Dealloying and Annealing Optimization of High Mass Activity Pt-Ni/NSTF ORR Cathodes for PEMFCs

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PEM fuel cell systems for automotive traction applications have stringent requirements of cost, durability, efficiency, power density, and operational robustness. While significant progress towards commercial viability continues, the membrane electrode assembly (MEA) cathode electrocatalyst is likely still insufficiently active and durable, requiring high precious metal loadings to achieve performance and durability targets (but not cost).

Membrane electrode assemblies (MEAs) utilizing the ultra-thin (<1μm) 3M nanostructured thin film catalyst (NSTFC) technology have several demonstrated advantages compared to MEAs comprising conventional, relatively thick (~10μm) carbon-supported catalyst, such as increased durability towards start-stop(1) and voltage cycling(2), higher specific activity(3), and high specific rated power (3). We have previously reported (4) a Pt-Ni alloy NSTF catalyst, which as-made demonstrated ORR mass activities ranging from 0.2 to 0.4A/mg, depending upon fabrication process parameters. Mass activities exceeding 0.6A/mg were obtained by application of a 3M annealing process, which significantly exceed ed the current U.S. Department of Energy (DOE) target of 0.4A/mg, depending upon fabrication process parameters. When integrated with optimized NSTF anode catalyst and flow fields, these improved Pt-Ni/NSTF catalysts have demonstrated MEA inverse specific power densities ranging from 0.16-0.13g/kW at 0.67V (150-250kPa, respectively), approaching the DOE 2017 target of 0.125g/kW (150-250kPa, respectively), with cathode PGM content which was too low (<0.1mg/cm2) to provide the high absolute activity and MEA performance required (5).

Here, we report progress on these two issues. Recently-developed proprietary ex-situ dealloying treatments have resulted in significant improvements in processing time (minutes or less), recent advances in annealing process development have allowed demonstration of mass activities exceeding 0.48A/mg (Fig.1) with cathode PGM content of ca. 0.12mg/cm2, compatible with the DOE 2017 total (anode+ cathode) MEA PGM target of 0.125mg/cm2. When integrated with optimized NSTF anode catalyst and flow fields, these improved Pt-Ni/NSTF catalysts have demonstrated MEA inverse specific power densities ranging from 0.16-0.13g/kW at 0.67V (150-250kPa, respectively), approaching the DOE 2017 target of 0.125g/kW (Fig. 2). Additional characterization, including STEM (Fig. 3), RDE, and XRD, will be discussed.

REFERENCES

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Fig. 1. (Left) Increased Rated Power After Improved Dealloying Process and (Right) Mass Activity, Specific Area Variation After Annealing.
Pt-Ni/NSTF Cathode with ca. 0.12mg/cm2.

Fig. 2. H2/Air Polarization and Inverse Specific Power at Various Reactant Pressures with 2013(March) Best of Class NSTF MEA. 0.137mg/cm2total (A+C).

Fig. 3. High-Angle Annular Dark-Field (HAADF) STEM Images of PtNi7 Cathode: As Deposited, After Dealloying, and After MEA Conditioning.