DEVELOPMENT OF ADVANCED CATALYSTS FOR DIRECT METHANOL FUEL CELLS

Charles K. Witham, S.R. Narayanan

Jet Propulsion Laboratory, Pasadena CA

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Program Objectives

Overall Objective

- Reduce Catalyst Cost for Direct Methanol Fuel Cells
- Develop a low-cost manufacturing technique for MEA fabrication

Specific Objective

- Demonstrate feasibility of reducing Pt-Ru catalyst loading to 0.5 mg/cm^2 using thin film deposition techniques
- Prepare and identify low-cost alternatives to Pt-Ru based on Ni, Zr, Ti.

Approach

- Sputter-deposited Multi-component Catalyst Layers
- Reactive Sputter-deposition
- MEA fabrication
- Electrochemical characterization in half-cells and full cell characterization
- Physical Characterization to determine structural and electronic properties

TEAM: JPL, Caltech, N.E. University.

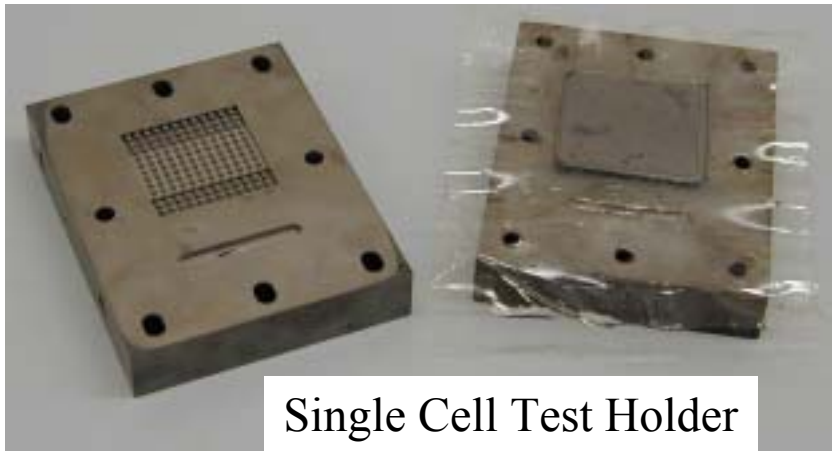
Program Schedule

Task	2001			2002				2003			
	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
1.0 **Thin Film Catalyst Layer Deposition**											
1.1 Deposit single Pt-Ru films											
1.2 Deposit Pt-RuO_x films											
1.3 Deposit Layered Pt-Ru/PtRuO_x films											
2.0 **Catalyst Physico-Chemical Characterization**											
2.1 XRD											
2.2 SEM / EDAX											
2.3 XPS											
2.4 EELS											
2.5 EXAFS											
3.0 **Advanced Catalyst Development**											
3.1 Baseline Pt-Mo and Ni-Ti catalytic activities											
3.2 Deposit binary and ternary Pt-based alloys											
3.3 Deposit corrosion resistant alloys.											
3.4 Deposit metal composites with proton-conducting oxides.											
4.0 **Reports and Reviews**											
4.1 Annual Reviews											
4.2 Annual Reports											

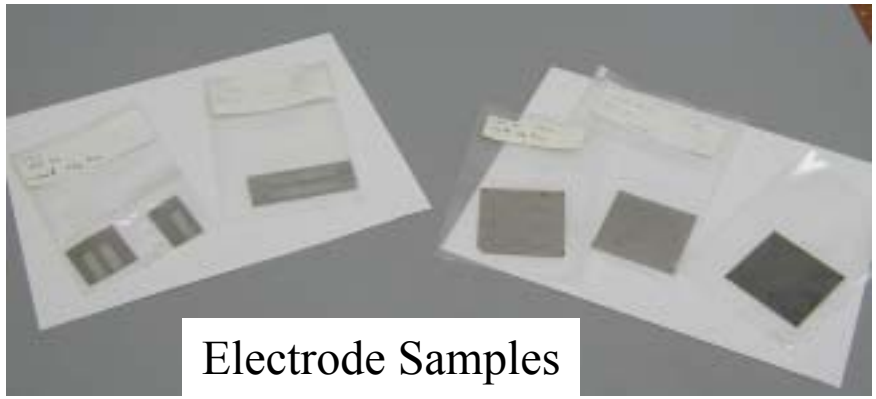
Milestone Schedule

Dec 2001	Deposit and characterize Single Pt-Ru Films
June 2002	Demonstrate 1000 mW/mg at 0.15 mg/cm^2
June 2002	Deposit and characterize $PtRuO_x$ and RuO_x films
Dec 2002	Deposit and characterize Pt-M'$_x$M''$_y$ films
June 2003	Demonstrate 2000 mW/mg at 0.1 mg/cm^2
June 2003	Deposit and Characterize corrosion resistant alloys
Dec 2003	Characterize metal/metal oxide systems
June 2004	Demonstrate 2500 mW/mg at 0.1 mg/cm^2

Test Equipment



Single Cell Test Holder



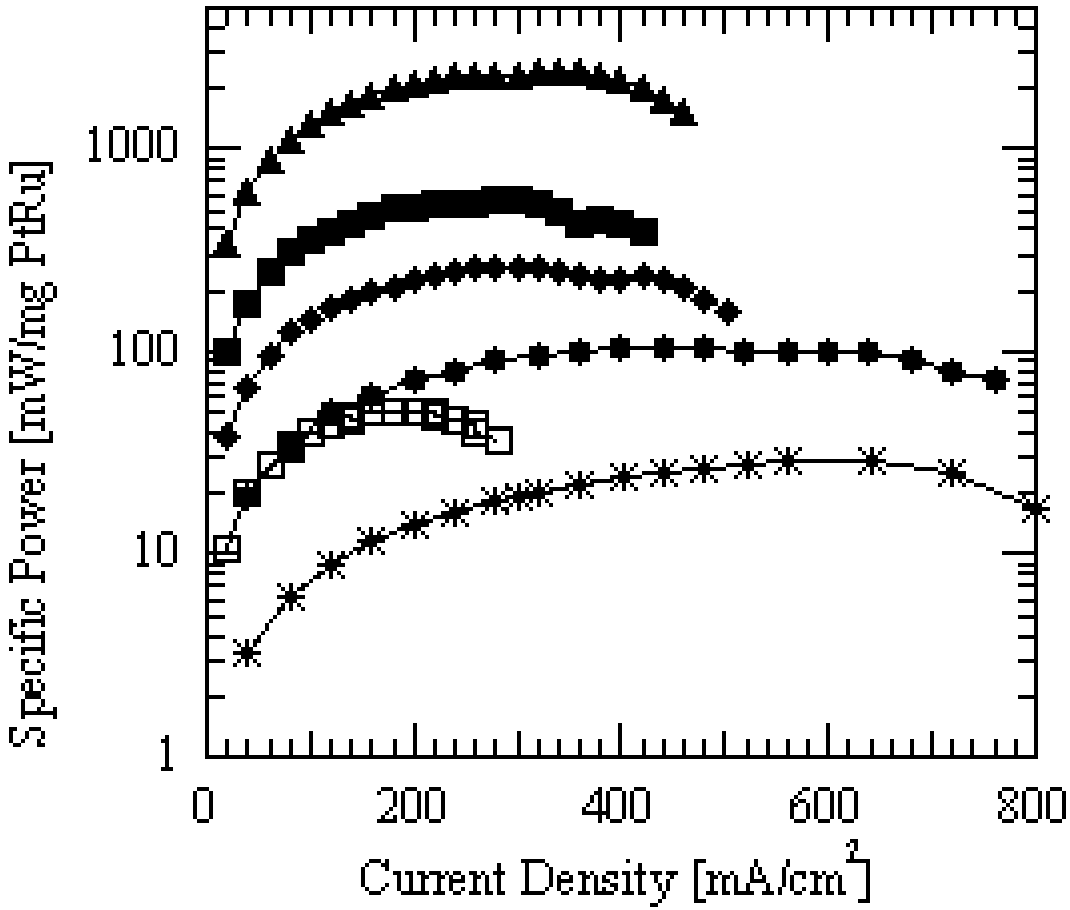
Electrode Samples

Single Cell Test Station

Half Cell Test Station

Sputter Deposition Chamber

Catalyst Utilization [mW/mg] of Sputter Deposited PtRu Anode Catalyst

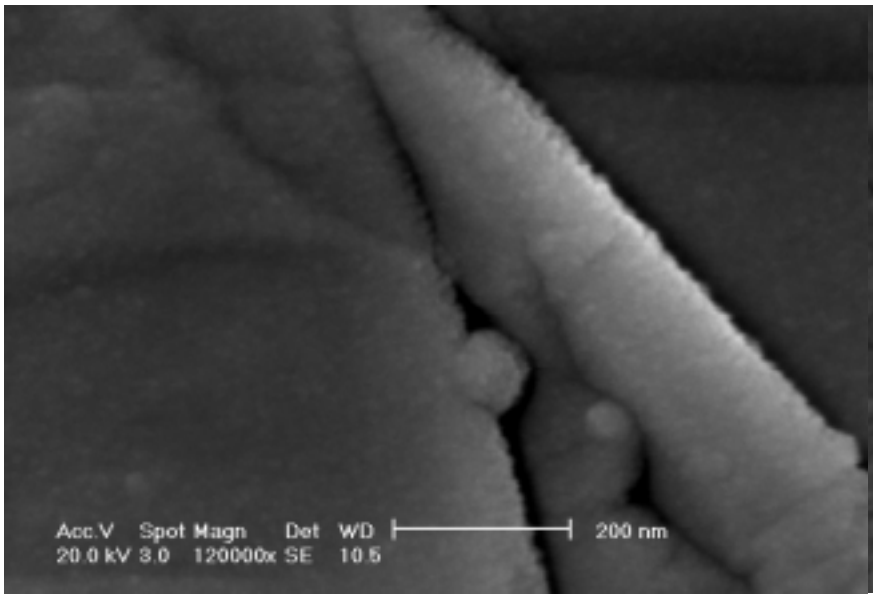


Anode Loading [mg/cm^2]

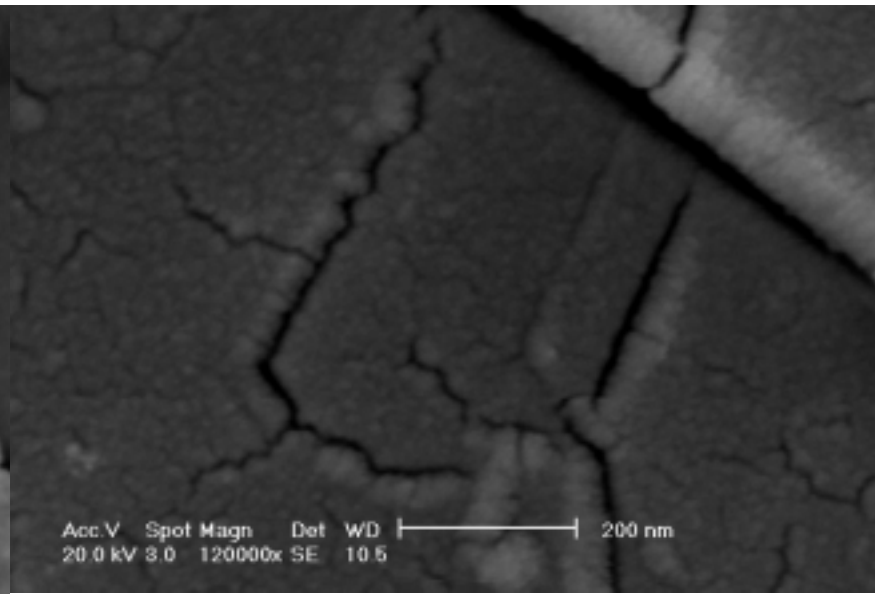
- ▲ - 0.03 Sputtered
- ■ - 0.1 Sputtered
- ♦ - 0.3 Sputtered
- ⬢ - 1.0 Sputtered
- □ - 1.0 Supported
- * - 8.0 Unsupported

~600 Å PtRu Sputtered on Pressed Graphite

Before Methanol Oxidation

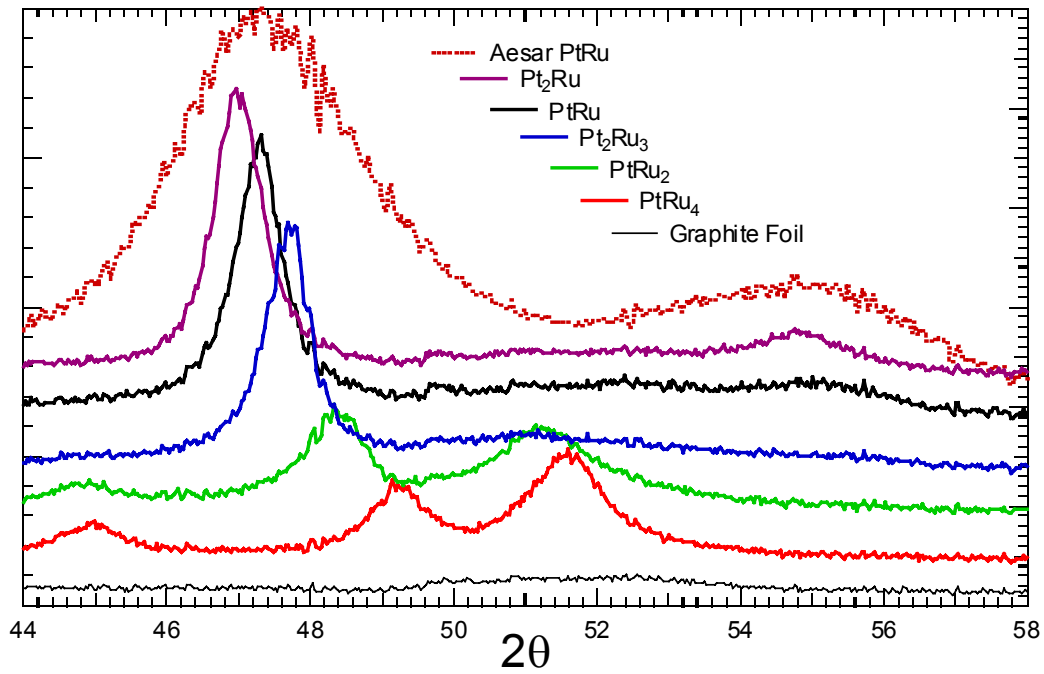


After Methanol Oxidation



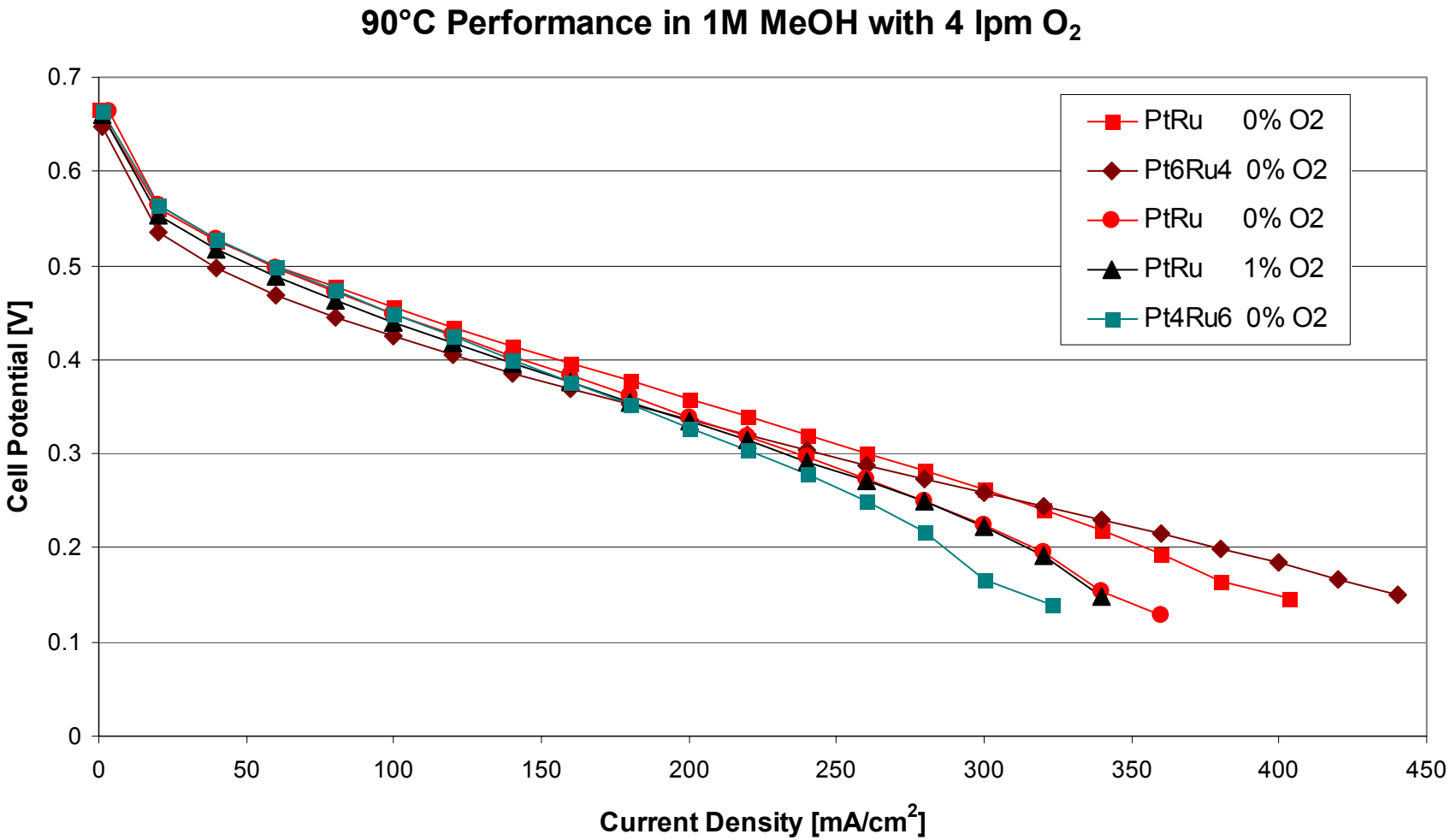
Use for Methanol Oxidation increases film roughness, may attack films at grain boundaries.

X-Ray Diffraction of Pt_xRu_{1-x} Alloys Sputtered on Pressed Graphite



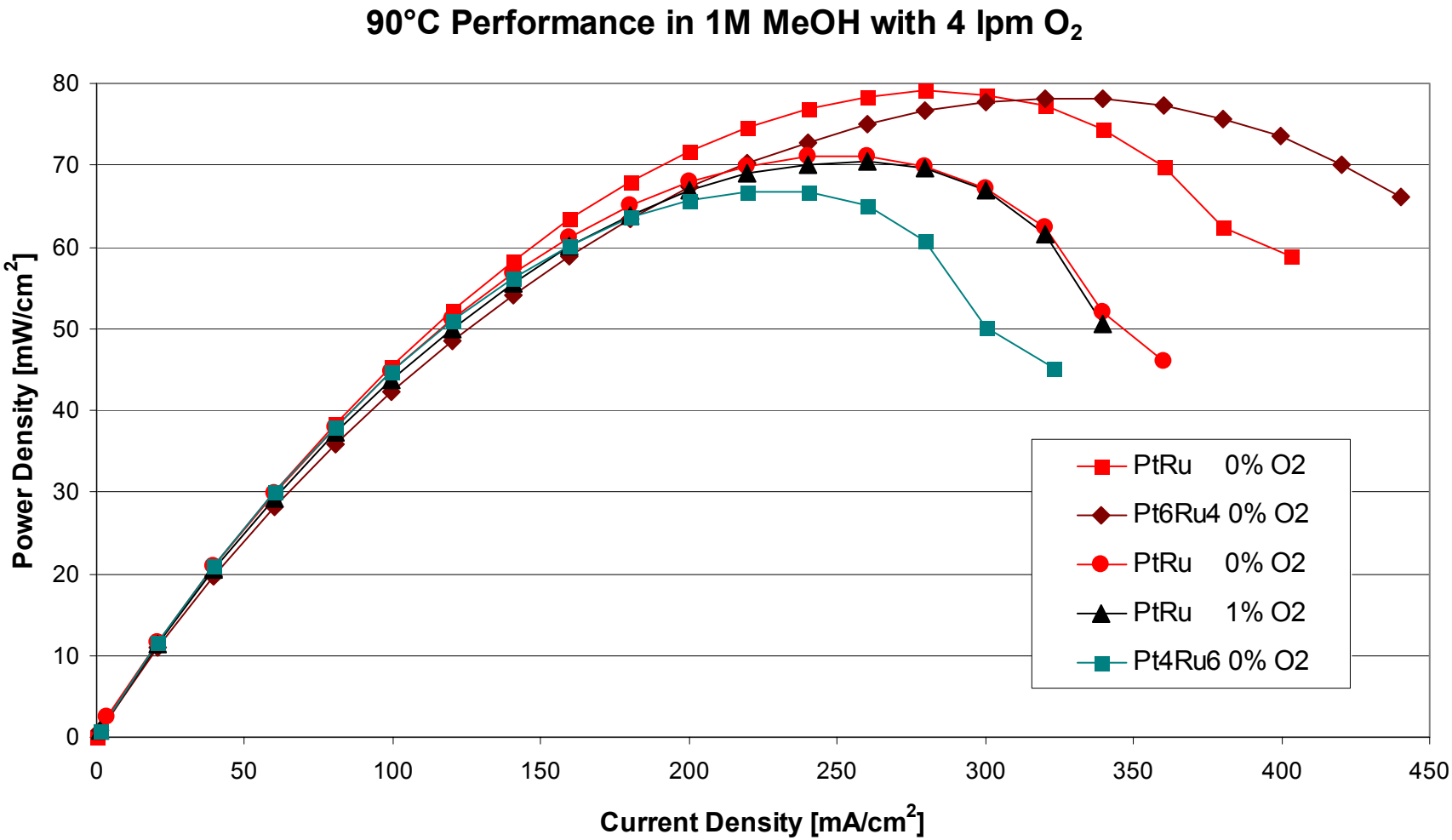
Diffraction Patterns show single-phase alloys.
Peak shifts correspond to composition variation.

Cell Performance



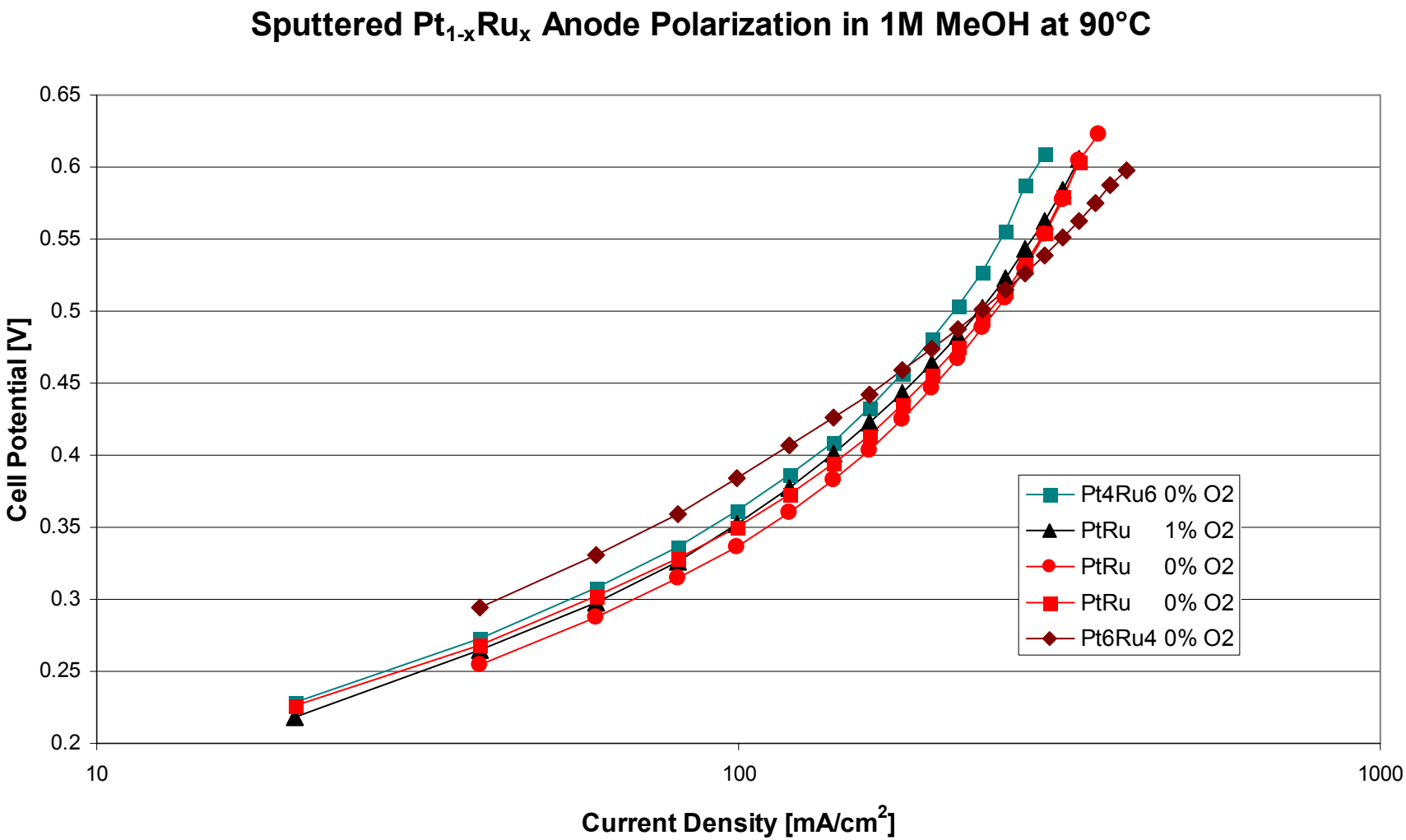
Impact of reactive sputtering with oxygen not significant.

Cell Power Density

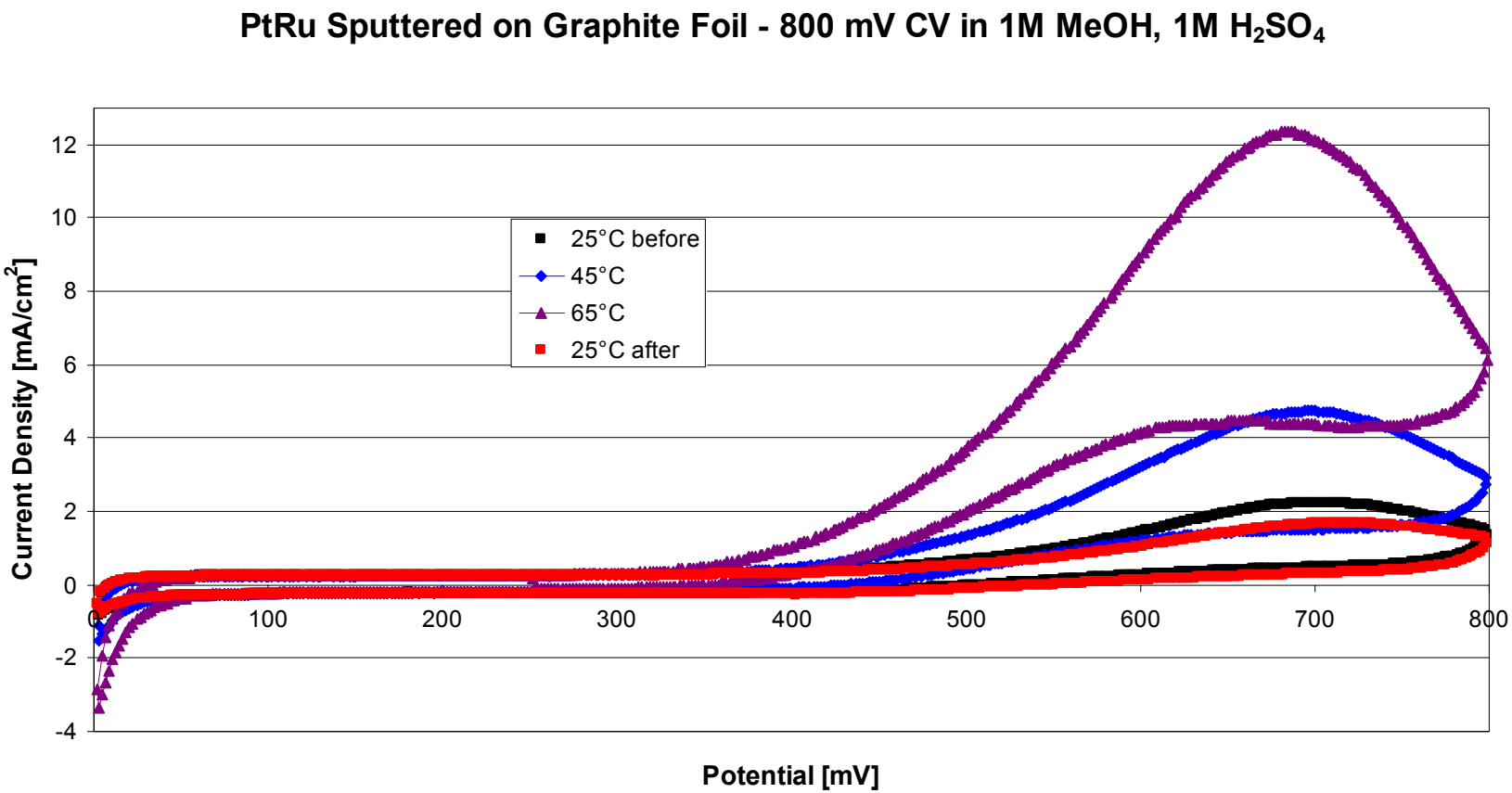


Composition variation changes cell performance, not peak power.

Anode Polarization



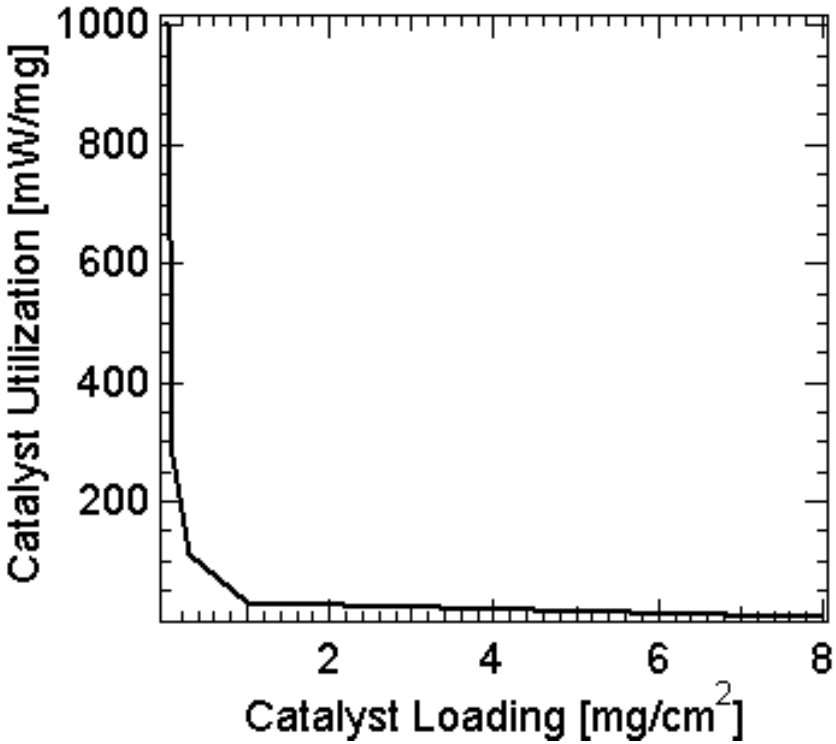
Cyclic Voltammetry

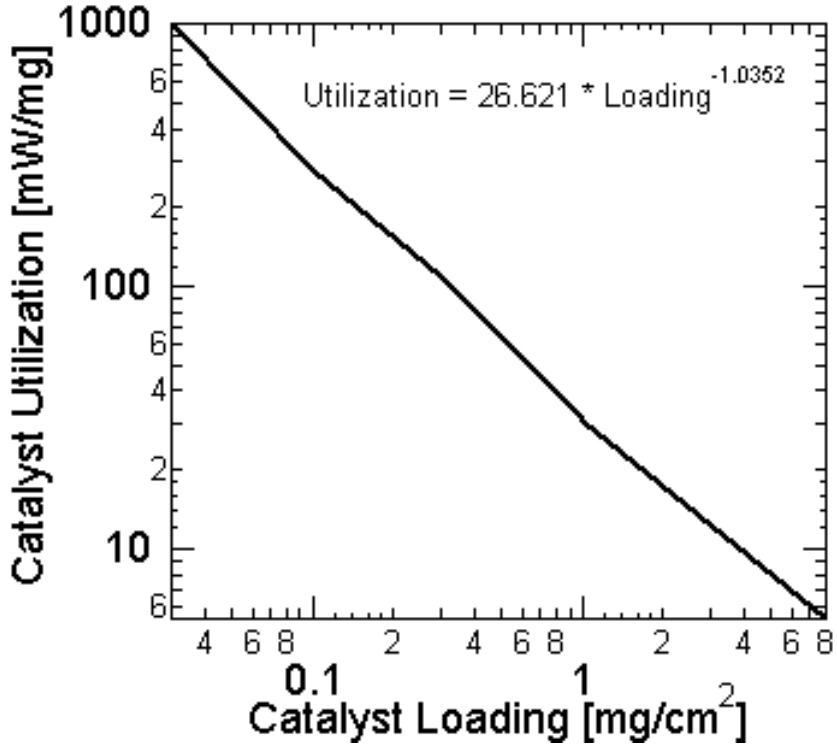


Methanol oxidation peak observed at ~670 mV vs. NHE.

Current reduction on cycling could result from re-construction or oxide growth.

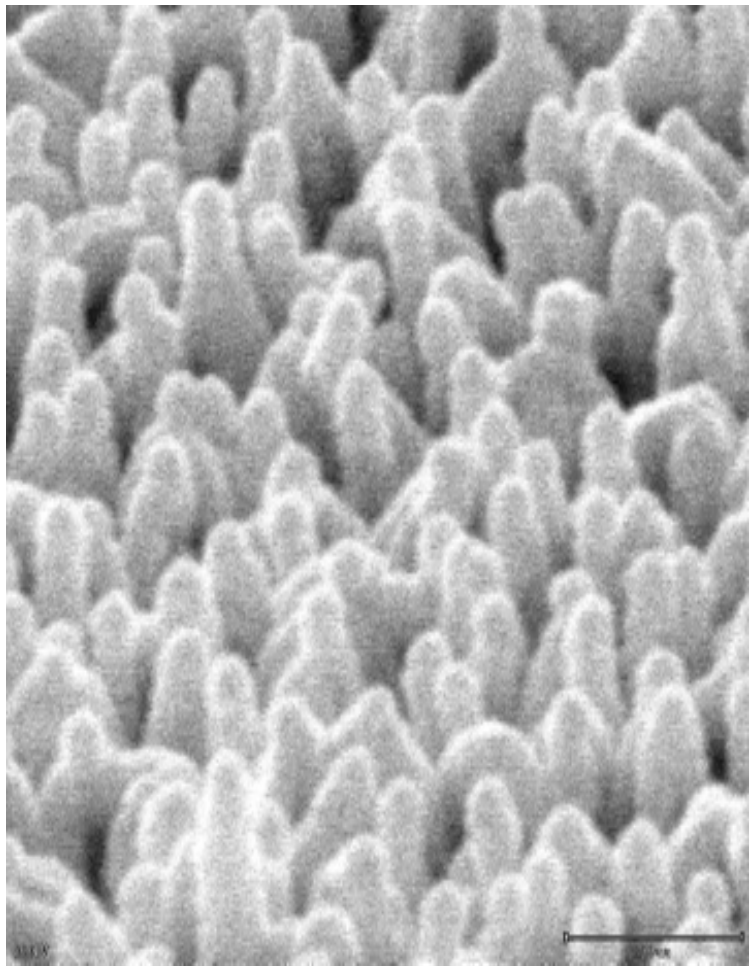
Catalyst Utilization at Peak Power





Thinner films (lower loading) have increased utilization of the Pt catalyst at the expense of areal power density. Challenge is to create high surface area film through etching, layering, etc.

1.0 mg/cm^2 Pt Sputtered on Etched Nafion



Pretreatment of Nafion by etching induces nanometer scale structures, increasing deposited catalyst surface area.

Milestones Achieved

- Sputter Deposition and Characterization of single Pt_xRu_{1-x} films
- Characterization of Sputter Deposited PtRu films in full cells
- Achieved Catalyst Utilization of 800 mW/mg at 0.1 mg/cm^2 with single Pt_xRu_{1-x} films
- Sputter Deposition of Single PtRu-O_x films
- Sputter Deposition and Electrochemical Characterization of unique metal structure on Nafion