Clean Energy and Environment Research

Mechanical Engineering
University of Delaware

ME Faculty Conducting Clean Energy and Environmental Research

Fuel Cells, Batteries, and Supercapacitors


Advani


Chou

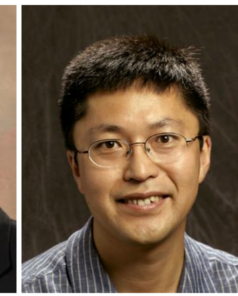

Hertz


Prasad


Roy


Santare


LP Wang

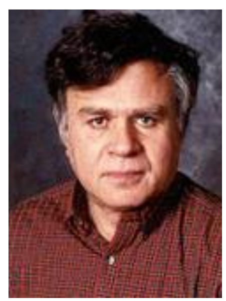

Wei

Wind Energy


Advani


Burris


Prasad

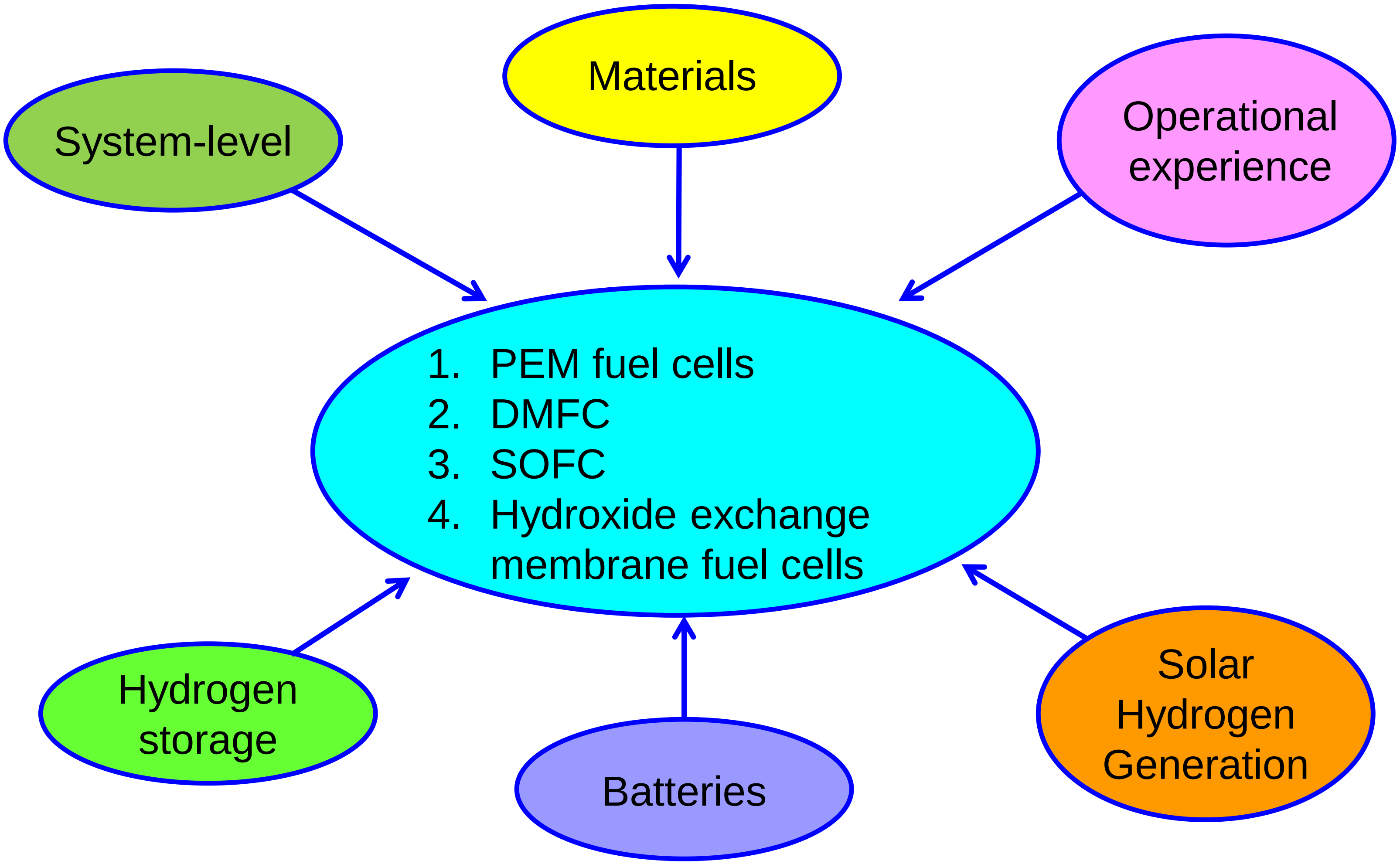

Schwartz

Environment


Prasad


LP Wang

Center for Fuel Cell Research
Director: Ajay Prasad



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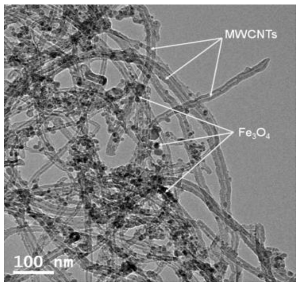
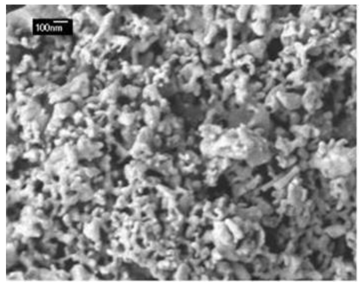
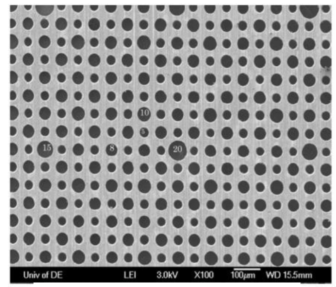
Novel Materials for PEM Fuel Cells



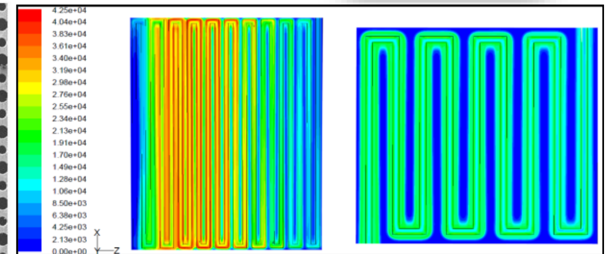
Novel composite membranes



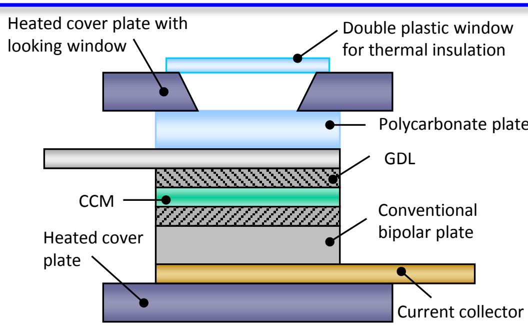
Tungsten Monocarbide catalyst



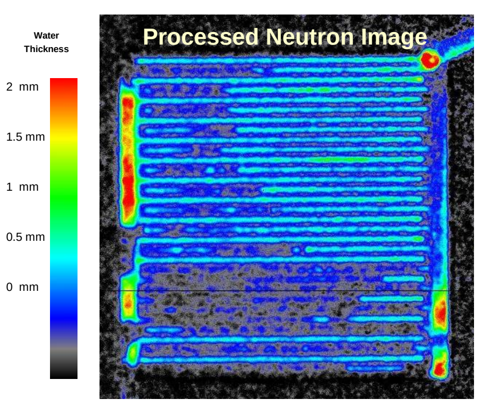
Novel metallic GDL



Design of flow channels using genetic algorithms

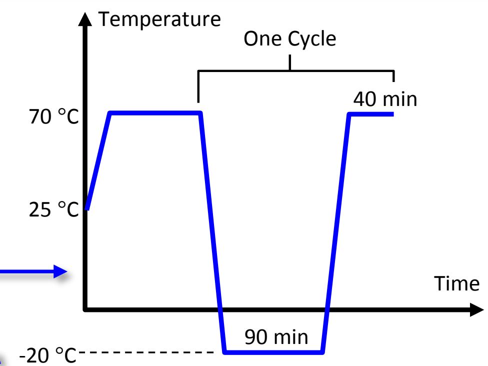


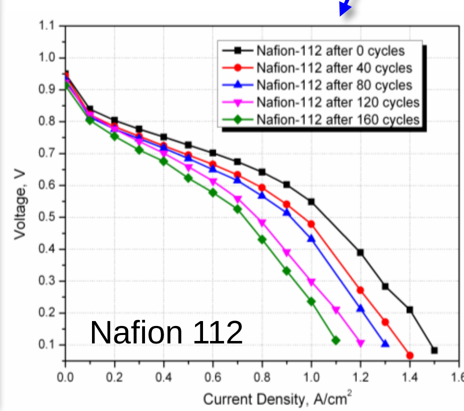
Transparent cell for optical access

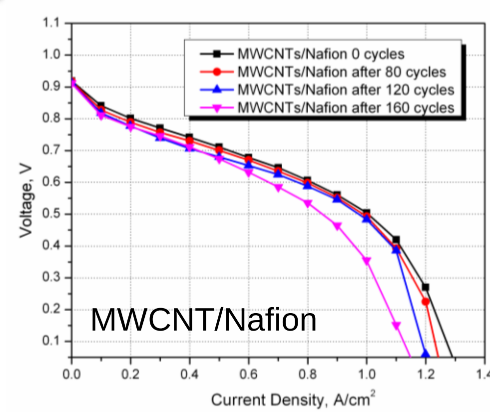


Durability Studies by Accelerated Stress Testing

- Humidity cycling
- Temperature cycling
- Freeze/thaw cycling of Nafion/MWCNT membrane







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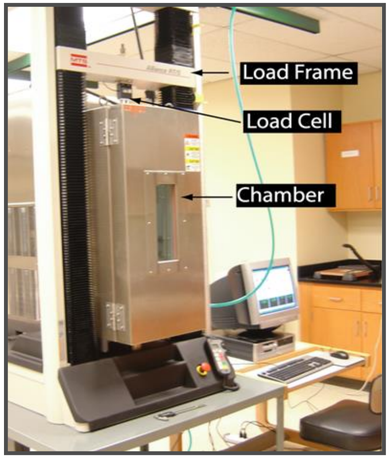
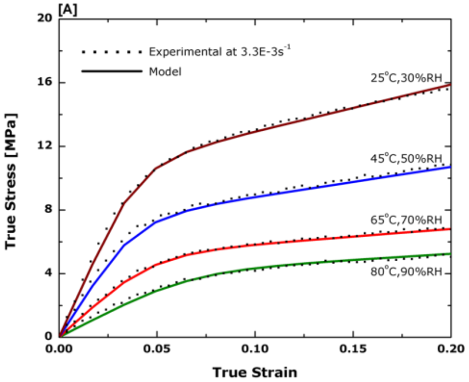
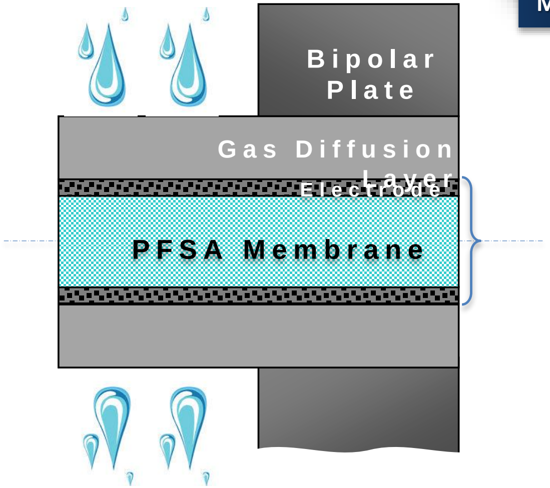
Michael Santare

Mechanics of Fuel Cell Membranes

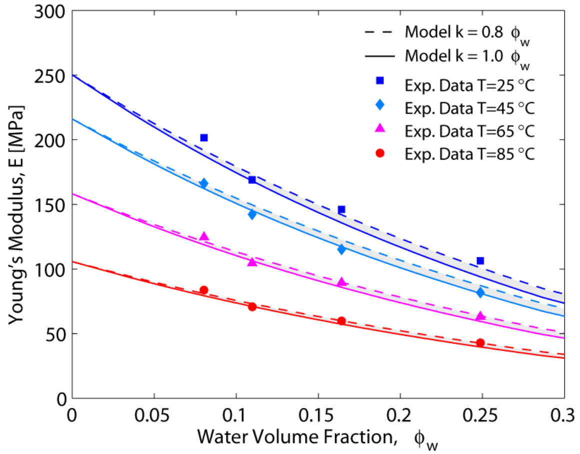
Experimental Materials Characterization

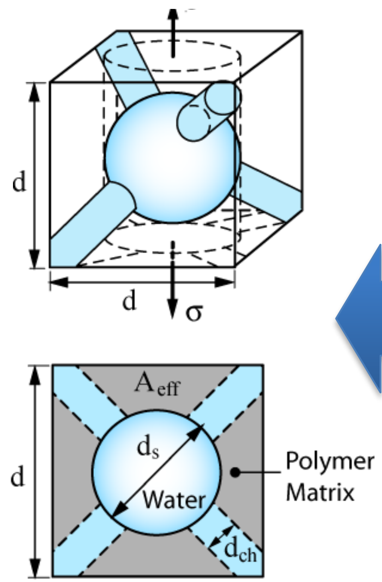


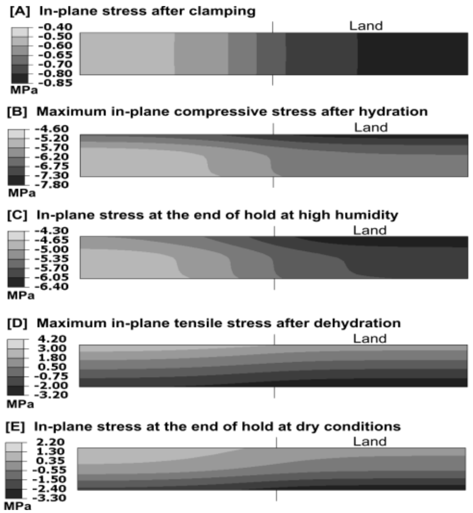




Numerical in-situ models And Results







Nano-structural models

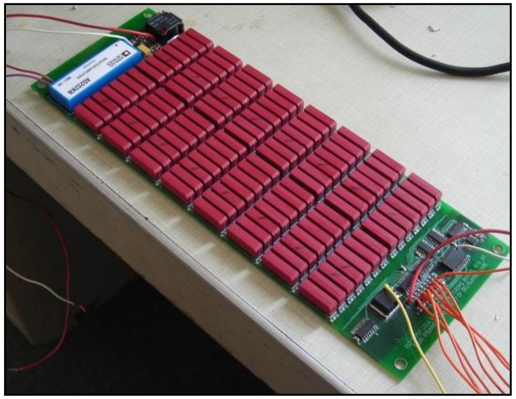
UD Fuel Cell Hybrid Bus Program (2005-present)

Bus #	Size	Stack	Batteries	Operation
1	22-ft	20 kW	Ni-Cad	2007
2	22-ft	40 kW	Ni-Cad	2009
3	40-ft	60 kW	Li-Ti	2014*
4	40-ft	80 kW	Li-Ti	2014*

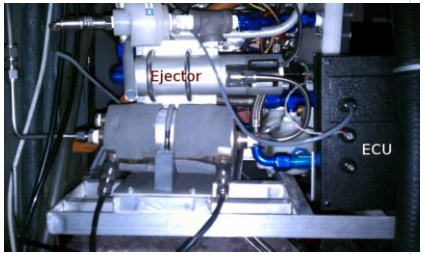
*Expected delivery

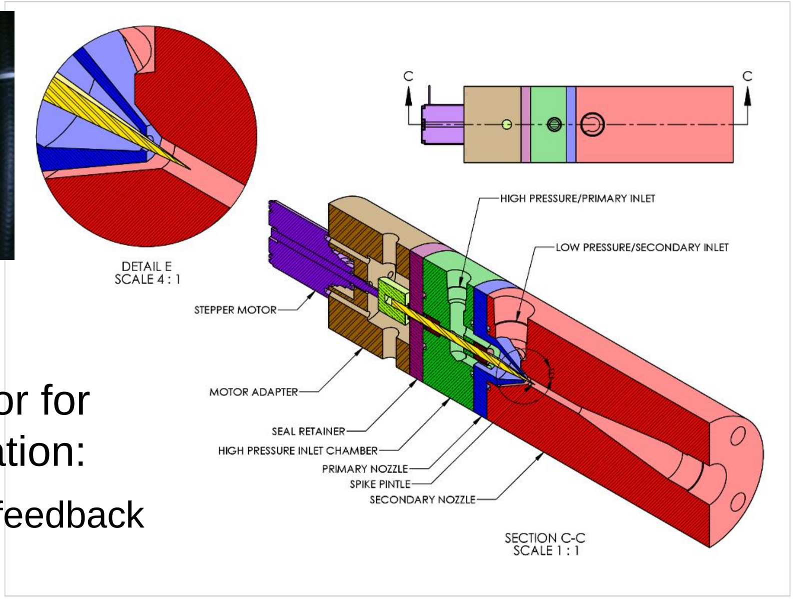

Bus 2


Bus 1



Cell voltage monitoring is an important diagnostic tool for fuel cell stacks and battery systems

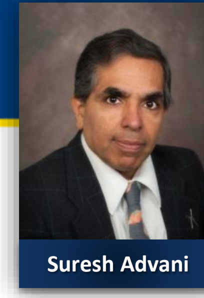




Variable-area Ejector for Hydrogen Recirculation:

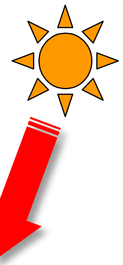
- Simple PI pressure feedback control system
- No moving parts
- Very low power consumption

Patent pending



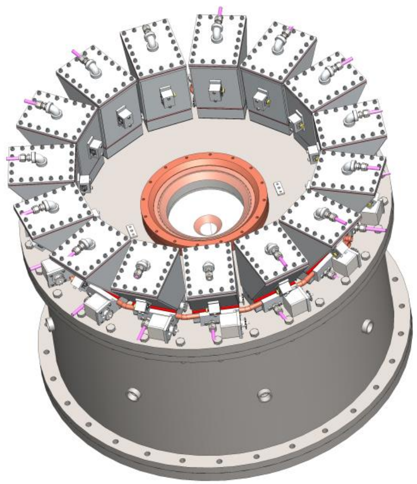
Solar Hydrogen by Thermochemical Cycles

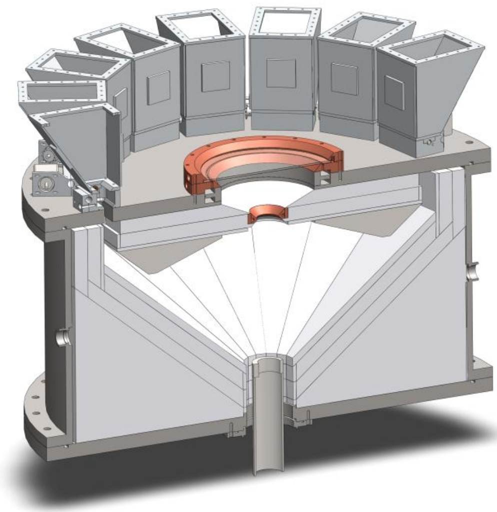
Concentrated sunlight (2000 K)

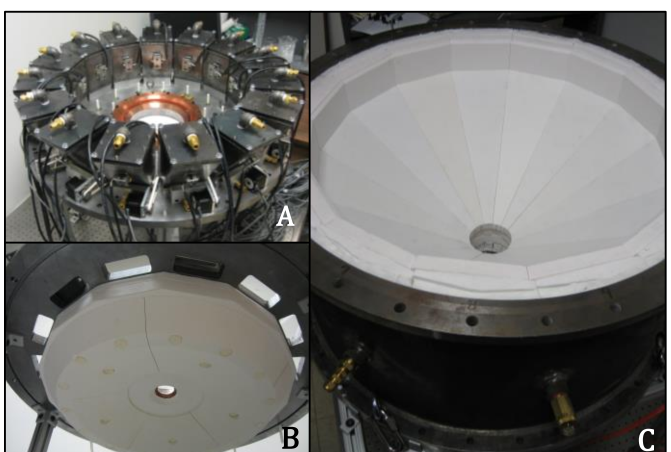


Step 1: $ZnO \rightarrow Zn + \frac{1}{2} O_2$

Step 2: $Zn + H_2O \rightarrow ZnO + H_2$

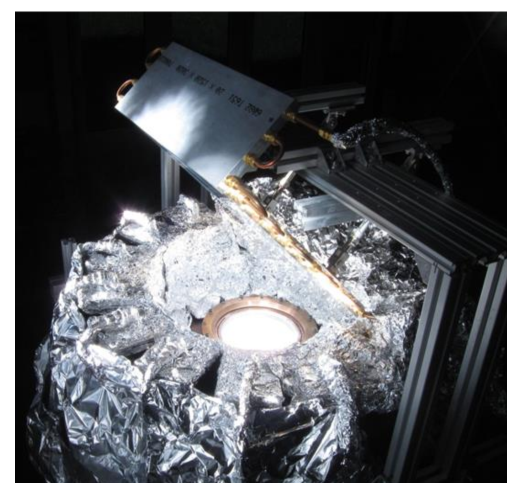






Tested at the Paul Scherrer Institute's high-flux solar simulator in Villigen, Switzerland (May 2012 and March 2013)

- 10 xenon-arc lamps delivering 50kW at a peak radiative flux of 11,000 suns.



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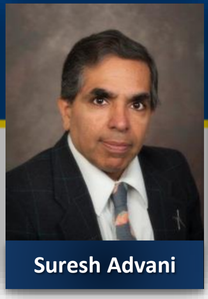
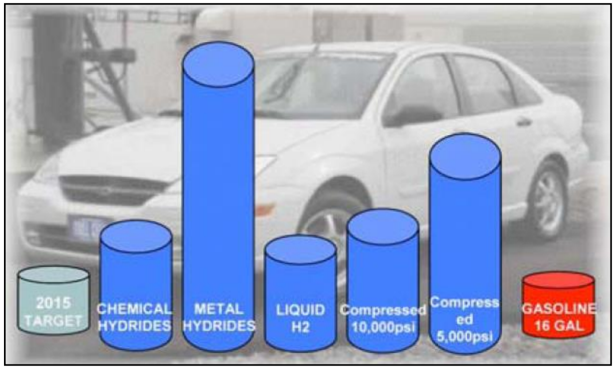
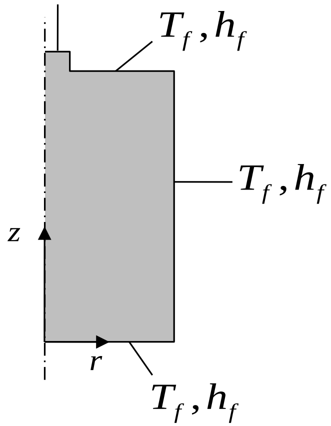
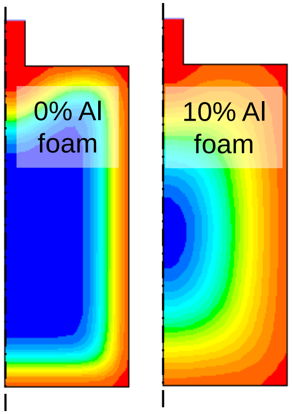


H_2 Storage with Solid-State Materials





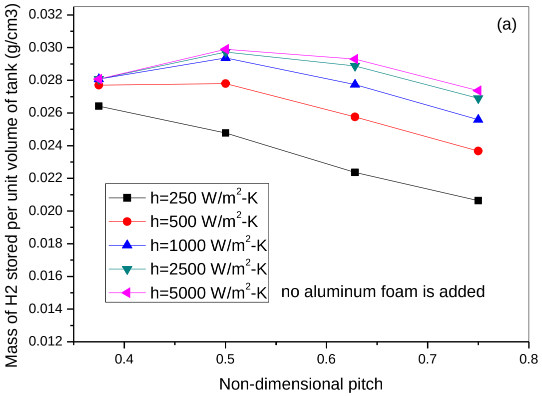
Contours of H2 storage



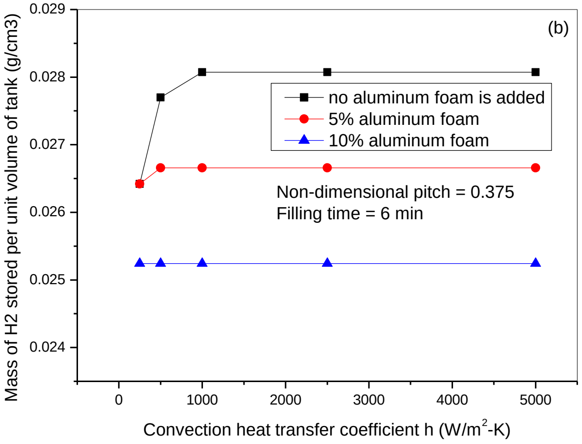
3 min charge

Internal cooling tube

Effect of pitch



Effect of heat transfer coefficient

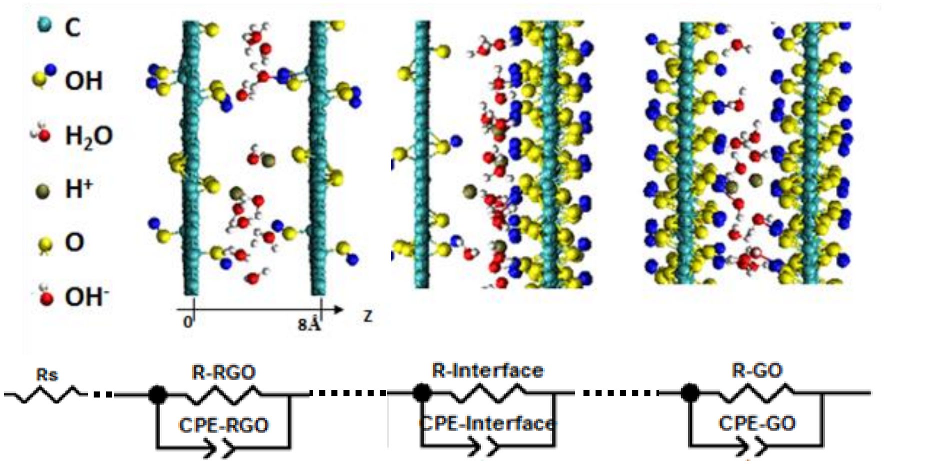


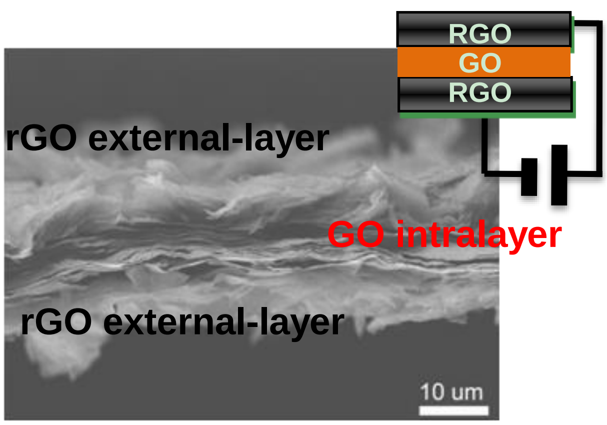
Bingqing Wei

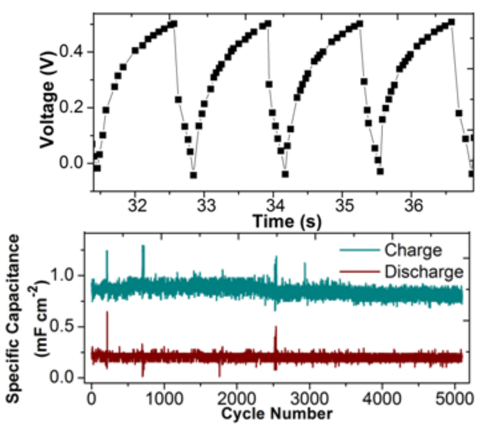
New Capacitive Mechanism for Energy Storage

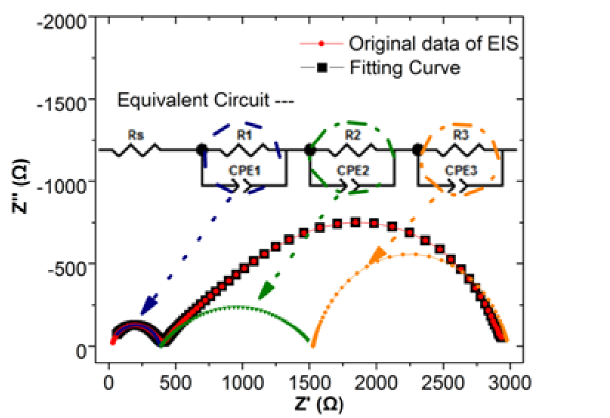
A new energy storage mechanism (Charge Close-Packed Model) is proposed to interpret anomalous capacitive behavior of energy density and ionic diffusion observed in one-body, all solid-state, sandwich-structured capacitor made from reduced graphene oxide films.

Charge Close-Packed Model on rGO/GO/rGO





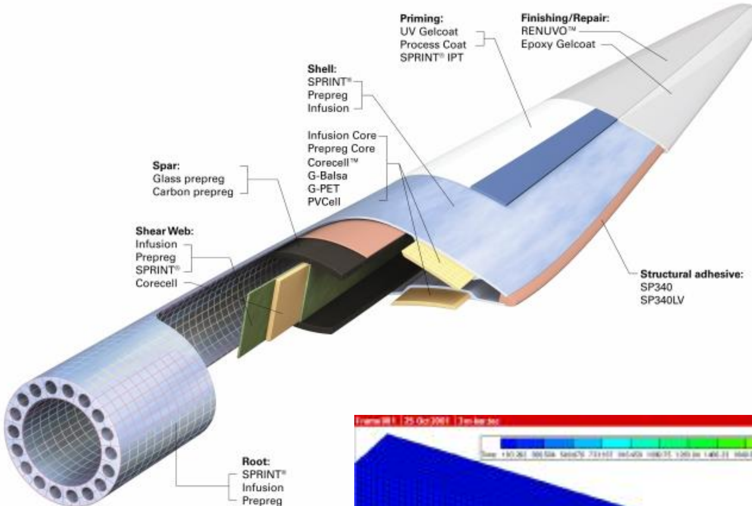


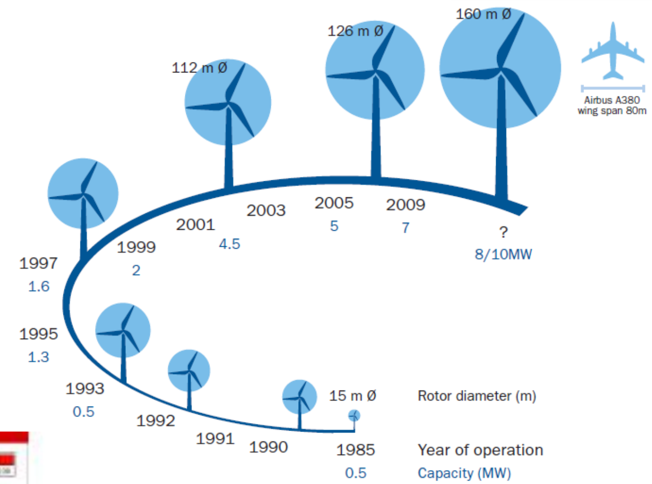


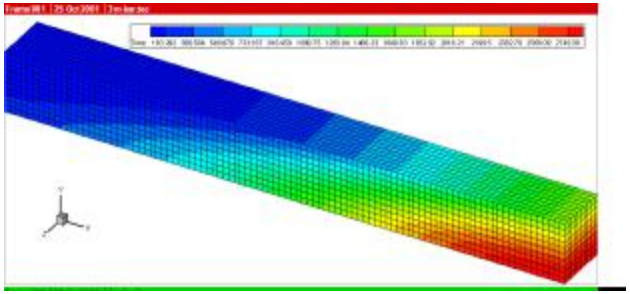
RGO – reduced graphene oxide; GO – graphene oxide

3D Resin Infusion To Simulate Wind Blade Manufacturing

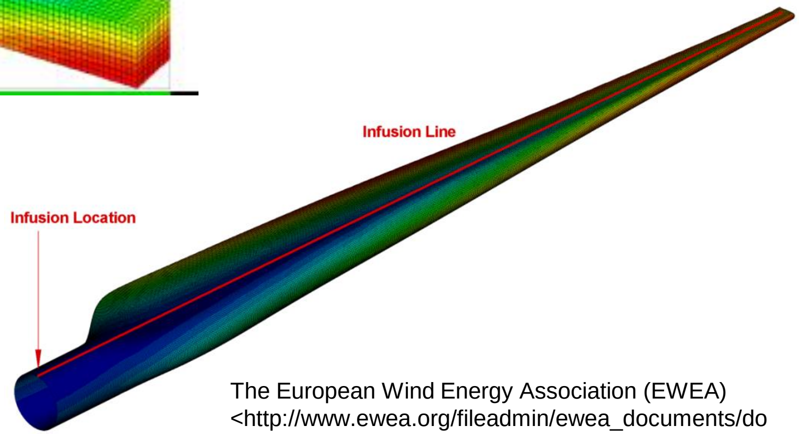
Suresh Advani







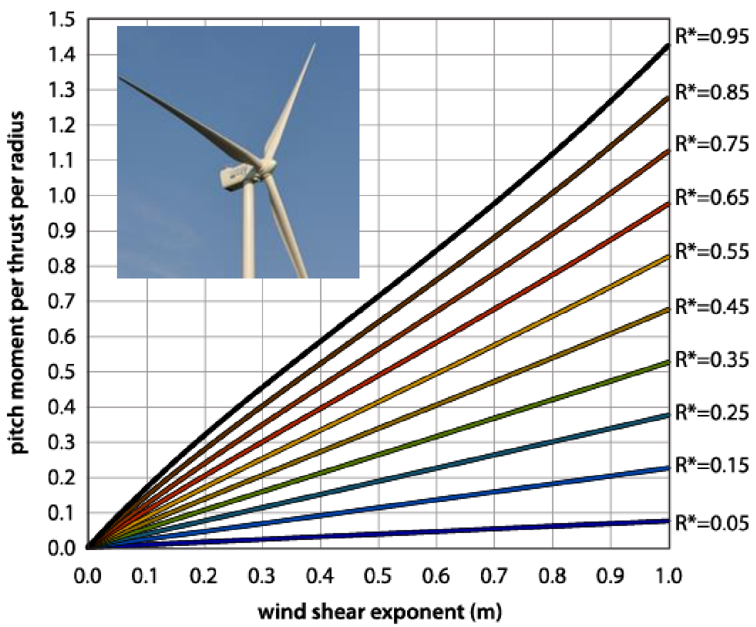
Gurit® - Break Down of a Wind Turbine Blade
http://www.gurit.com/breakdown-of-a-turbine-blade.aspx

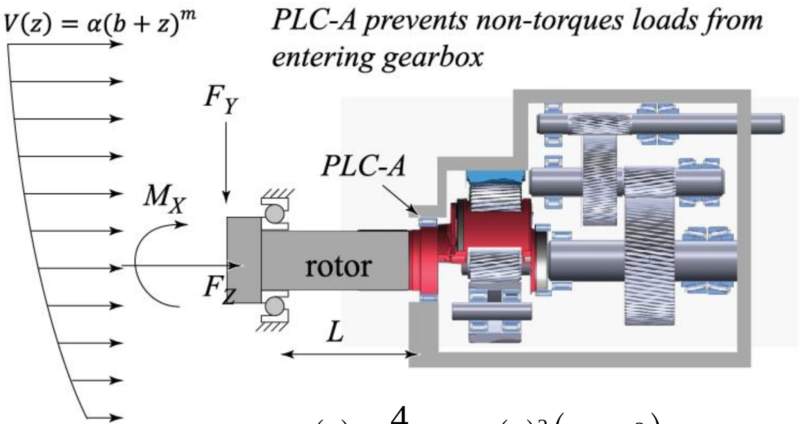


The European Wind Energy Association (EWEA)
<http://www.ewea.org/fileadmin/ewea_documents/documents/publications/factsheets/Factsheets.pdf>

Estimating Wind Turbine Drivetrain Loads

- Premature gearbox failure significantly increases cost of wind power
- It is unclear how non-ideal conditions affect drivetrain loads or reliability
- Smith et al. 2005: failure rates increase with wind shear at night
- Blade element theory: determine effect of wind shear on ***mean*** M_x and bearing load





$$dF(r) = \frac{4}{3}\pi\rho r V(z)^2 \left(a - a^2\right) dr$$

Implications:
Fatigue limit PLC-A = 184 kN (GRC standard)
Smith *et al.*: m_{day} = 0.21 and m_{night} = 0.43
V_{ave}=10 m/s→***F* = 81 kN**, ***T* = 230 kNm**@22RPM

Day: M_x = 254 kNm, F_{PLCA} = 52 kN < limit
Night: M_x = 527 kNm, F_{PLCA} = 219 kN > limit

There is a direct and detrimental effect of wind shear on drivetrain reliability

Environmental Multiphase Flows

Approach: High-performance computing and analytical tools to understand complex multiscale fluid transport/transformation in the environment.

Specific applications:

- *Cloud physics and warm rain formation:* Effect of air turbulence on collision rates and collision efficiency of cloud droplets; impact on warm rain initiation.
- *Soil contamination and soil biodiversity:* Fate of nanoparticles released to the environment; how to model transport and retention of contaminants?
- *Industrial processing of multiphase wastes:* mixing, resuspension, sedimentation, non-Newtonian behavior, and scale-up of particle-laden flow in a controlled mixing vessel.