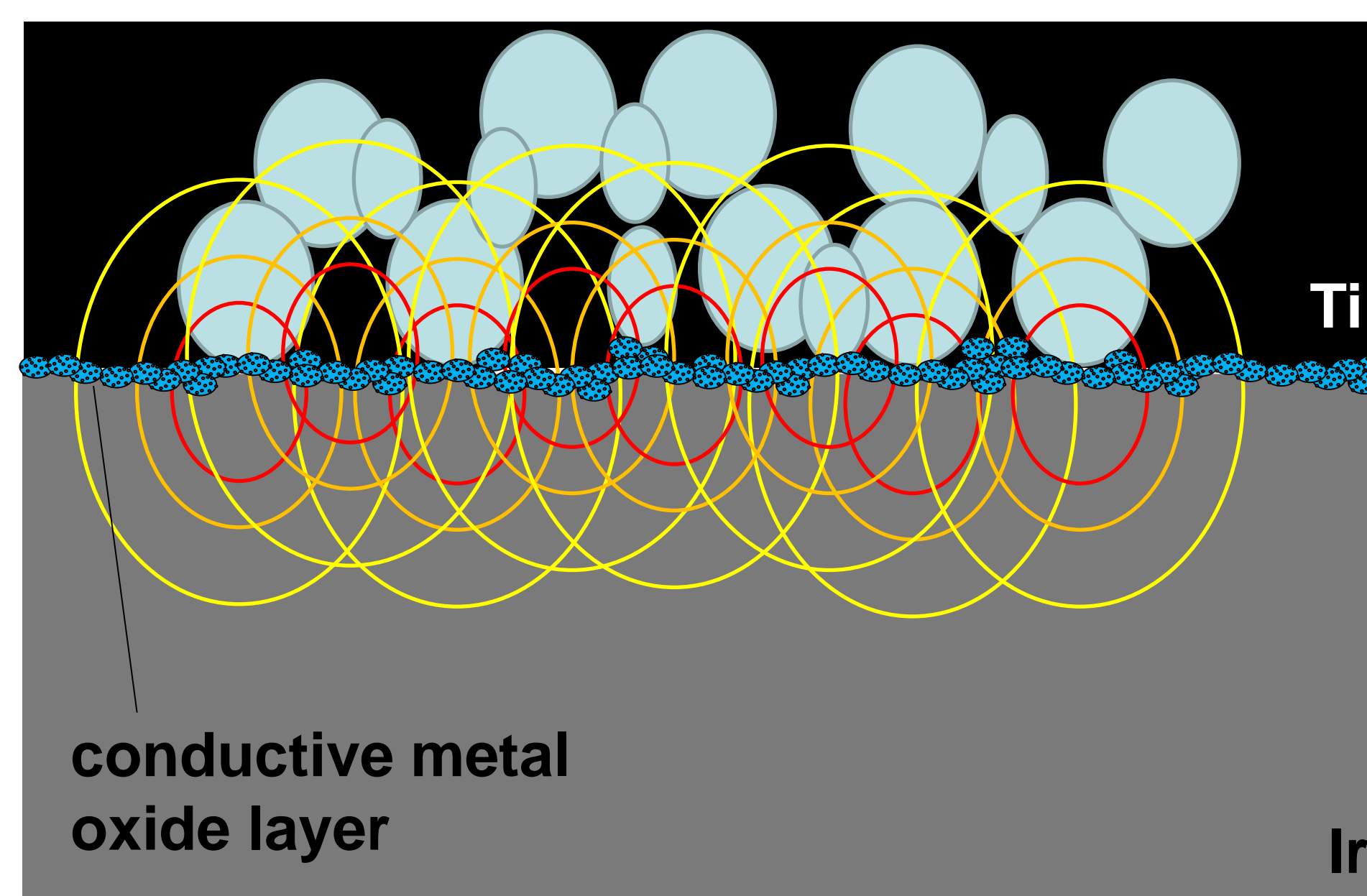
Non-conductive supports can be contiguously coated with PGM to form conductive layers but still lose this conductivity with support corrosion

Effect of Conductive Oxide Layer on Ir black contact with Ti sinter



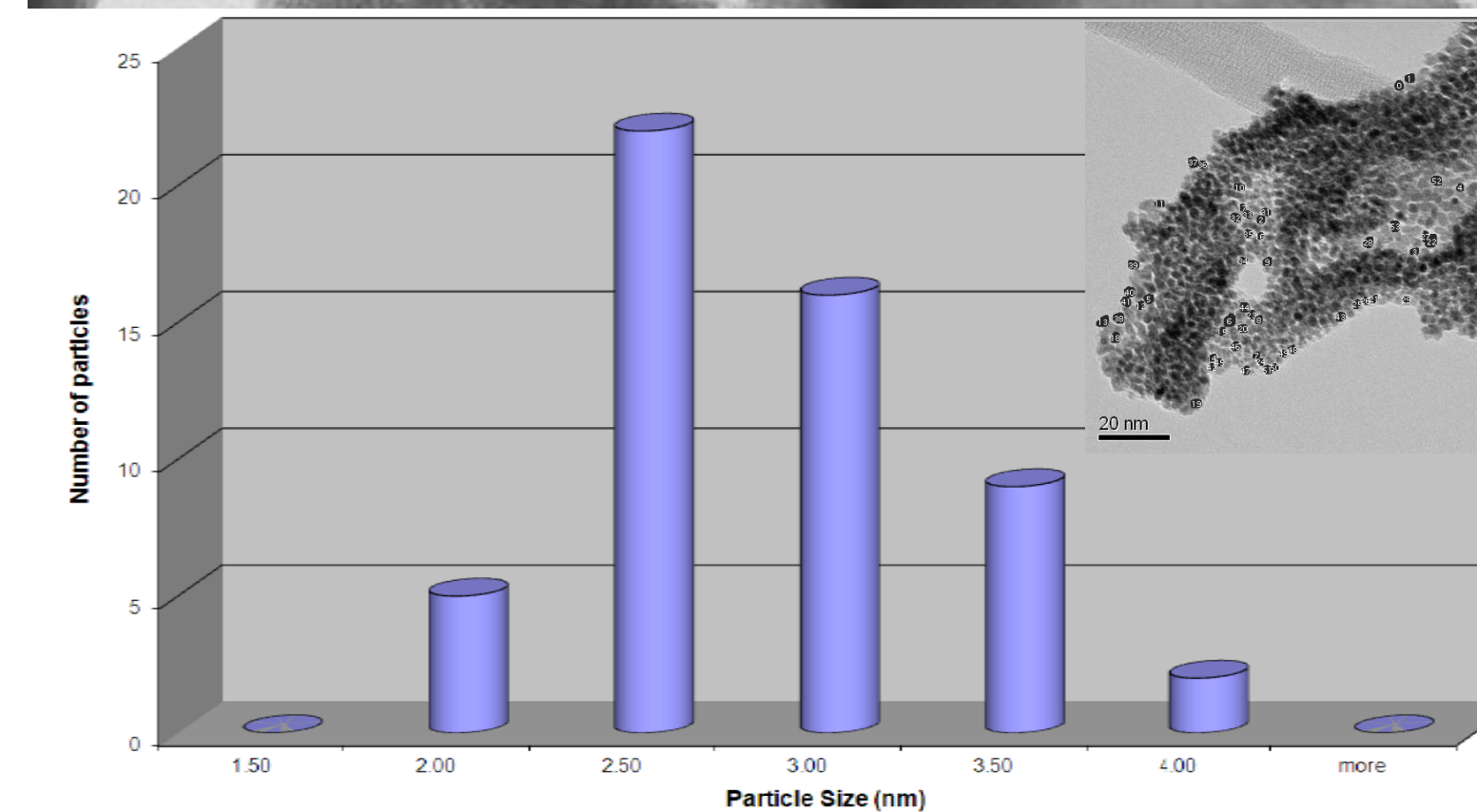
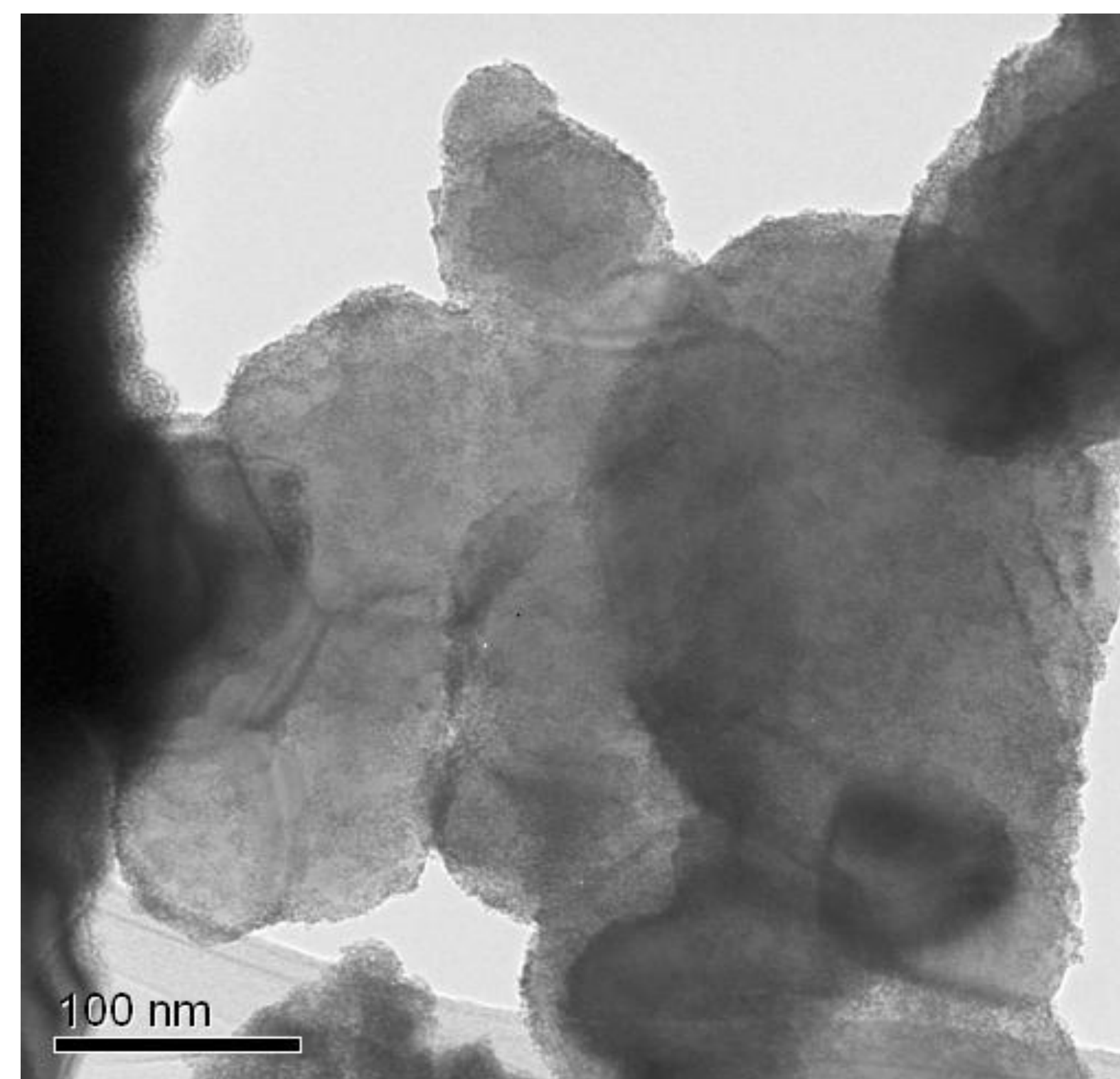
Difficult balance of Ir black particle size and porosity vs contact with Ti sinter required to optimise catalyst utilisation without mass-transport limitations

Thin or low conductivity layers can lead to large areas of inactive catalyst.

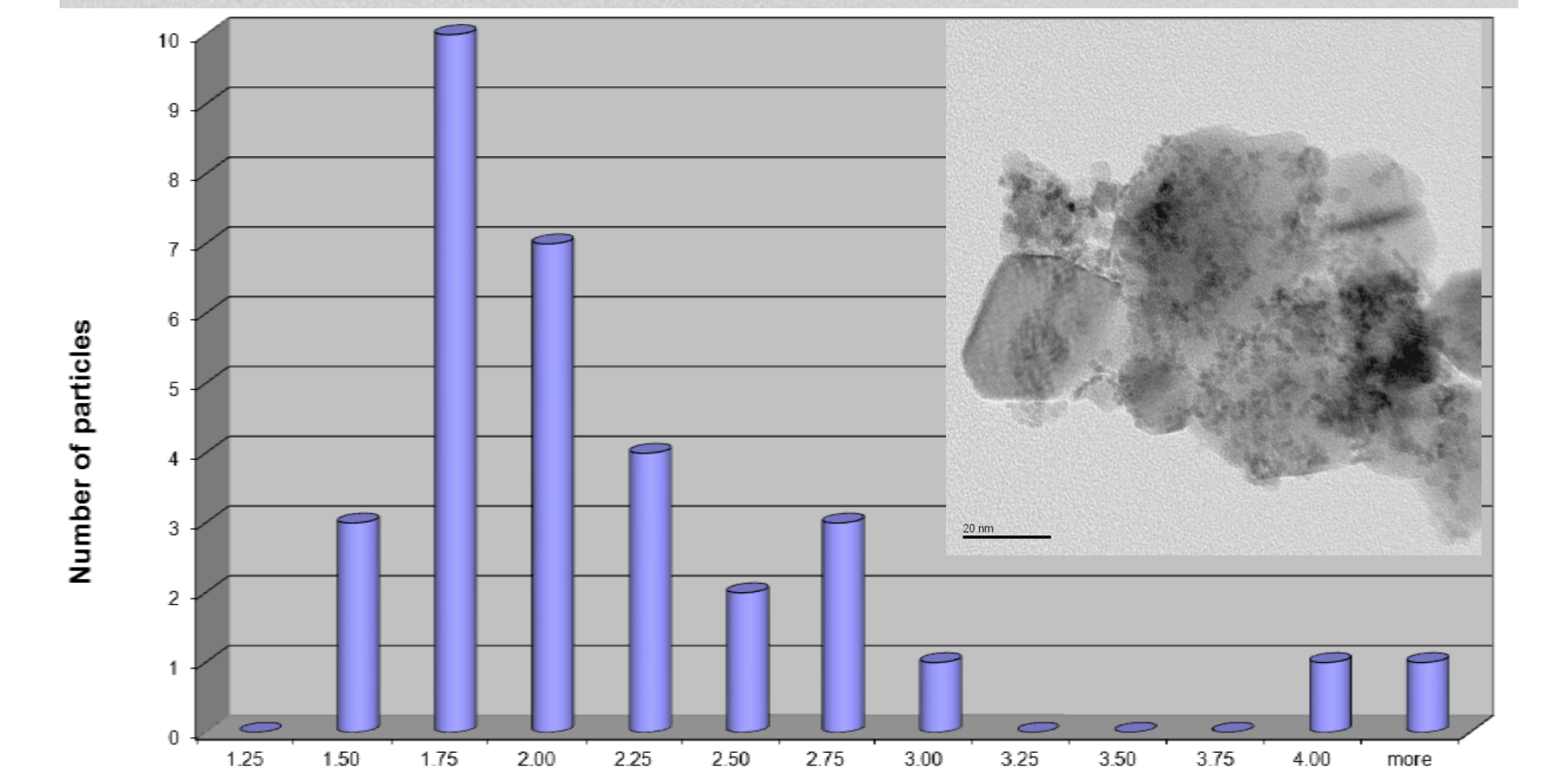
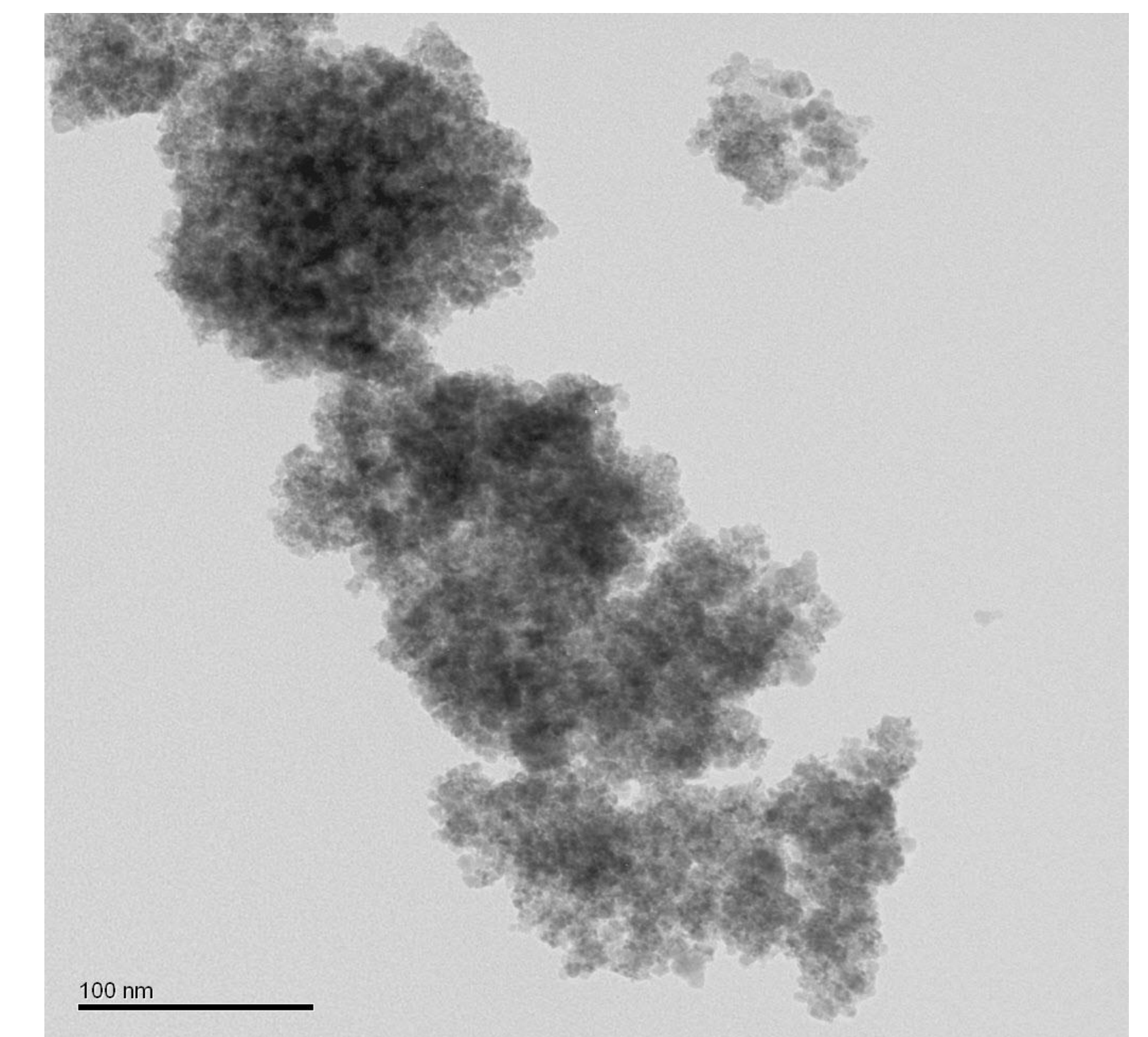


The use of 100 nm scale conductive metal oxides could act as a 'bridge' to allow better electrical contact between the 100 μm scale Ti sinter and few nm Ir black catalyst crystallites ensuring full utilisation of precious metal

Conductive Oxides Nb/Ti and Sb/Sn



Light field TEM image of Ir decorated mixed Nb/Ti oxide



Light field TEM image of Ir decorated mixed Sb/Sn oxide

As fuel cell supports catalysed with Pt show good activity in ex situ (RDE) testing but contribute significant resistance losses in large scale testing¹

Ir can be deposited with small narrow particle size distributions by simple, scalable methods demonstrating good interaction. Supported Ir nanoparticles can again show improved performance in RDE testing but significant layer losses in electrolyser layers.

Stability of electrical conductivity and porosity important; high conductivities achieved at relatively low surface areas

Sn oxides susceptible to reduction but thought to be stable to oxidation; Nb doped Ti oxides reported to be stable under oxygen evolution conditions²

Conclusions

PEM electrolyser systems requires all anode layer components to be oxidatively stable, electrically conductive and porous

Carbides are found to be easily oxidised to CO₂ and metal oxides at high potentials.

Conductive oxides can be formed with particles sizes in the 100 nm range and catalysed with Ir nanoparticles.

Un-catalysed, stable, conductive oxides could be useful as 'bridge layers' to ensure conductive contact between Ir catalyst and Ti GDL

Further stability testing under electrolysis conditions needed