EFFECT OF MANUFACTURING METHODS ON THE CORROSION RESISTANCE OF STAINLESS STEEL BIPOLAR PLATES

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ABSTRACT
Hydrogen fuel cell electric vehicles are one of the key solution to decarbonize the transport sector. Especially for larger transport segments such as heavy duty vehicles, construction equipment, rail and aviation, electrification via fuel cells can be more time, space and weight efficient than battery electric vehicles. In a recent study by Svensson et al. it was found that fuel cell powered airplanes can cover up to 97% of the Nordic travel distances[1]. However, there is still potential to minimize the space and weight of the fuel cell. The proton exchange membrane fuel cell (PEMFC) is the most used fuel cell today for commercial application within the mobility sector. One of the components in focus is the bipolar plate, which ensures separation and distribution of the reactant gases as well as the cooling liquid, electrical conductivity through the stack and mechanical stability[2]. In this work, the effect of manufacturing methods on the corrosion resistance of bipolar plates are the focus.

For transport applications, metallic bipolar plates are the material of choice due to the compactness[3], with stainless steels such as AISI 304 and 316L as the most researched alloys. Although both alloys are of stainless steel grades with high corrosion resistance, the interfacial contact resistance (ICR) becomes too high due to the thick, passive oxide film, hence protective, conductive coatings are needed. Currently, carbide, nitride and carbon based coatings by physical vapour deposition are the most commonly used. These are brittle and require vacuum during deposition. Still, there are commercially available solutions for precoated stainless steel. The effect of hydroforming as well as laser cutting of the precoated stainless steel has been studied in the current work and tested both in electrochemical cells and in a PEMFC. The forming tool has not been designed especially for pre-coated materials, hence defects due to the deformation did occur. Defects were analysed both in pristine and aged samples (Fig.1). It was found that in addition to the type of defect, the location of the defect on the plate is a determining factor for whether or not corrosion will occur, and to which degree.

Another option to reduce the ICR of the bipolar plate, but avoid PVD coatings, is to apply screen printing on the land area of the bipolar plates exclusively[4]. In this case, to lower the ICR between the two half plates of the bipolar plate, laser welds may be placed inside the active area. To assess the corrosion resistance of a laser weld in a stainless steel 304 without coating. Extensive microstructural and chemical analysis by electron back scatter diffraction and x-ray photoelectron

spectroscopy, respectively, gives insight into the chemical stability of the weld compared bulk material.

Based on the results from the corrosion analysis of formed, welded and cut plates in simulated and single cell PEMFC conditions, recommendations for design principles for bipolar plate manufacturing to ensure low ICR and high corrosion resistance, while enabling the use of time and cost-efficient manufacturing methods.

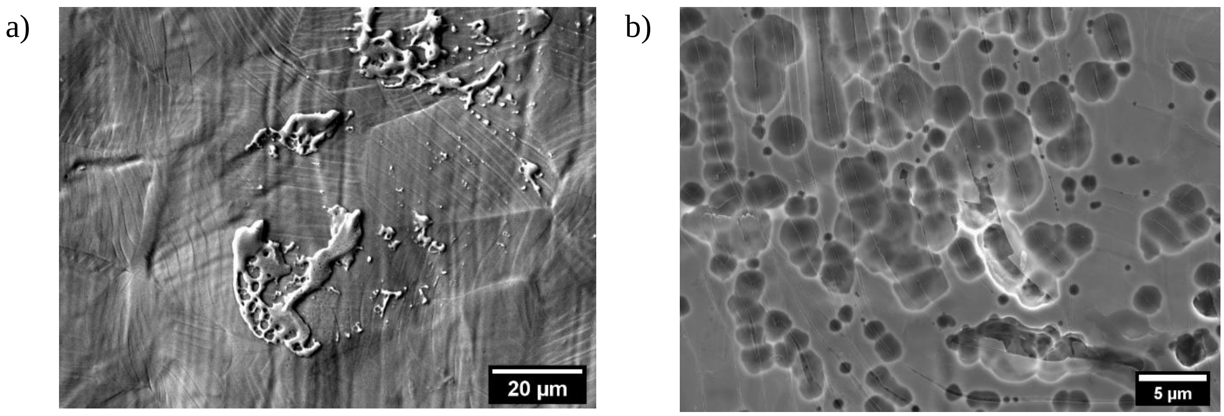

Figure 1: SEM micrographs of a precoated stainless steel showing (a) metal oxide droplets from laser welding and (b) corrosion attacks due to cracks in the coating.

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