Breakout Group 2: MEAs, Components and Integration
Participants

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BREAKOUT GROUP 2: MEAS, COMPONENTS AND INTEGRATION
KEY TECHNICAL BARRIERS

FUNDAMENTAL	COST	PERFORMANCE	DURABILITY
• Fundamental understanding of proton transport in electrodes • Theoretical limitations of PEM conductivity vs. RH • Fundamental understanding of GDL structure • Understanding of Pt-O coverage versus V • Water phase change - evaporation and condensation in non-wetting porous materials • Fundamental understanding of transport mechanisms in catalyst layers (unresolved loss mechanisms) • Idealized performance with H_2 & O_2 (non-reformed)	• Low volume targets 100s/yr - for catalyst loading, seal, membrane, plate, GDL • Integration - MEAs currently assembled from discrete parts – need new concept on how to manufacture MEAs • Reduction of component mass to save costs • Low-cost electrode processing • Getting to high volume (to reduce cost) • Reducing costs of GDMs to necessary levels with current technology • One key approach to reducing cell resistance is reduction of membrane thickness – can crossover be controlled at e.g. 5-10 µm? • Seal – MEA concepts that allow integrating seals in a one-step process • MEA subcomponents designed for manufacture	• High current density H_2/air performance of low loaded electrodes • Water management for thin electrodes • Reduce gas crossover • Insufficient CO tolerance and tolerance to other impurities • GDL compatibility with MEA requirements • Understanding catalyst layer structure and structure-function relationships • Durability of high temperature MEA, performance in HT MEA • Low temperature operating conditions (LTOC), meeting requirements for military operations under varying conditions • Will "system solutions" for protecting catalysts really work under real world environments?	• Catalyst durability with start/stop cycle • Impact of real life operations • Durability of HTMEAs (need for accelerated tests, protocols) • Performance and durability under a wide range of temperatures and % RHs both dry and wet • Control of electrode structure for durability and water management • Membrane degradation localization mechanisms – effects of electrode, GDL, operation conditions • MEA component interactions on FC durability • Durability - polymer integrity in electrode structures focus (most work so far is focused on catalyst) • Understanding of H_2 crossover effects on Pt dissolution • Effect of electrode roughness on PEM durability • Durable sealing for operation at 120°C - 200°C • Stack compressive stress state affects performance – what is influence on stack durability?

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Critical R&D Needs

Membrane	Ionomers	Measurements/ Characterization	Seals	MEA
• Development of low-cost membranes that meet 2015 performance and durability targets operating at 95°C. Durability and performance to be characterized at ex-situ, single cell and stack level • High Temperature, low Relative Humidity membranes • Develop, test, integrate robust low cost membrane technology to handle impure reformate in manufacturable durable low cost systems	• Develop ionomers for electrodes	• Experimental methods for in-situ measurement of properties related to transport and reaction in catalyst layers (potentials, concentration) • In-situ submicron CL diagnostics to determine proton and water production and movement • Development of novel imaging techniques to quantify interface structure and location/amount of water accumulation • In situ techniques to observe at microns scale • In-situ measurement of electrode water content in-situ to assist proton resistance studies	• Durable low cost seals - materials, integration with MEA, low-cost processes • Develop or identify sealing materials or concepts for MEAs operating at 120° - 150°C	• Develop MEAs that are stable under dynamic operating conditions (membrane, electrode, GDL, and interface stability) • High temperature PEM MEA (150-200°C) optimization capability – accelerated stress test development, failure mode prediction as a function of system operation, degradation as a function of MEA parameters • Mechanistic understanding of voltage decay in H_2/Air systems at high (>1.5 A/cm^2) current density • Chemical and structural analysis across interfaces (GDL/MPL electrode (ionomer)/ membrane) to elucidate performance relationship and degradation mechanisms • Performance and durability of high temperature (150-200°C) MEA: demonstration in stacks/ systems

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CRITICAL R&D NEEDS (CONT'D)

ELECTRODES	INTERFACE	CORRELATING REAL WORLD TO LAB PERFORMANCE AND DURABILITY	MECHANICAL TESTING/ ANALYSIS
• Electrodes that are operable over a wide temp/RH range, are manufacturable, have optimized ionomer/support structures, and an understanding of the interface as it relates to transport and durability • Structural and transport relationships in electrodes at the nanoscale • Improved low temperature performance from tailoring of electrode/MPL/GDL surface energies and structures (for loadings meeting DOE targets) • Quantification of Pt dissolution versus ionomer structure and H_2 crossover (with relevant electrodes) • Fundamental study of electrodes and ionomers in electrodes	• Design and development of tailored interfaces for high performance and durable operations • Development of novel diagnostic tools, performance testing protocols and models to evaluate and quantify the interface • Develop understanding of relation between interfaces and durability • Techniques for measurements of protonic/electrical/thermal interfacial resistances that are validated versus in-situ performance (including effects of compression) • Answer the question "what are the key characteristics of a good interface?" Investigate membrane - electrode, electrode - GDL, GDL - plate, or ionomer - catalyst. Might require the development of new characterization methods, expertise in microscopy, and surface science	• Develop accelerated durability tests that will correlate to real world decay mechanisms for all components. (How do we know our current tests are adequate?) • Determine degradation as a function of - current, temperature, RH, dynamic operation, start/stop and contaminant exposure • Standardized accelerated testing	• Stress/FEA model of integrated electrochemical package, including an experimental campaign and protocols regarding mechanical properties of MEA, CL, GDL and flow field/plates, as a function of (dimensions, chemical/mechanical composition, RH/λ, temp) • Develop methods to measure MEA mechanical and physical properties in a stack at BOL and EOL. Relate changes to stack performance and durability • Mechanistic understanding of MEA durability as it applies to the optimization of performance under all operating conditions • Membrane stress-strain model within MEA during transient operation, with linkages to membrane properties

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Critical R&D Needs (cont'd)

GDL	Analysis, Cost, Targets, Risk	Transport	Stack/MEA Integration	Miscellaneous
• Gas diffusion media integration - develop and standardization of MPL and catalyst layer interface characterization methods, link interface characteristics to MEA performance and component durability • Development of low-cost GDLs with tailored properties to enable robustness to dry and wet conditions (relevant electrode/PEM context)	• Identify and develop material properties that impact manufacturing cost (membrane, GDL, sealing) for MEA • Develop catalyst components (catalysts, supports, membrane integration) that can exceed current and projected performance durability and cost targets with realistic safety margins for automotive FC commercialization • Carbon inventory approach/model development to facilitate long term material selection for reduction of GHG production	• Sensitivity of transport (proton, electron, thermal, species and water) to gradients in compression, temperature, and species with integrated components • Improved method for measuring water transport as a function of RH, T - diffusion and electro-osmotic drag coefficient (EODC)	• Integration of advanced materials (low loaded catalysts), robust membranes, etc. to enable achievement of MEA and stack cost performance and durability targets - project criteria: system level testing, scalable (manufacturable) integration methods • Determine GDL requirements to identify and address interfacial issues with new membrane technologies and produce rolled products for integration into MEAs for 2015 targets • Develop standard for stack MEA - border, dimensions, seal • For portable power application - thinner components affect seals, clamping pressure, membrane interaction, etc. Studies to integrate thinner components and assemble them, and for swelling and clamping of interactions • Integrated demos that meet/excess 2010/15 targets (>0.6V - 2A/cm^2) - freeze start 30 s at -30°C, DFM design - path to cost (study), 50 kW stack demo, 2000+ hrs cycle	• Large scale deployment ~ 5,000 systems • Development of non-SS BPP which are lower cost, higher performance, longer life