Metal Oxide Coatings of Carbon Supports for Supercapacitor Applications

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Dr. Timothy J. Boyle
Sandia National Laboratories
Advanced Materials Laboratory
1001 University Blvd SE
Albuquerque, NM 87106
Phone:(505) 272-7625
Fax: (505) 272-7336
Email: tjboyle@sandia.gov

Prof. Sang M. Han
University of New Mexico
Department of Chemical & Nuclear Engineering
209 Farris Engineering Center
Albuquerque, NM 87131
Phone:(505) 277-3118
Fax: (505) 277-5433
Email: meister@unm.edu

Dr. Charles D. E. Lakeman
TPL, Inc.
3921 Academy Parkway North, NE
Albuquerque, NM 87109
Phone: 505/342-4427
Fax: 505/343-1797
E-mail: clakeman@TPLINC.com
http://www.tplmicropower.com

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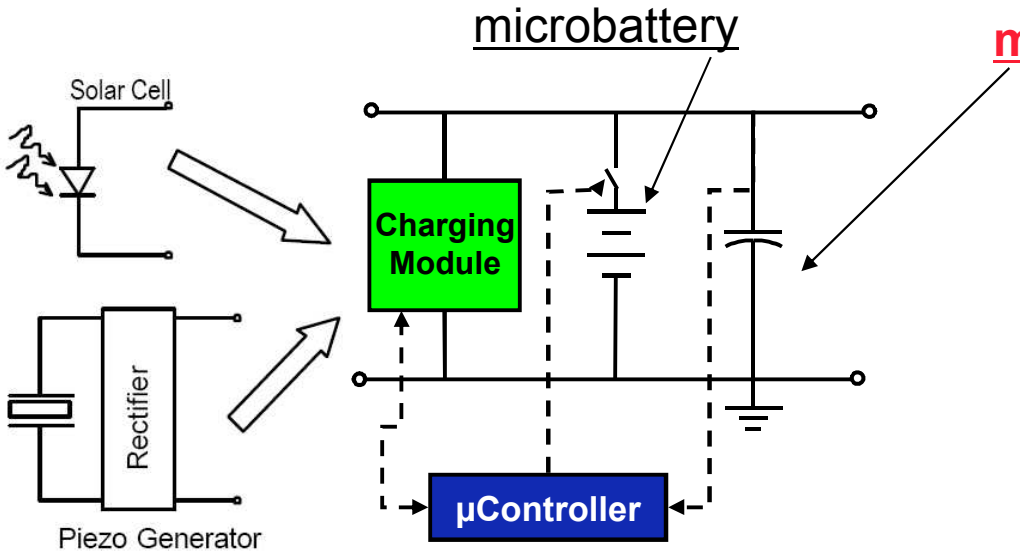
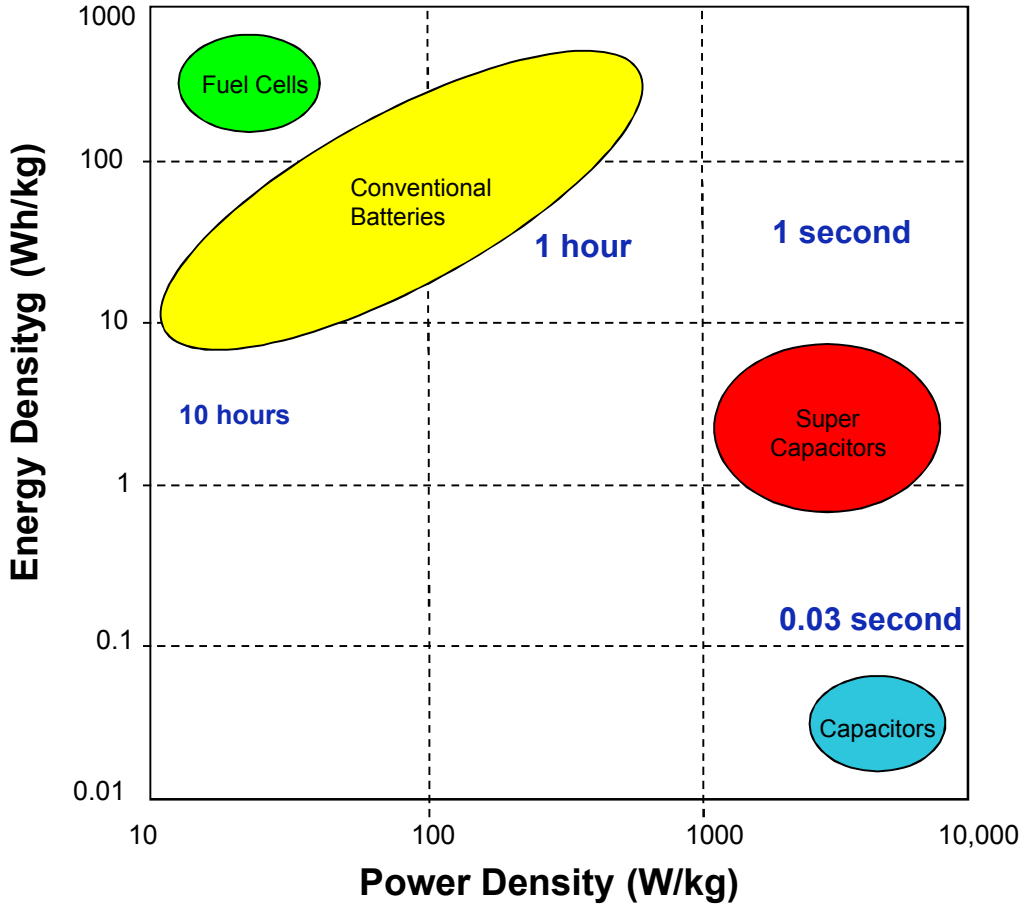
Microsupercapacitors are a critical component of TPL's EnerPak™



- Harvester provides trickle charge
- Output voltage always on
- Output can be configured for 3V, 5V or 9V
- Microsupercapacitor delivers short, high power pulses
- Microbattery is used for back-up power
  - –switched in when harvester output decreases or fails

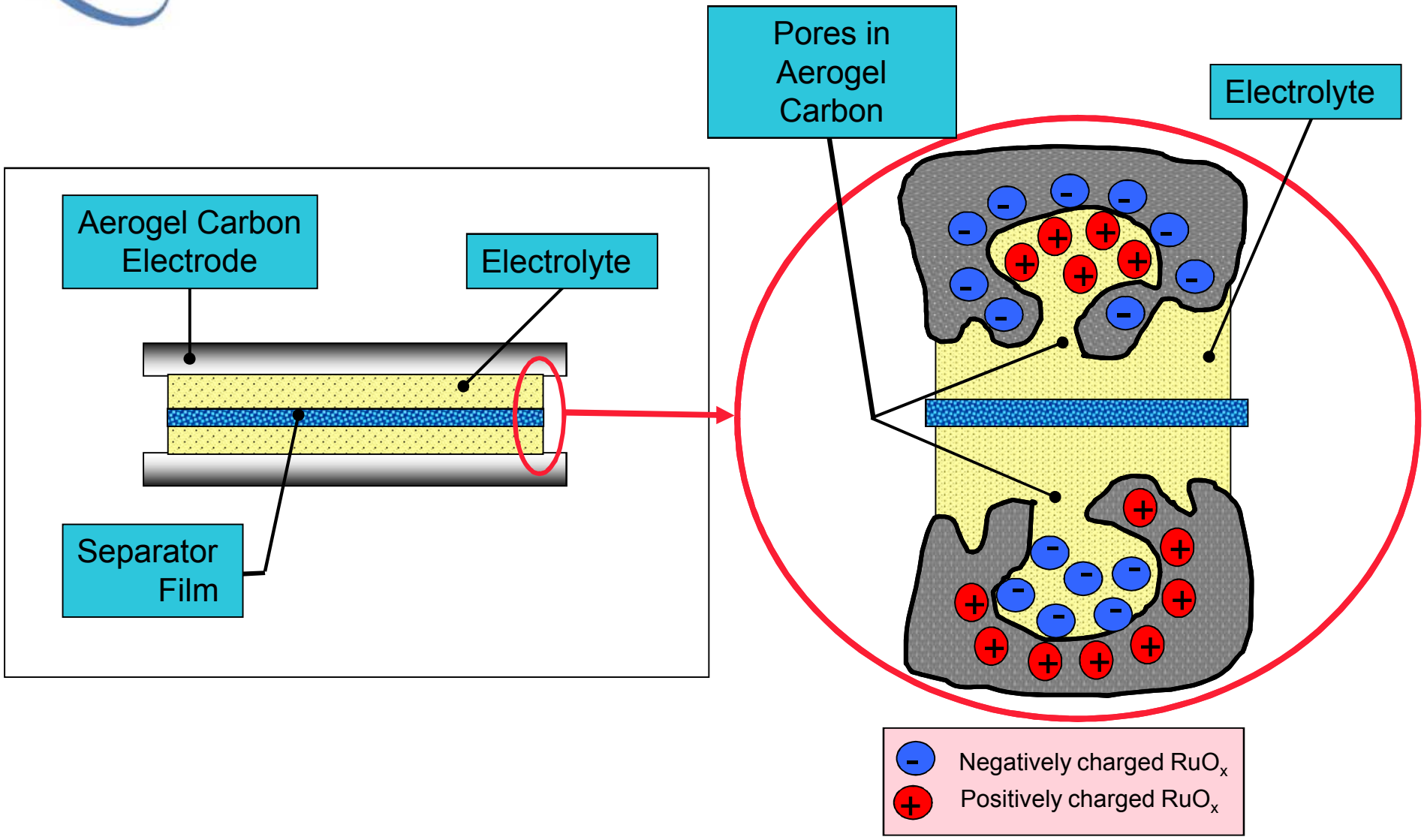
What is a Supercapacitor?

capacitor - an electrical device that can store energy



Supercapacitor - electrochemical capacitor that has an unusually large amount of energy storage capability relative to its size

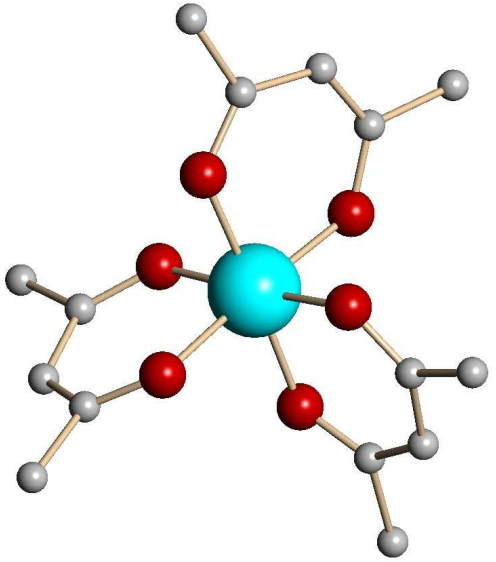
Double layer of charge accumulates on the surface of a supercapacitor.



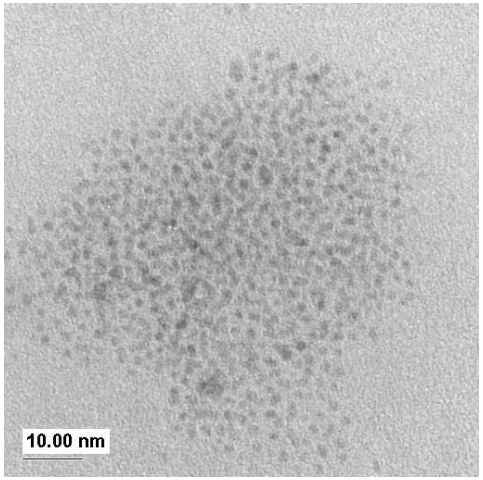
RuO_x undergoes faradaic reactions to provide “pseudo-capacitance” - an increase over the conventional electrostatic capacitance, increasing the energy density ($E=1/2CV^2$).

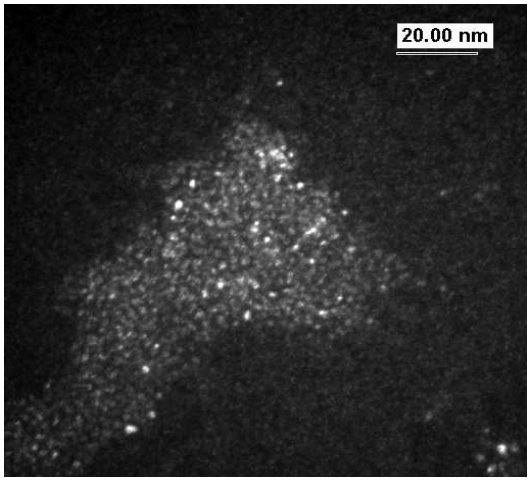
New problems

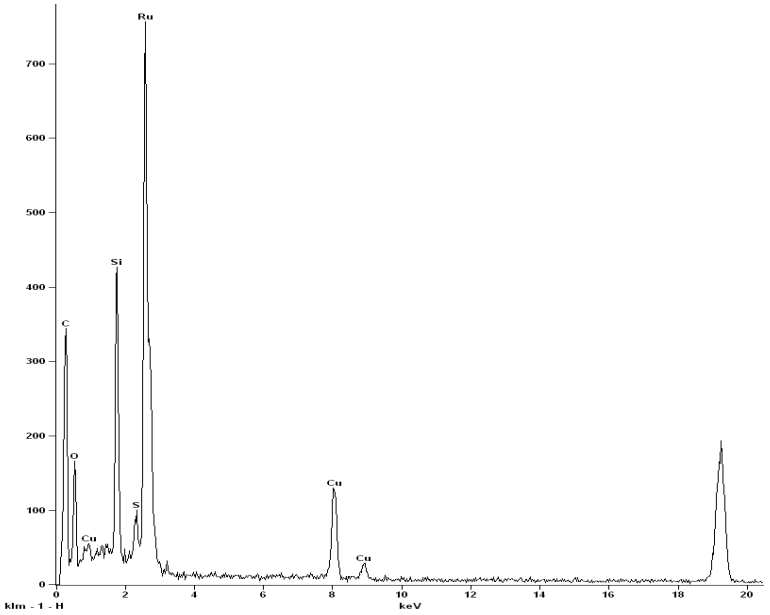
1. Nano sized RuO_x
2. Size specificity of RuO_x
3. Functionalization of RuO_x
4. Testing of results



$Ru(acac)_3$



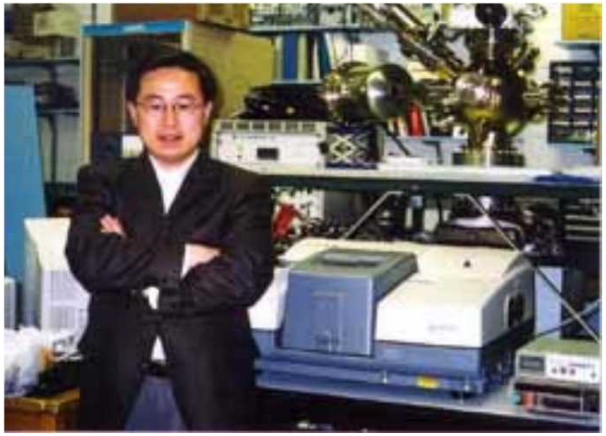




Diverse Research From an Experienced Team

Dr. Timothy J. Boyle
Sandia National Laboratories

Areas of Research
- Inorganic Synthesis
  - + metalorganic - metal alkoxides
  - + organometallic
- Materials Synthesis/Processing
  - + Sol-Gel
  - + MOCVD
  - + Nanoparticles



Prof. Sang Han
University of New Mexico

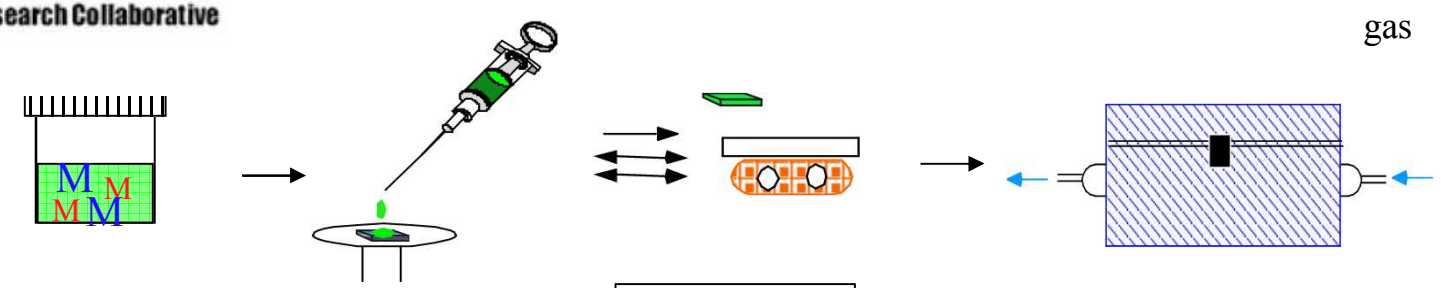
- Semiconductor Manufacturing Technology
- Plasma Etching and Deposition

Dr. Charles D.E. Lakeman
TPL, Inc.

TPL µPOWER
Powering the Wireless Sensor Revolution

- Minaturized electrochemical storage devices
  - + microbatteries
  - + microsupercapacitors
- Micropower systems
  - + Energy harvesting
  - + Low power charging

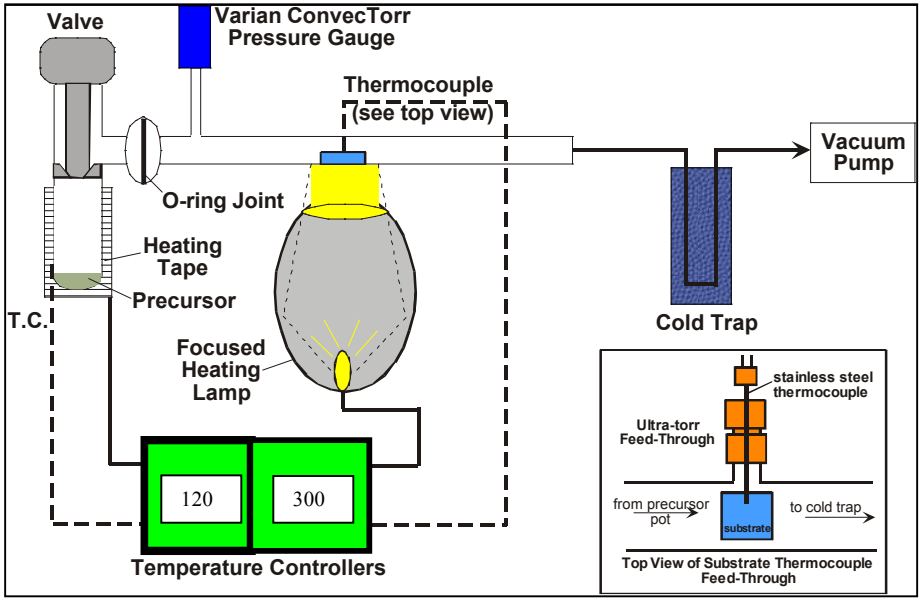
Inorganic chemistry for various applications

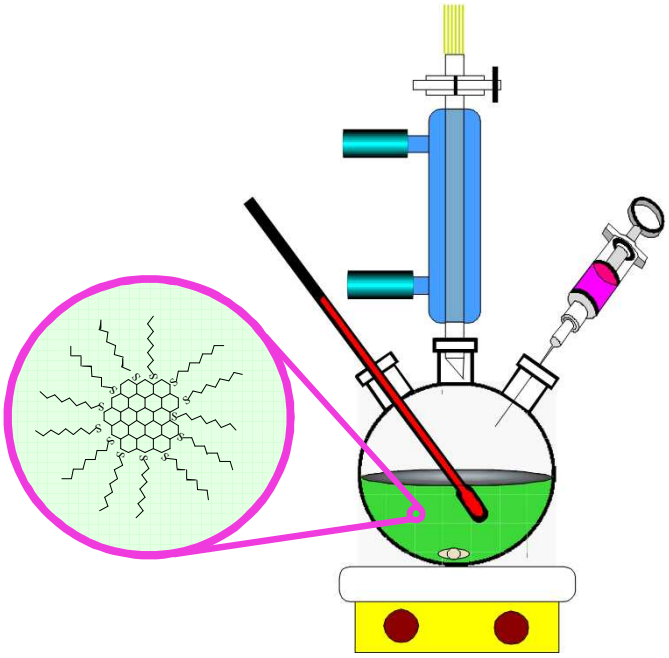


Sol-Gel

MOCVD

Nanoparticles





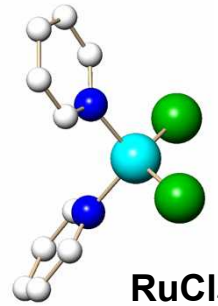
Goal: Develop tailor-made precursors to generate optimized materials.

Novel Precursors to RuO_x Required

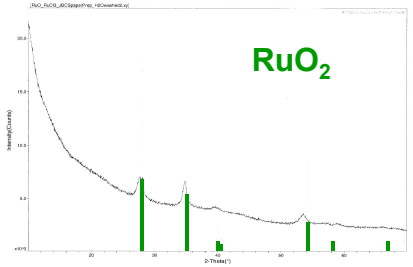
Most literature RuO_x solution preparative routes for RuO_x involve $RuCl_3$.

- Chi-Chang Hu et. al. *Elec. Chem. Soc.* (**2004**).
- L.M. Rossi et. al. *J. Brazilian Chem. Soc.* (**2004**).

Harry Pratt



$RuCl_2py_2$



Alkyl and Amides

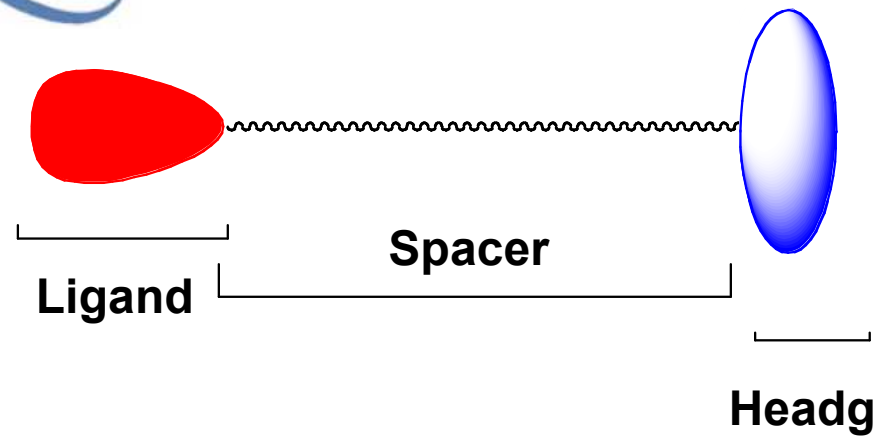
$$RuCl_3 + 3\,MR \longrightarrow Ru(R)_3$$
$$RuCl_3 + 3\,M(NR_2) \longrightarrow Ru(NR_2)_3$$

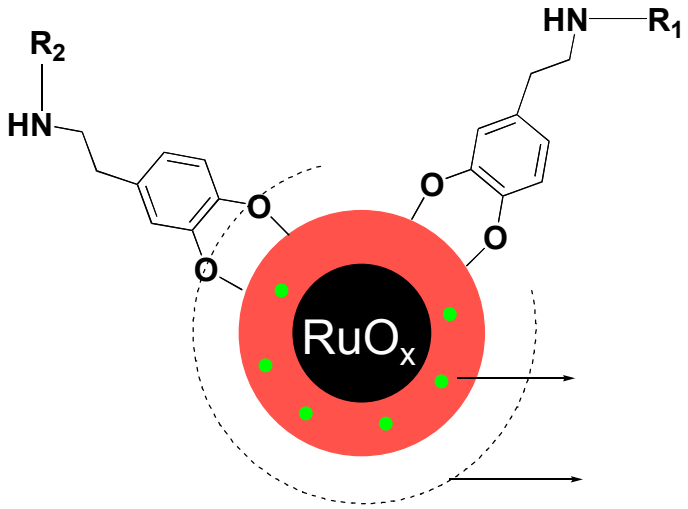
Alkoxide

$$Ru(R)_3 + 3\,HOR \longrightarrow Ru(OR)_3$$
$$Ru(NR_2)_3 + 3\,HOR \longrightarrow Ru(OR)_3$$

Louis Tribby

Functionalization of RuO_x

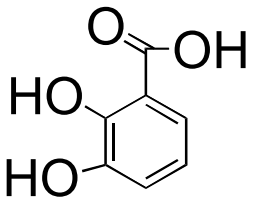


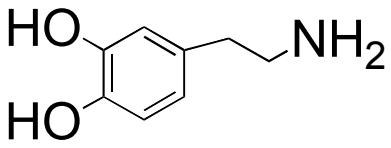


Ligands: catechols, carboxylates, phosphates etc. ***(things that like to bind to ceramic surfaces)***

Spacers: hydophobic, hydrophillic

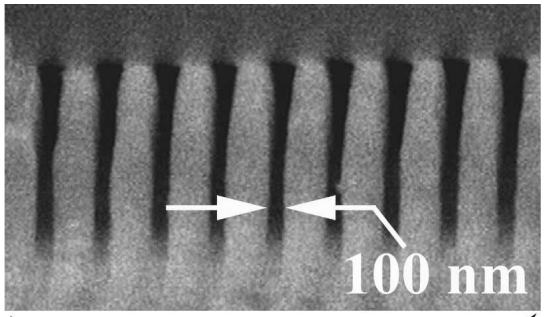
Headgroups: Carboxylates ***[anionic (-)]*** or amines ***[cationic (+))***



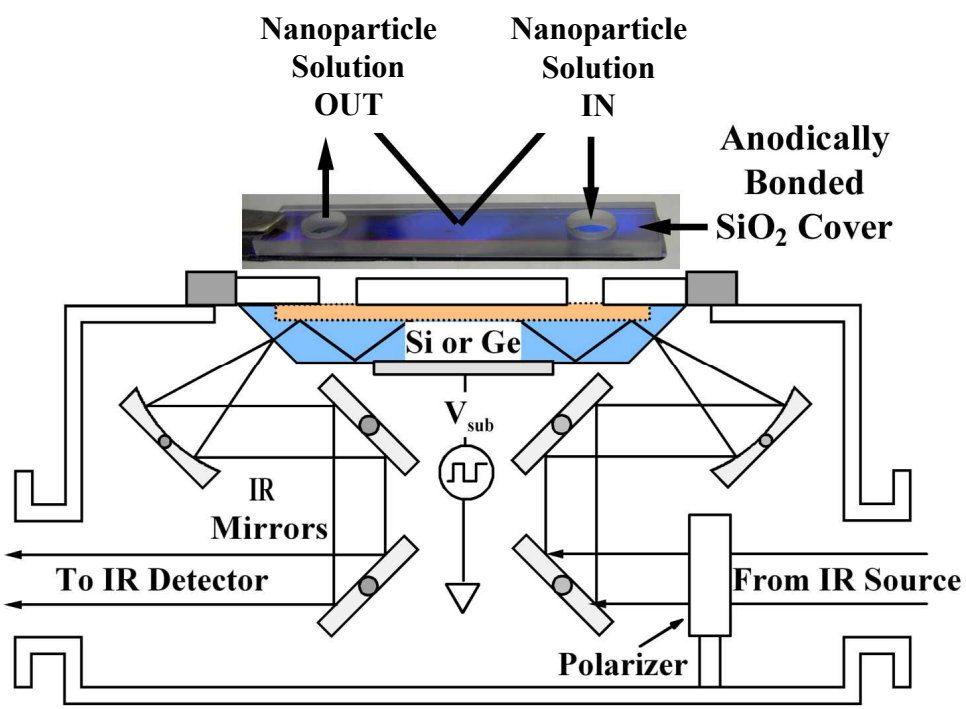


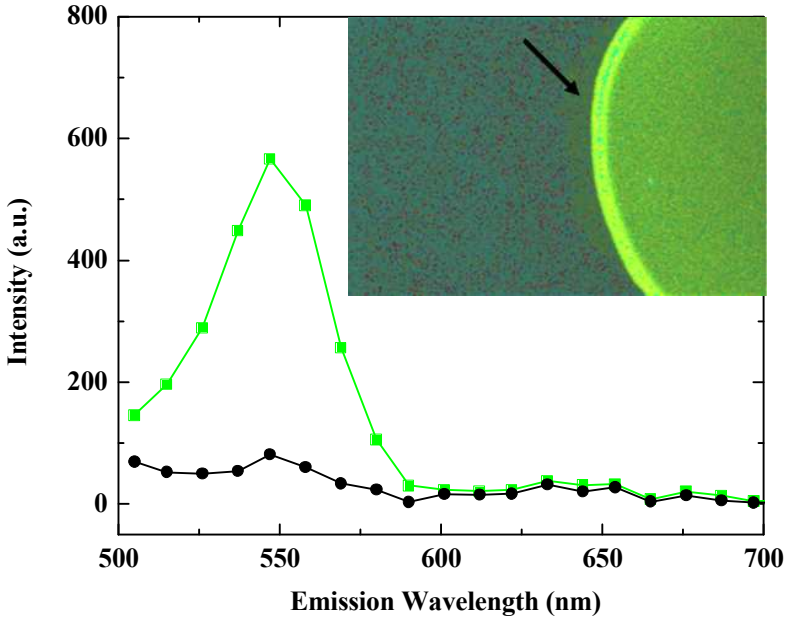
Nanoparticle Separation and Size-Focusing Through Nanochannels

Separation by fractionation
Investigation of particle transport
Confocal fluorescence microscopy
Infrared spectroscopy

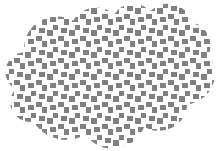


Nanochannels





Assembly and Testing of Supercapacitor



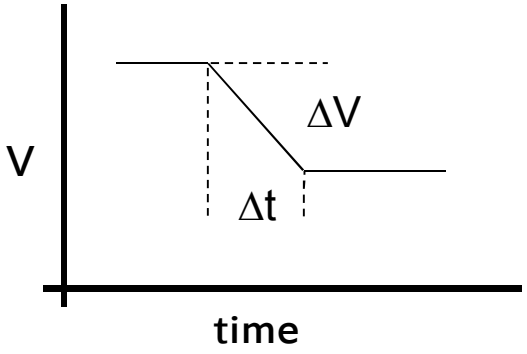
Powder received from Sandia/UNM

Form electrode sheets

Assemble coin cells for testing

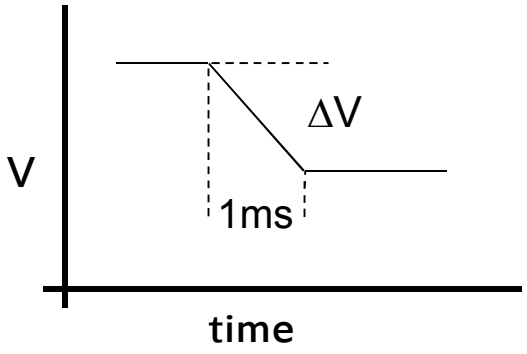
ARBIN BT2000

Discharge at rated current, I

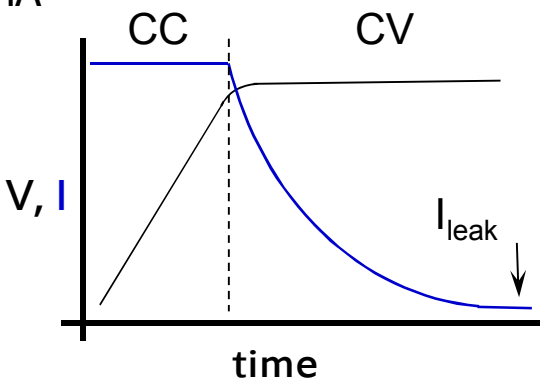


$$C = \frac{I\Delta V}{\Delta t}$$

Discharge at constant current, 9mA



$$ESR = \frac{\Delta V}{9mA}$$



$$P = \frac{\Delta E}{\Delta t} = \frac{C(V_{max}^2 - V_{min}^2)}{2\,\Delta t}$$

Rated current is that constant current at which the capacitor voltage, V, is reduced to V/2 in 5s

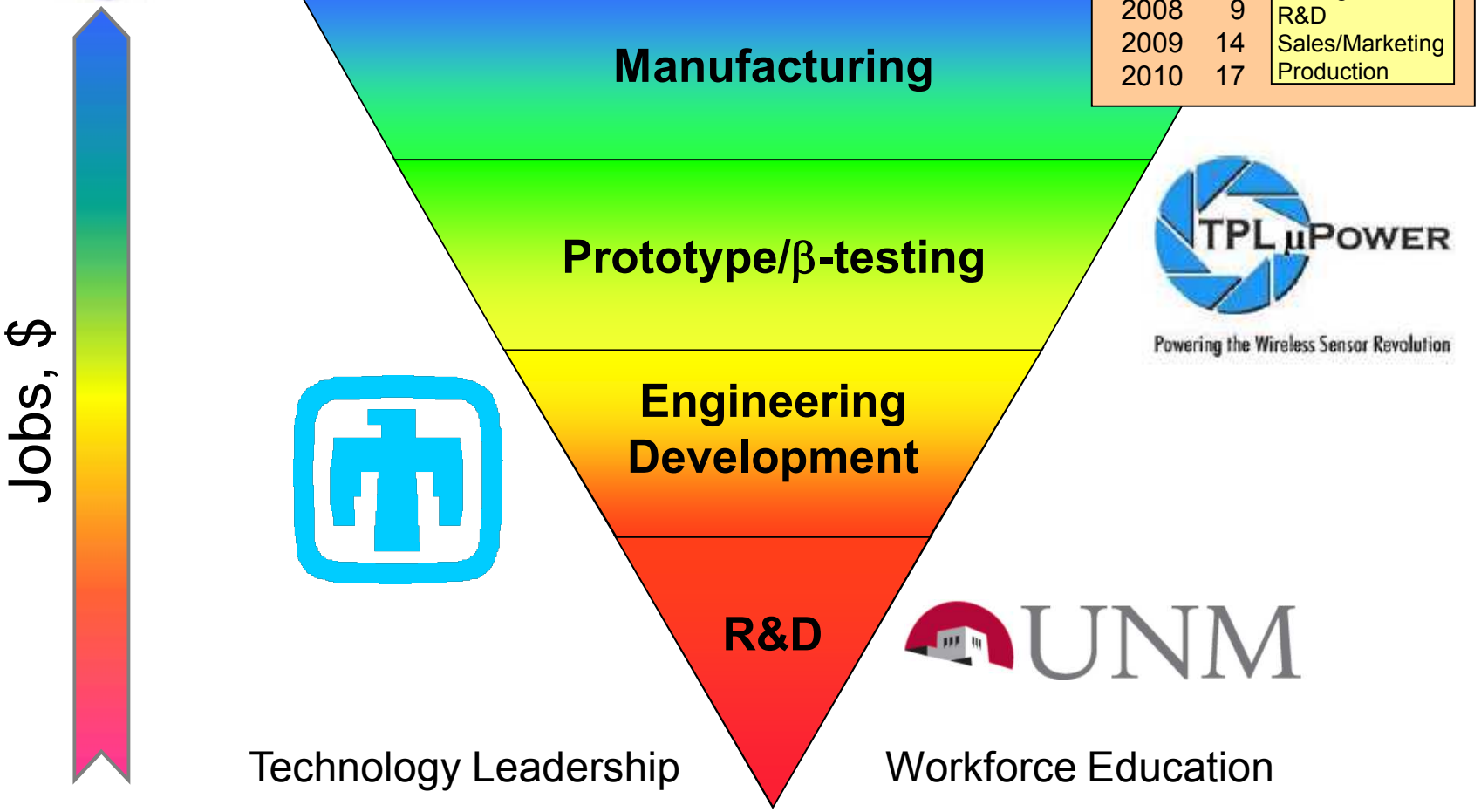
Impact on New Mexico

TRC New Mexico
Technology Research Collaborative

Spin-off Company

Total Staff	
2008	9
2009	14
2010	17

Management
R&D
Sales/Marketing
Production



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UNM

AML
Advanced Materials Laboratory

Microsupercapacitor Gantt Chart