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Novel Stack Concepts: Patterned Aligned Carbon Nanotubes as Electrodes in MEAs

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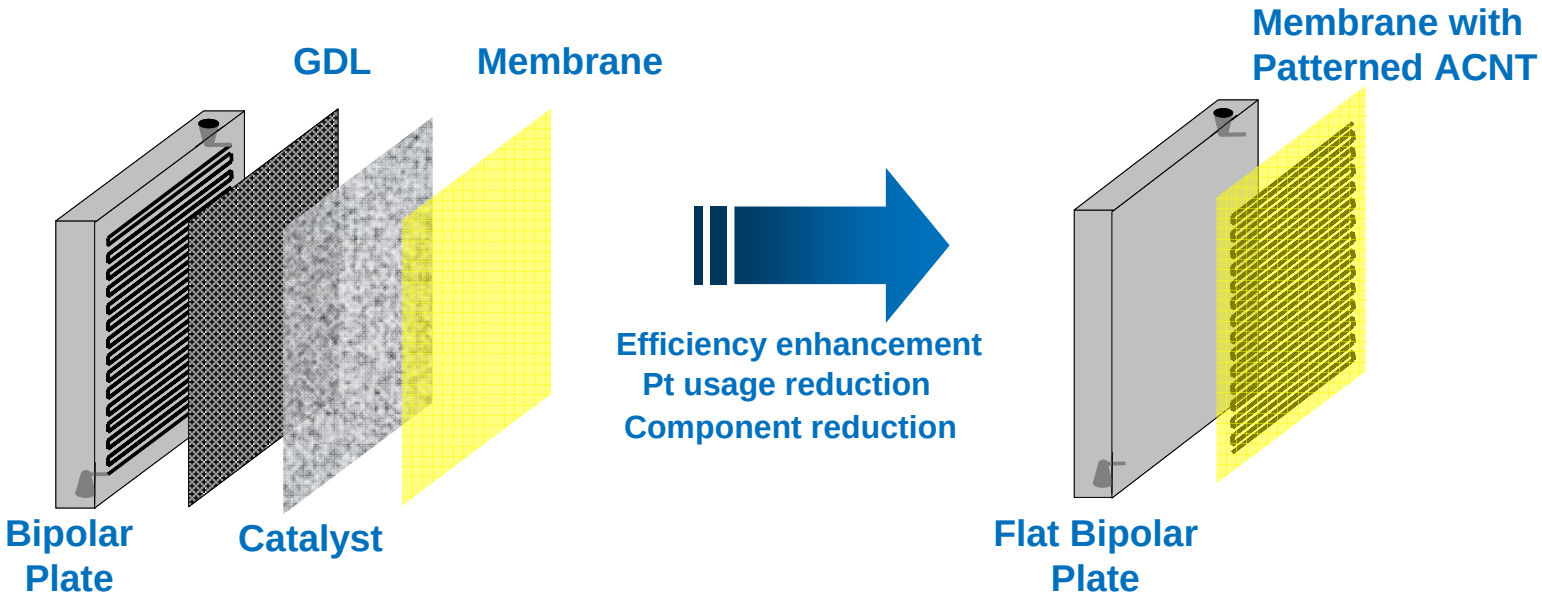
This presentation does not contain any proprietary or confidential information

Objective

- To develop a novel aligned carbon nanotube (ACNT)-based membrane electrode assembly and fuel cell with:
  - improved efficiency
  - reduced Pt usage
  - simplified stack design
- Topic 5A – Innovative Stack Concepts
- $ 500 K per year for 2 years



Relevance to FreedomCAR & Fuel Technical Barriers & Targets

This project addresses the following technical barriers:

A. Durability

- Replace amorphous carbon with more chemically inert graphitic ACNT

B. Cost

- Reduce or replace Pt with built-in transition metal catalytic site
- Eliminate GDL and simplify bipolar plate design with 3-D ACNT “carpet”

C. Performance

- Improve fuel utilization and conductivity through novel nano-architecture

D. Water Transport & Thermal Management

- Improve water/mass transport and thermal conductivity through patterned nanotubes with micrometer-dimension flowfield

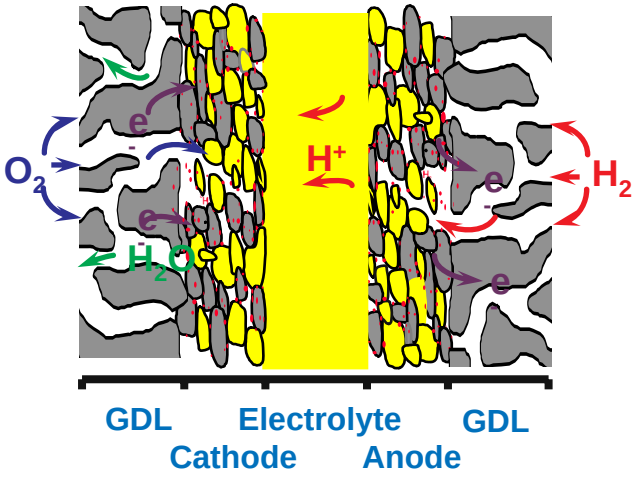
This project addresses the following technical targets for MEA:

- **MEA Cost: $10/kW**
- **Durability: 5000h @ 80ºC**

Technical Approach

Concept of Aligned Carbon Nanotubes (ACNT) as MEA for PEFC

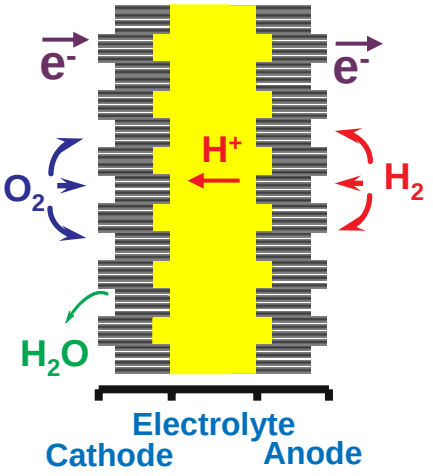
Conventional MEA

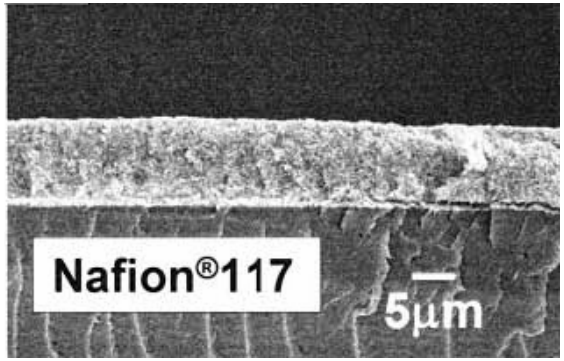


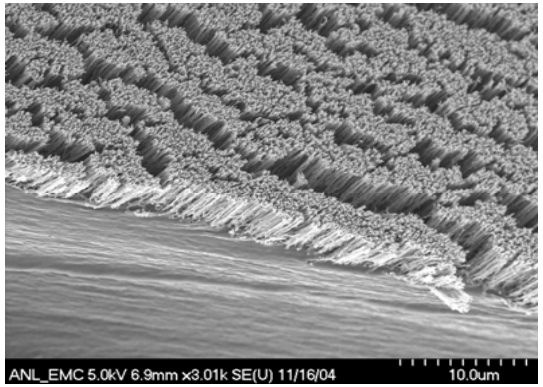
Advantage of ACNT MEA

- Better catalyst utilization
- Better support stability
- Better electrical & thermal conductivity
- Better humidity management
- Better mass transport
- Built-in catalytic activity through functionalized ACNT with potential to replace costly Pt/C

ACNT MEA

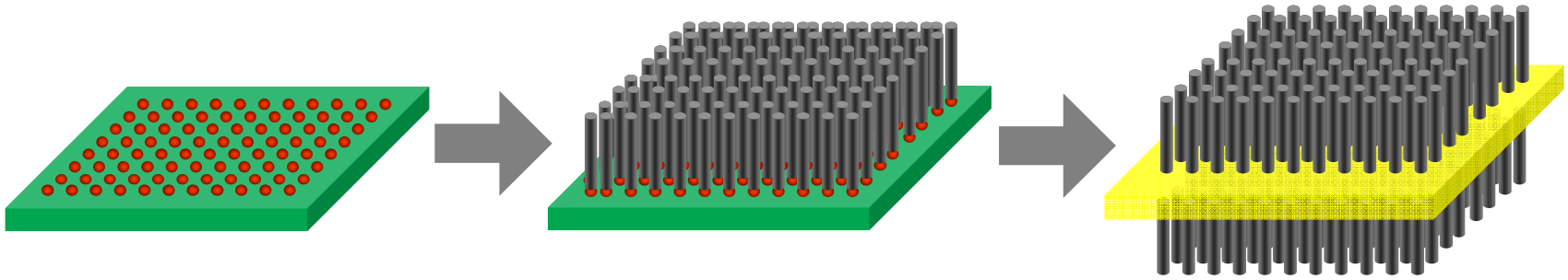




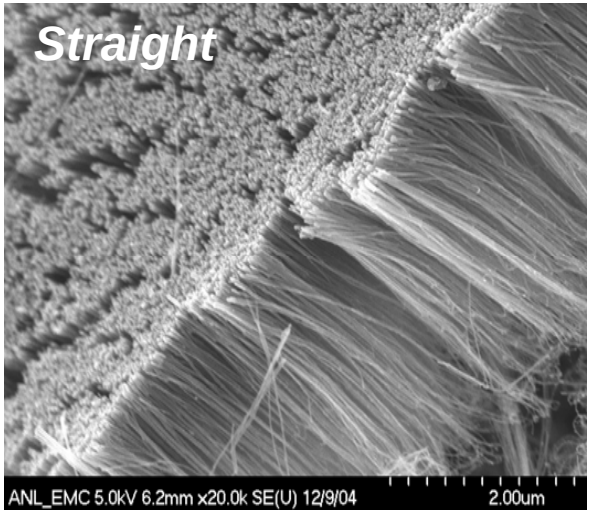


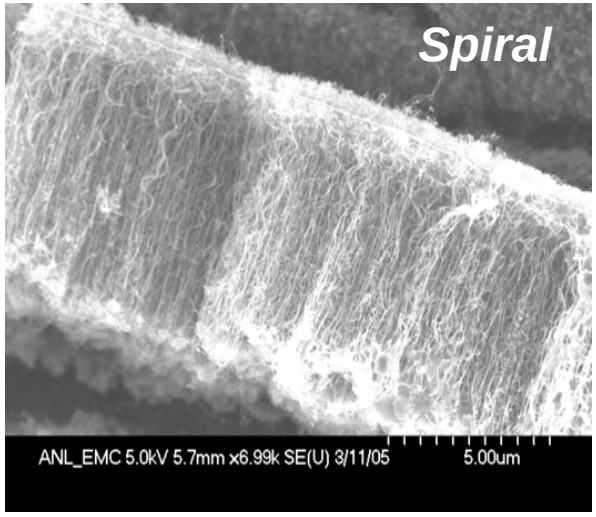
Technical Approach

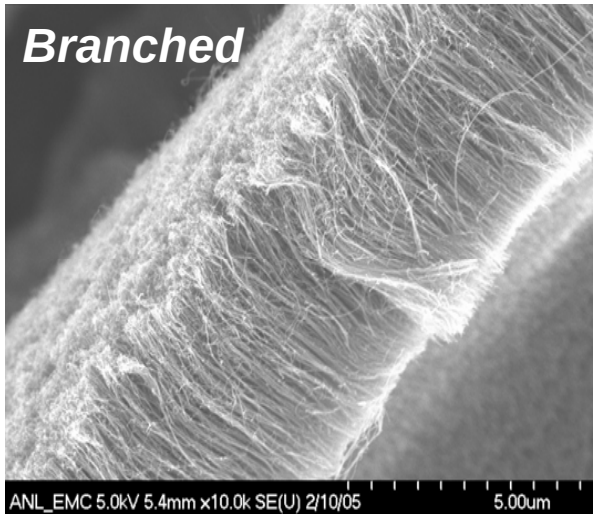
Process of Fabricating ACNT as MEA for PEFC



Growing and Catalyzing ACNT *Forming MEA*

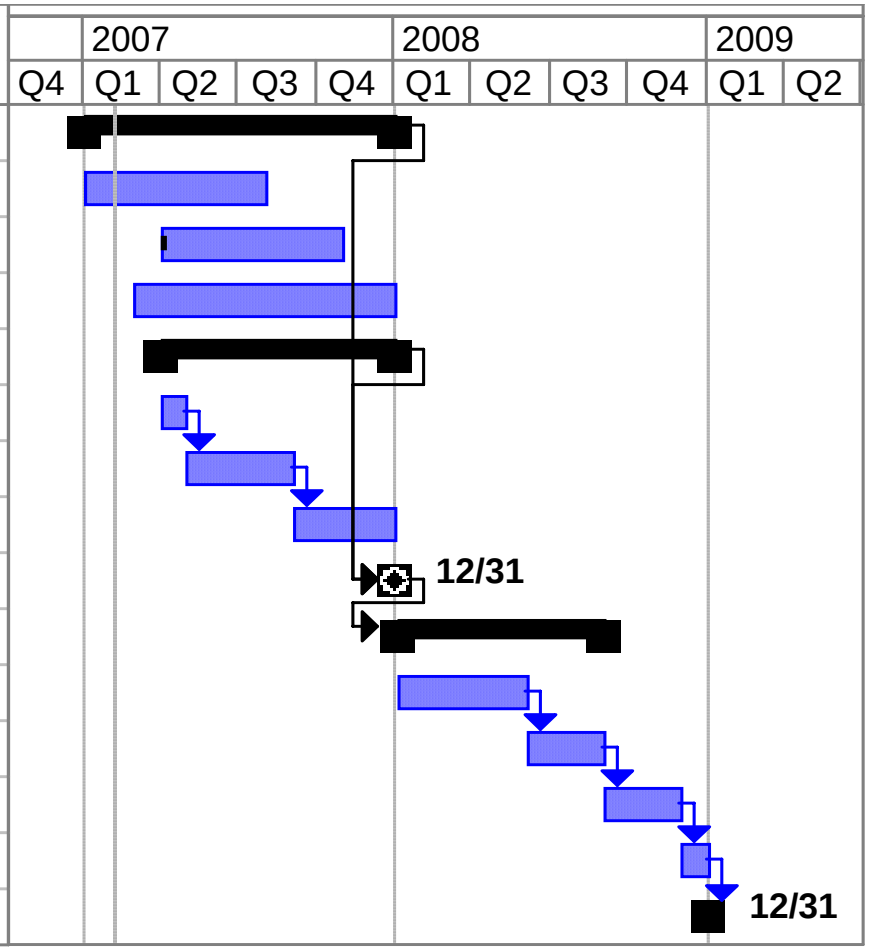






Project Timeline

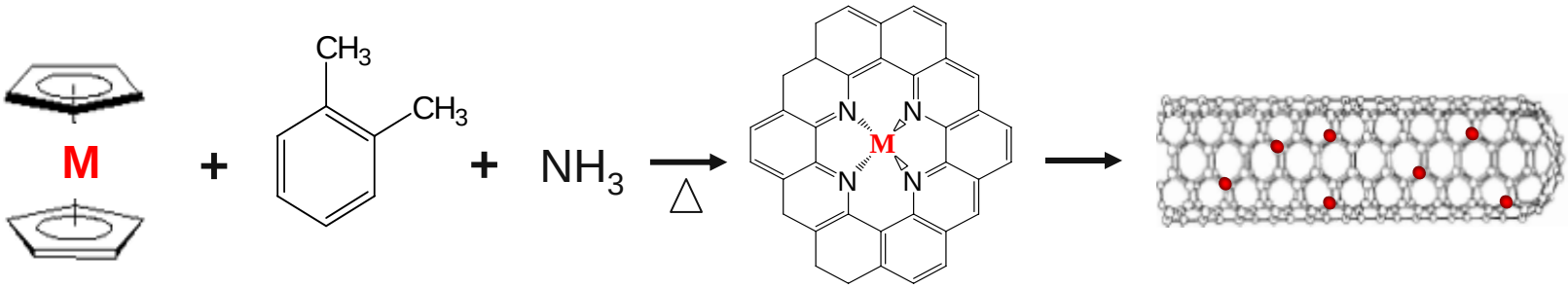
ID	Task Name
1	**1. Catalyze ACNT through CVD**
2	1.1 CVD Catalyzing Development
3	1.2 Wet chemistry catalyzing development
4	1.3 Activity/structure characterization
5	**2. Building 3-D MEA**
6	2.1 Flowfield modeling & selection
7	2.2 Method development for patterned ACN
8	2.3 Method development for ACNT MEA
9	**Midterm Go/No-go decision**
10	**3. Packaging & Testing**
11	3.1 Packaging development
12	3.2 Cell evaluation
13	**4. Scale-up**
14	**5. Report & Documentation**
15	**Project Completion**



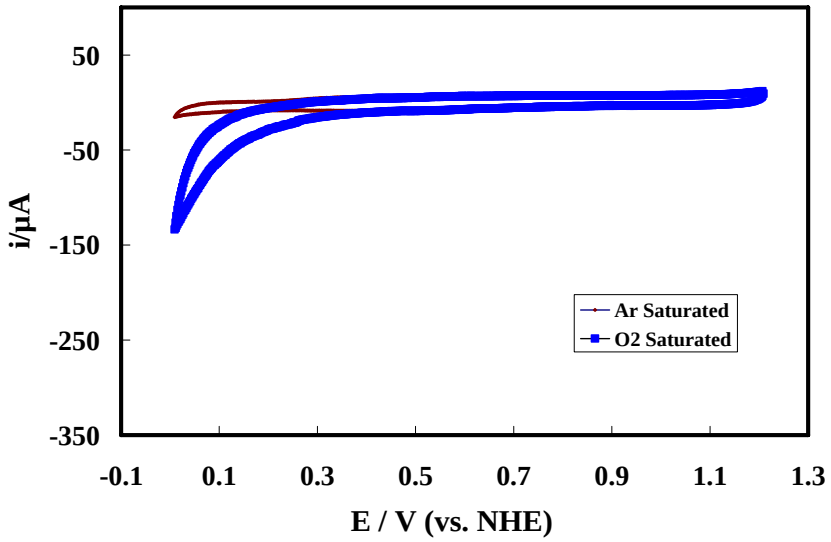
Gantt chart based on calendar quarters

Functionalize ACNT with Electrocatalytic Activity

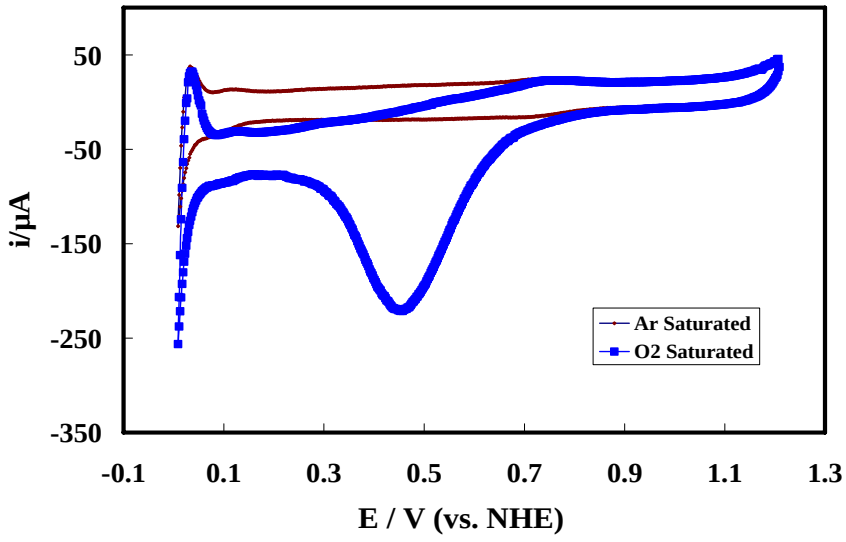
Building ORR Active Site through TM & N-doping During CVD Process



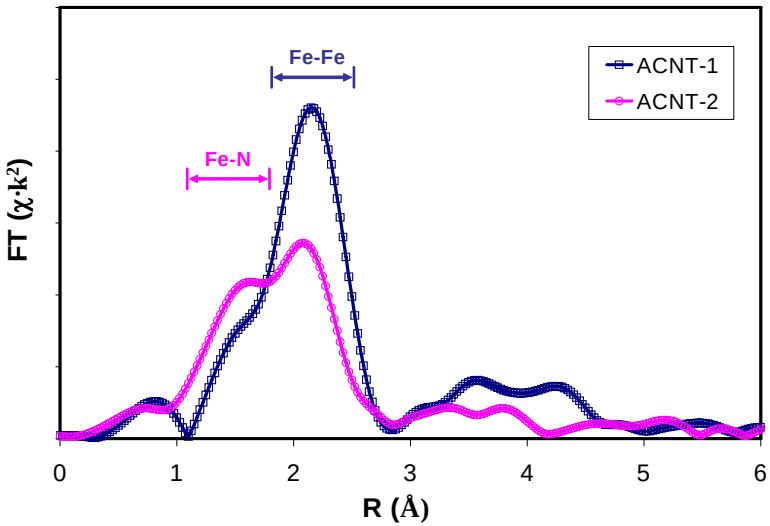
ACNT without N-doping



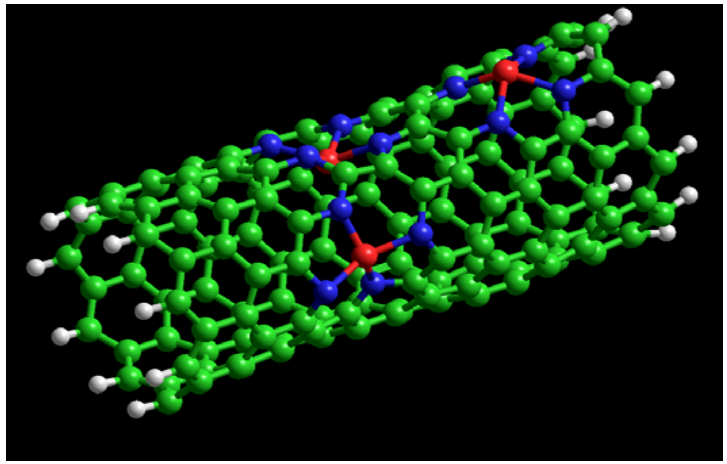
ACNT with N-doping

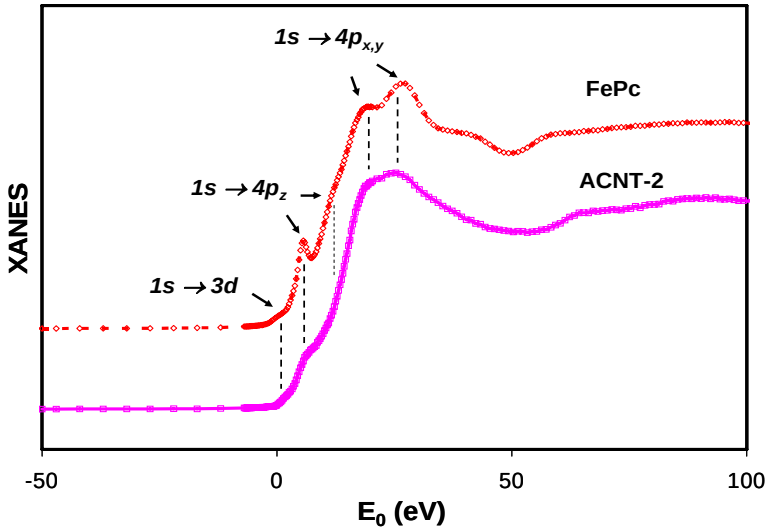


Probing ORR Active Site Through X-ray Absorption Spectroscopy



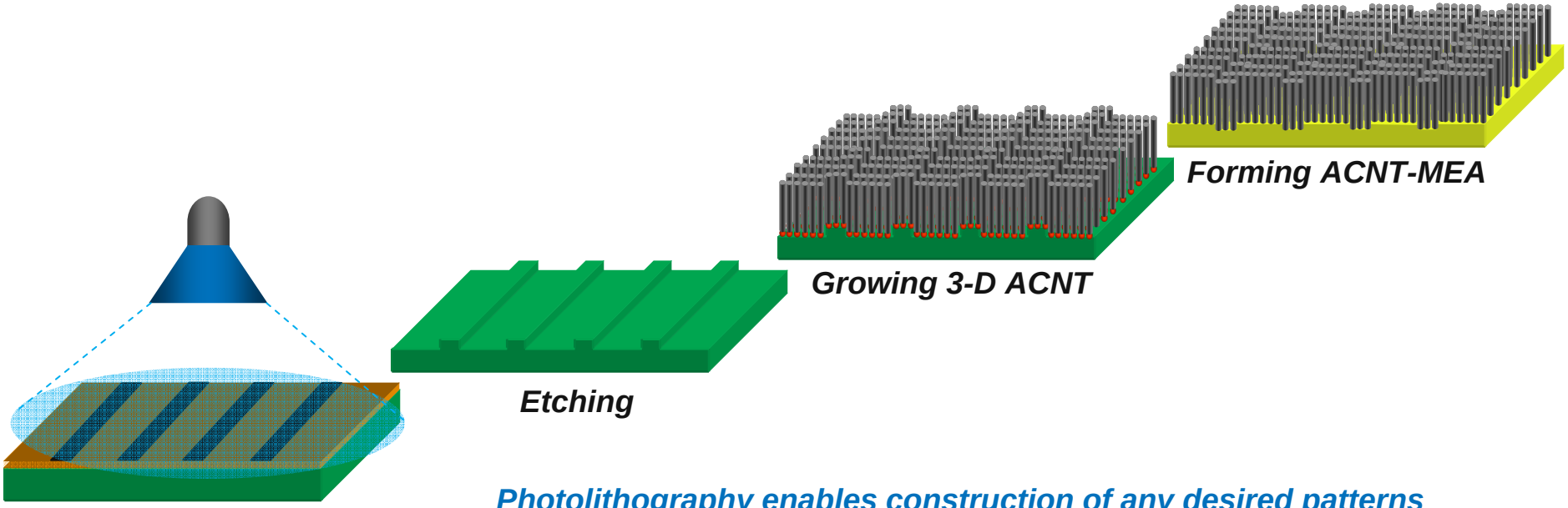
Shell	N	R (Å)	σ^2
Fe-N	4.2	1.95	0.00001



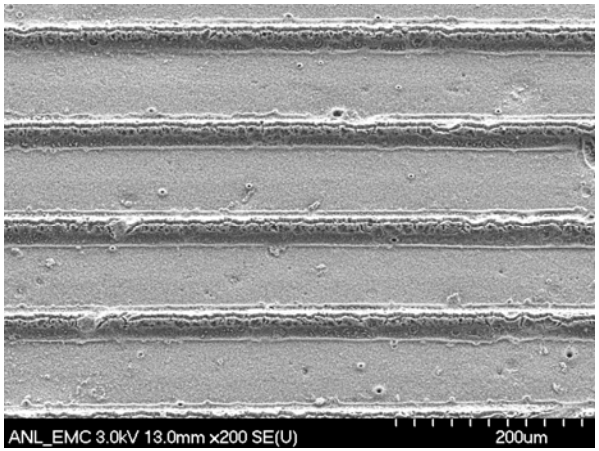


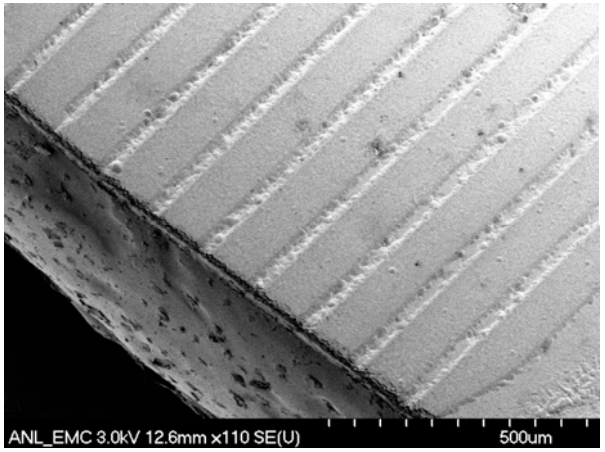
ORR likely involves a redox process around active site –FeN_4-

Building Three-Dimensional ACNT/MEA



Photolithography enables construction of any desired patterns for gas distribution channels with micrometer resolution





Key Milestones & Go/No-go Decision

- Demonstrate catalytically functionalized ACNT by completing development of two CVD catalyzing methods and two wet chemistry methods, followed by electrocatalytic activity and structural characterization – (Q1 FY08)
- Demonstrate the feasibility of ACNT based MEA by completing patterned layer preparation and membrane transfer technique development – (Q1 FY08)
- Demonstrate ACNT based PEFC by completing packaging method development and cell testing – (Q4 FY08)
- Complete feasibility analysis for material and engineering scale-up and documentation to DOE – (Q1 FY09)

A midterm go/no-go decision will be made at Q1 FY08 based on electrocatalytic performance against the benchmark and success of ACNT-MEA fabrication

Inputs/Needs

- We will seek industrial teams' input and guidance on the research direction through each phase of the project
- We will consult with the experts from fuel cell manufacturers and other labs during stack packaging and integration development
- If successful, we will search for industrial partnership to develop roadmap for potential technology transfer and commercialization

Argonne Team Members & Collaborators

- Junbing Yang
- Magali Ferrandon
- Suhas Niyogi
- Nancy Kariuki
- Jennifer Mawdsley
- Dennis Papadias