



# *Commercializing CNT Materials for Coatings & Composites*

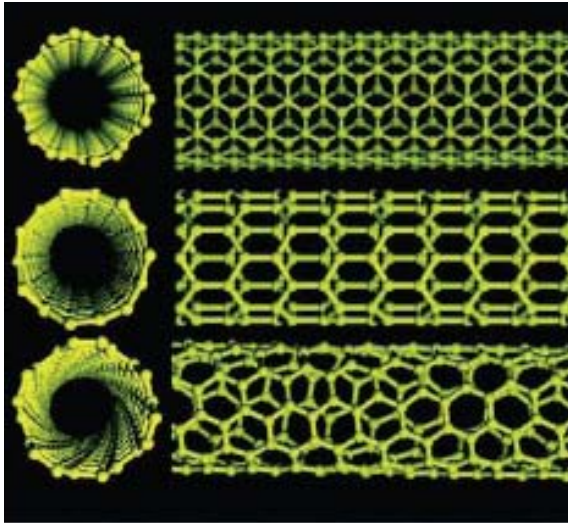
David J. Arthur, CEO  
SouthWest NanoTechnologies, Inc.  
<http://swentnano.com>

New England  
Nanomanufacturing  
Summit  
June 23, 2010

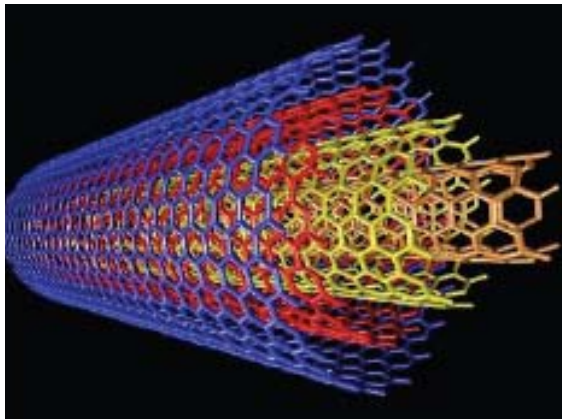


# Carbon Nanotubes

Single-wall



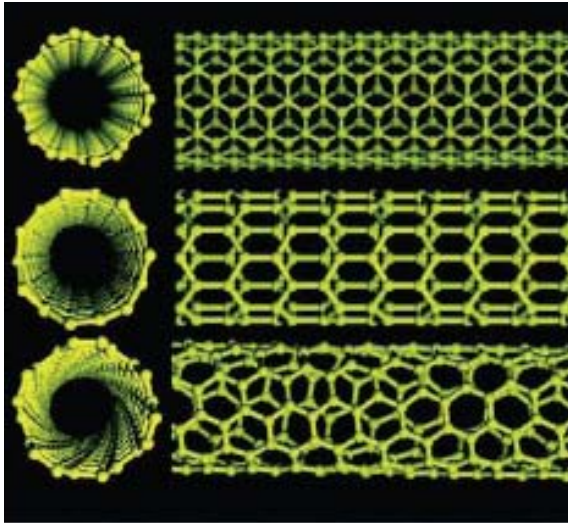
Multi-wall



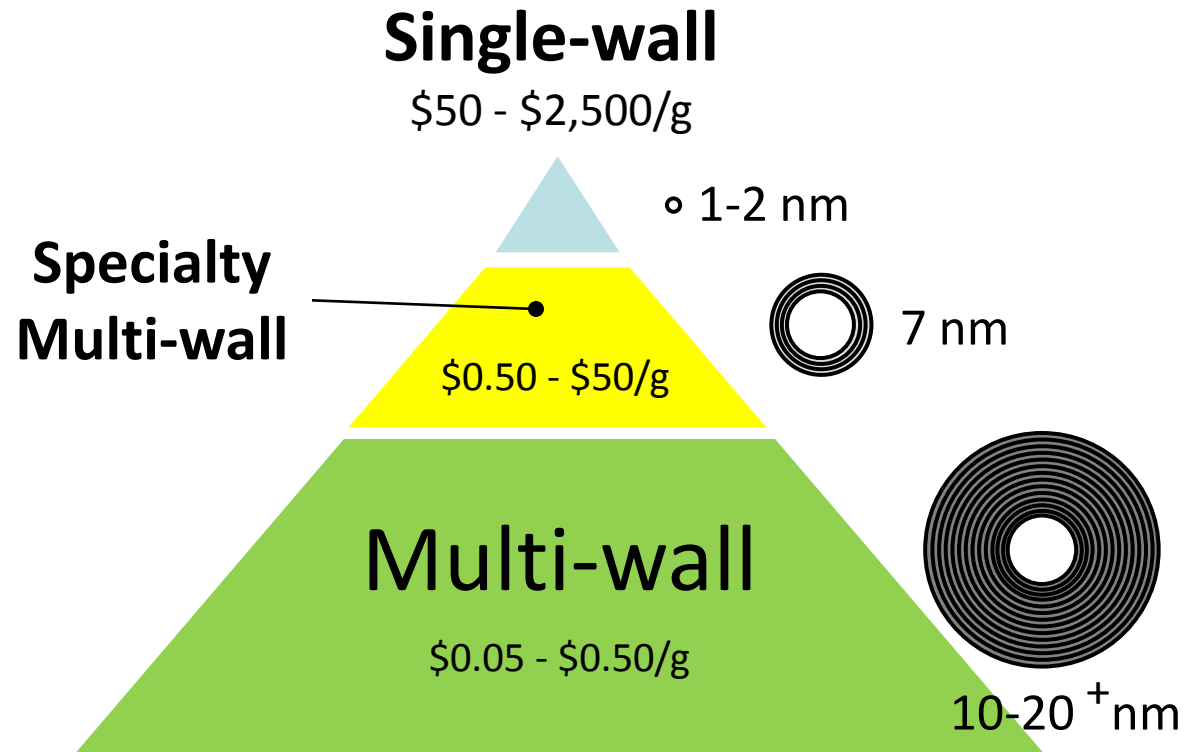
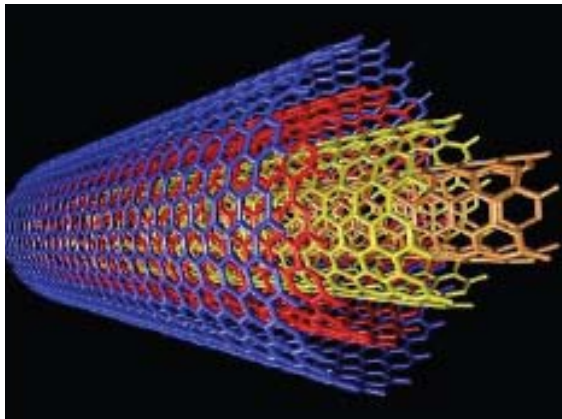
- Hollow Graphite Tubes
  - Strong, Light & Flexible
  - Conduct Electricity & Heat
  - Chemistry of Carbon
- Nanoscale Diameter
  - Huge Surface Area
  - Molecular Scale Interactions
- High Aspect Ratio
  - Low Percolation Level
  - Robust Networks

# Carbon Nanotubes

Single-wall



Multi-wall



# Leading Manufacturer

## Single-wall & Specialty Multi-wall CNTs



2001

Founded



Dr. Resasco



2008

Large Scale Production



Norman, OK

2009

“The Standard”

NIST

*Standard Reference  
Material for CNTs*

2010

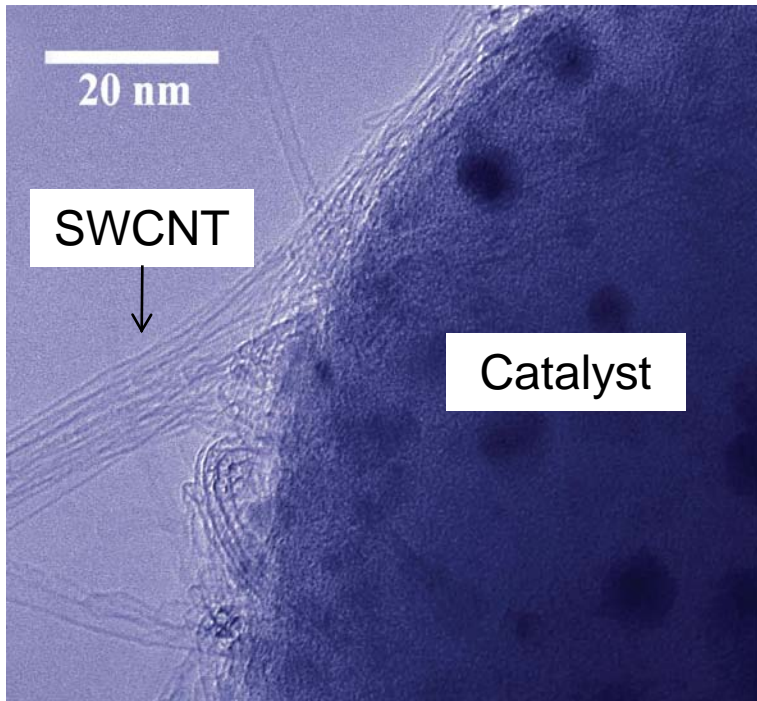
“Best Practices”

F R O S T & S U L L I V A N

*North American Technology  
Innovation Award for Best  
Practices in the Field of CNTs*

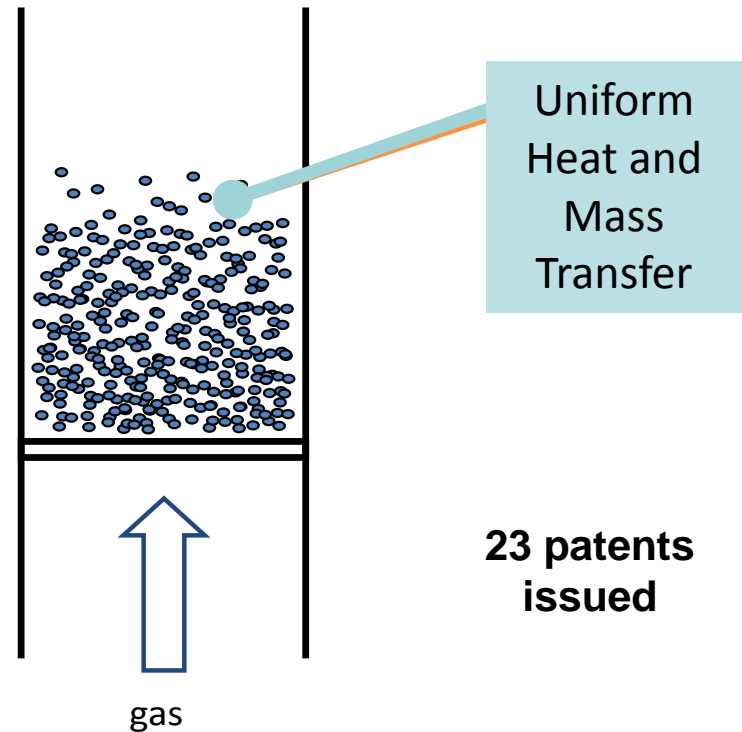


# CoMoCAT<sup>®</sup> process



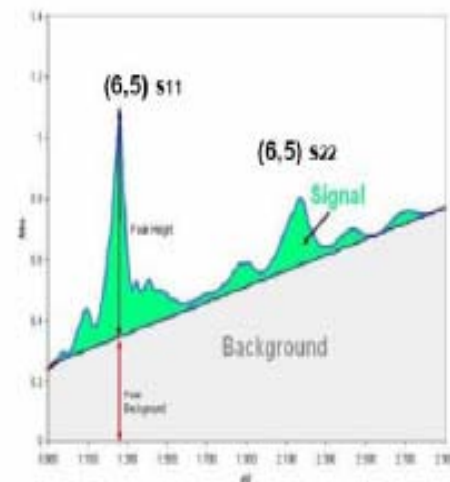
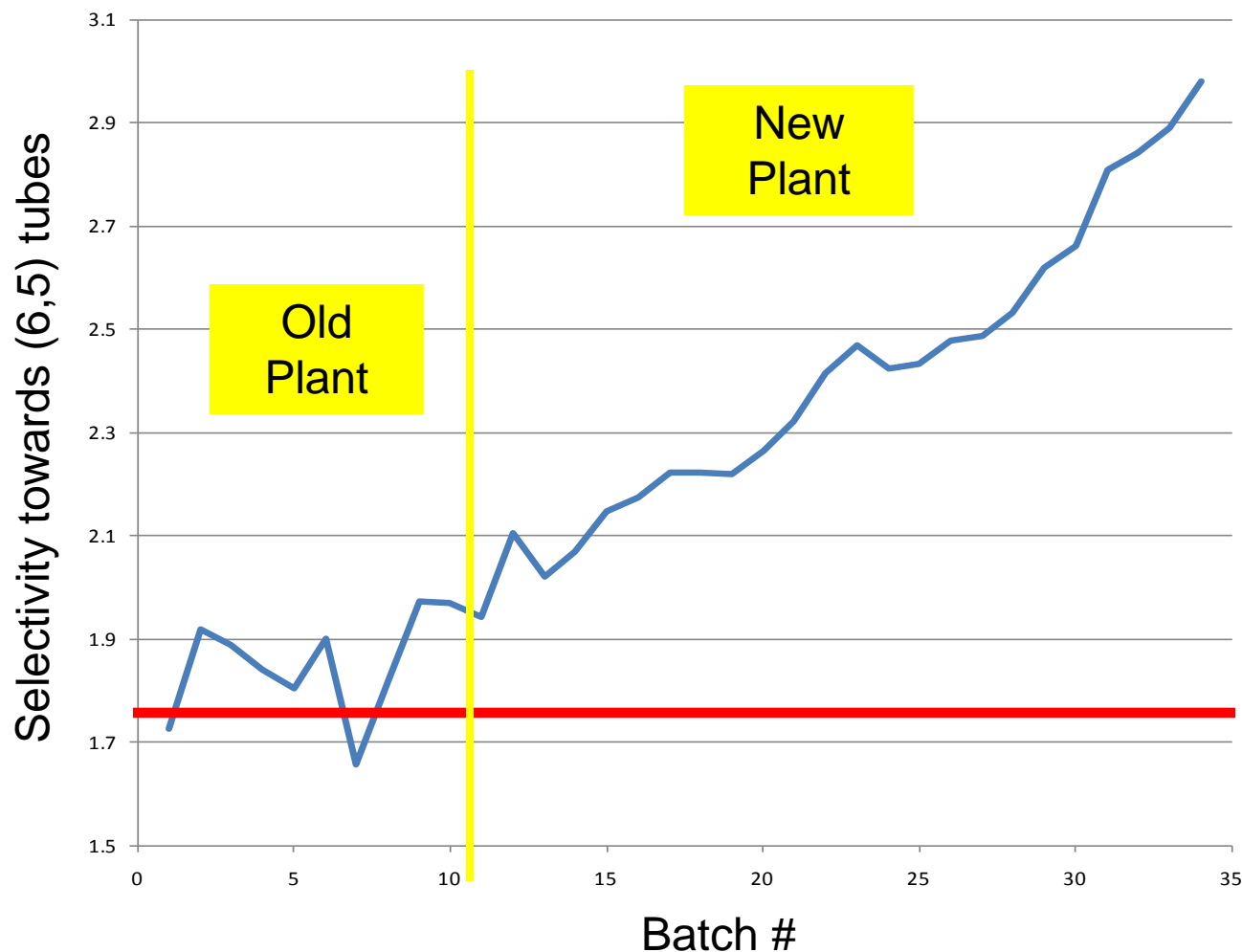
**Proprietary Catalyst  
(Selective Synthesis)**

**Fluidized Bed  
(Inherently Scalable)**



# Selective Synthesis

SG-65 Quality (P2B)

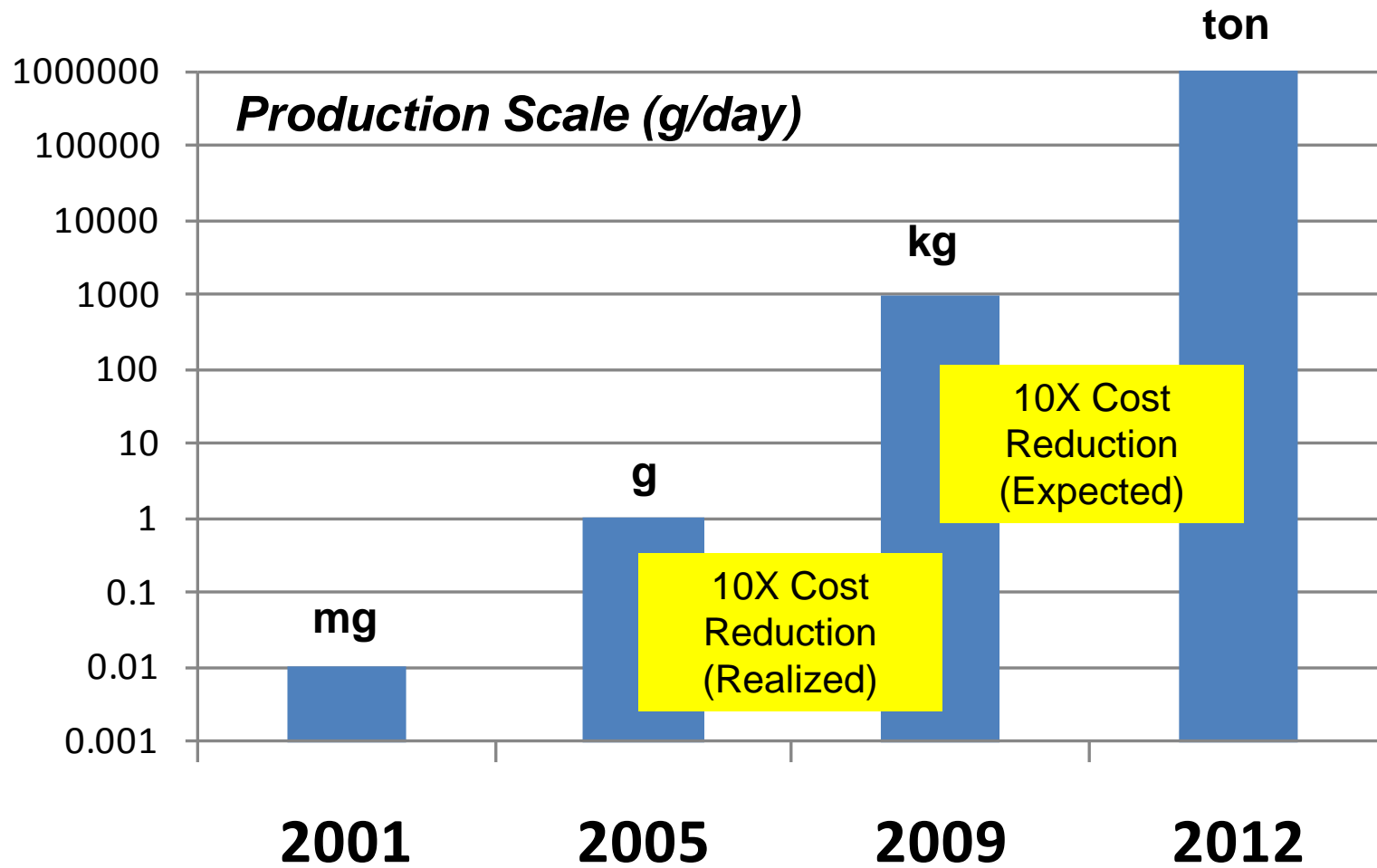


— P2B Moving Average

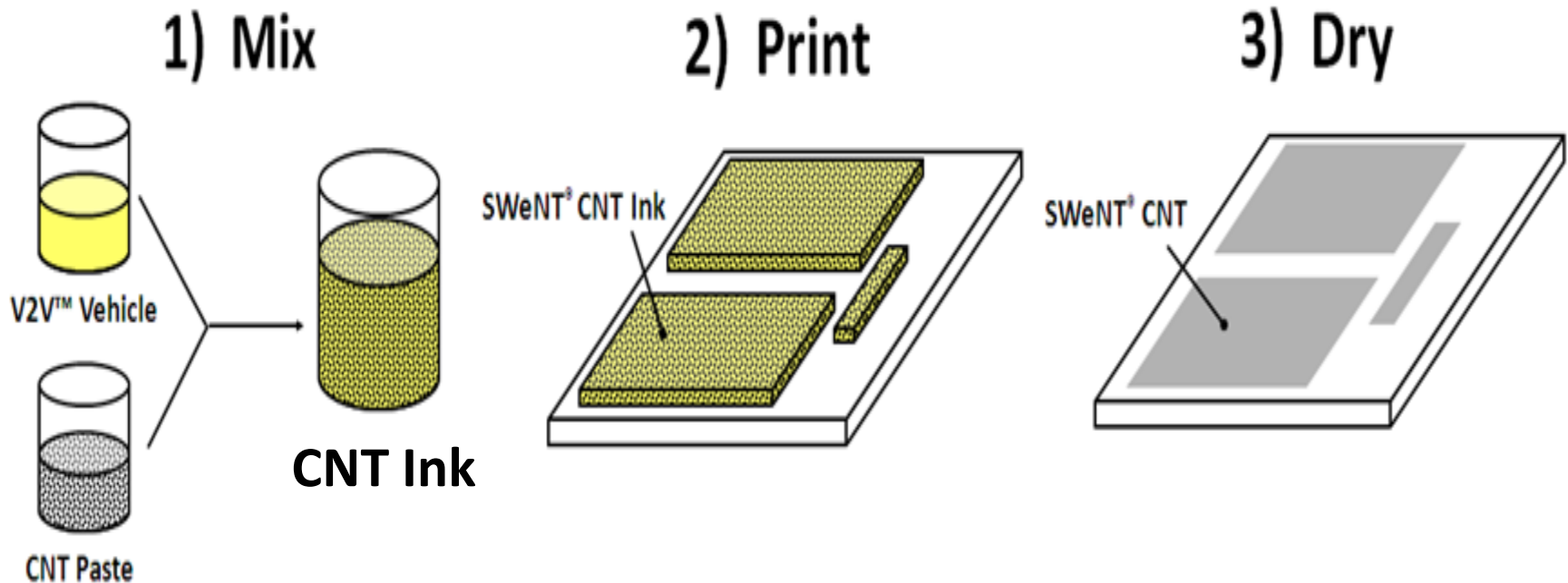
Spec for Standard Product

$\geq 90\%$  SC  
 $\geq 40\%$  (6,5)

# Economies of Scale



# V2V™ Ink Technology\*



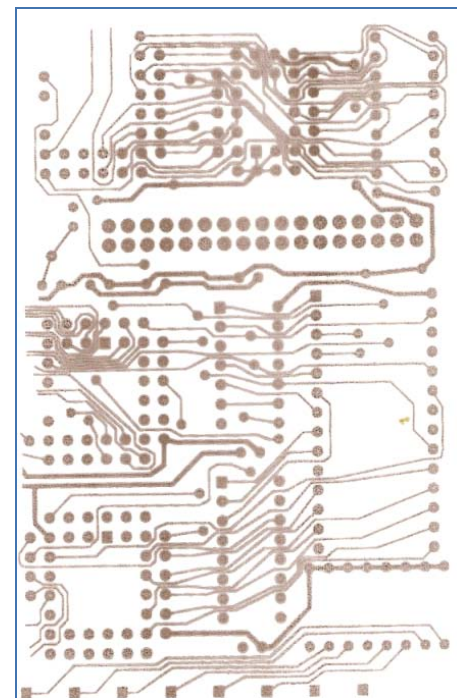
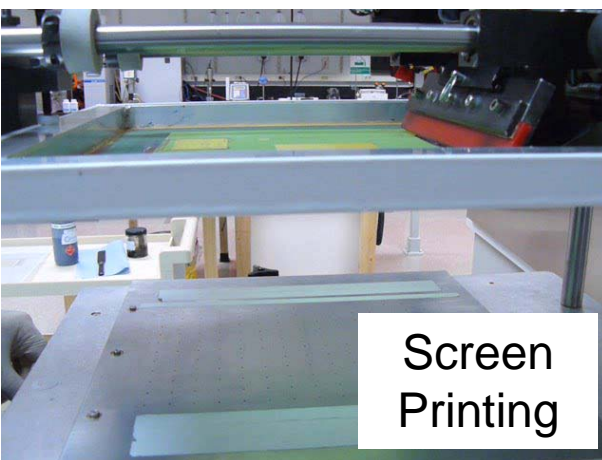
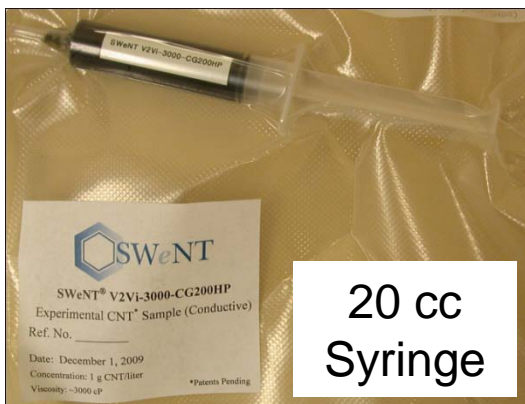
CNTs can be printed using Standard Industrial Printing Equipment

\* Patents pending





# V2V™ Ink Technology\*



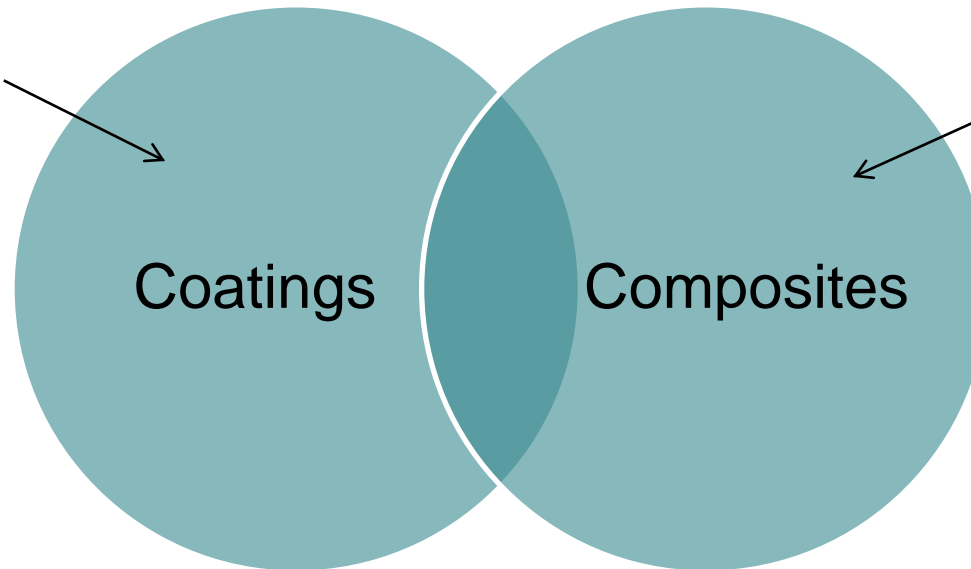
\* Patents pending



## “Tailor Tubes” for Target Applications

### Single-wall

SG65  
SG76  
CG100  
CG200  
& more



**SMW™**

## Deliver “Total Product Solutions”

Product Forms that are Easy and Safe to Use.

Collaboration with Alliance Partners and Customers.

# CNT Inks Collaboration



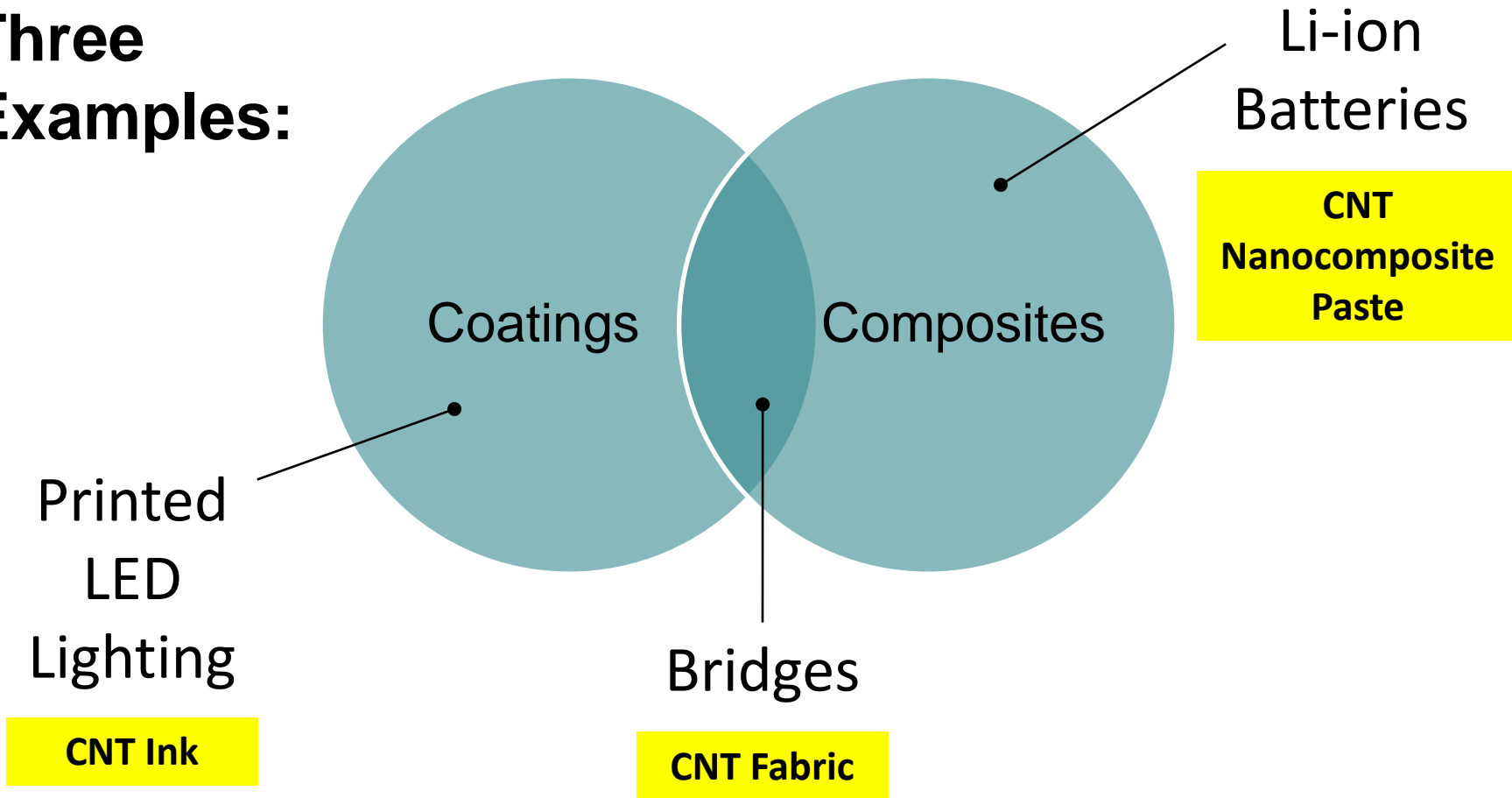
“Brewer Science and  
Southwest NanoTechnologies  
Announce \$6.5 Million NIST  
TIP Award”



High Quality, Low Cost  
Semiconducting &  
Metallic Enriched  
CNT Inks

# Commercialization

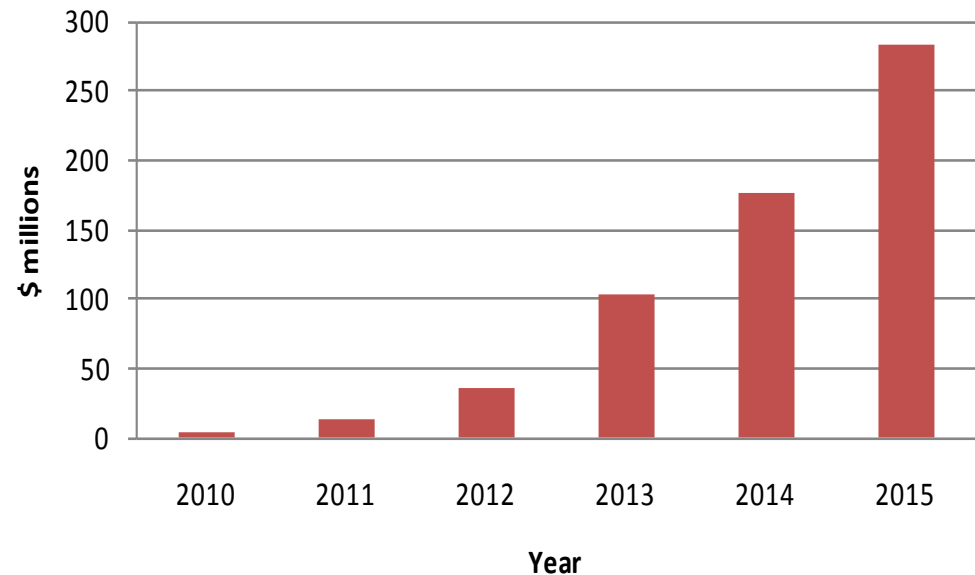
## Three Examples:



# Printed Electronics



## CNT for Printed Electronics Market



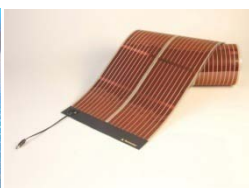
LED Lighting



Displays



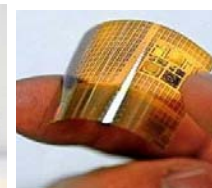
Solar



TFTs



RFID

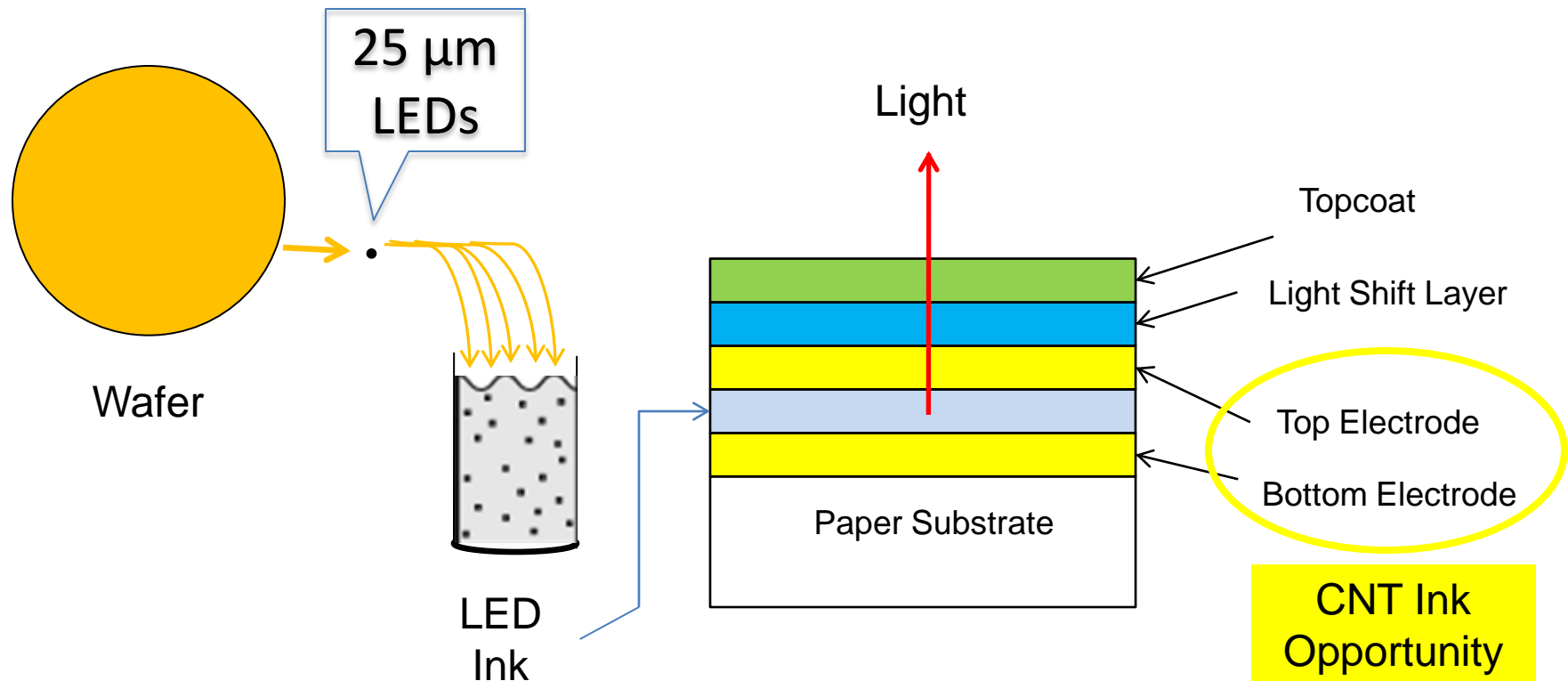


Sensors





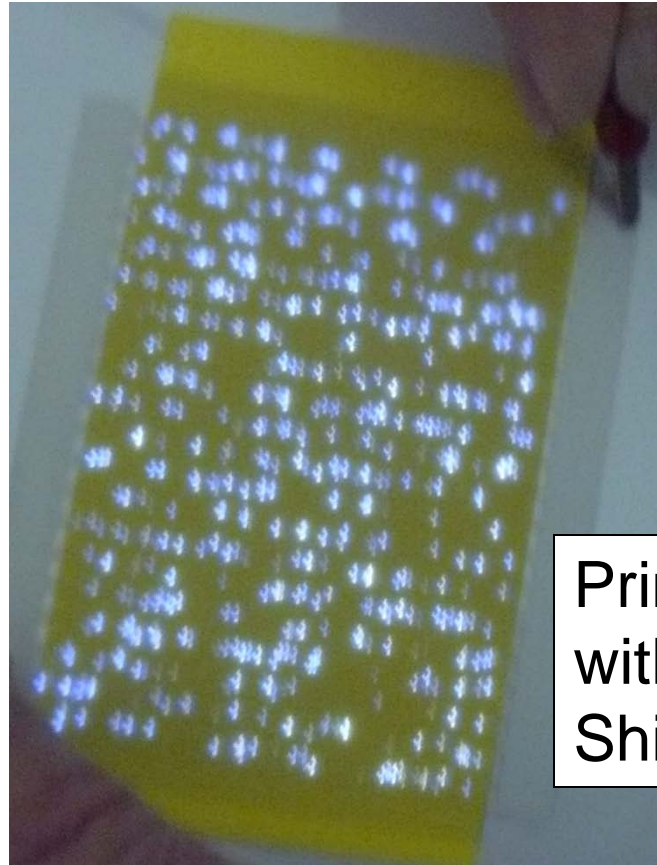
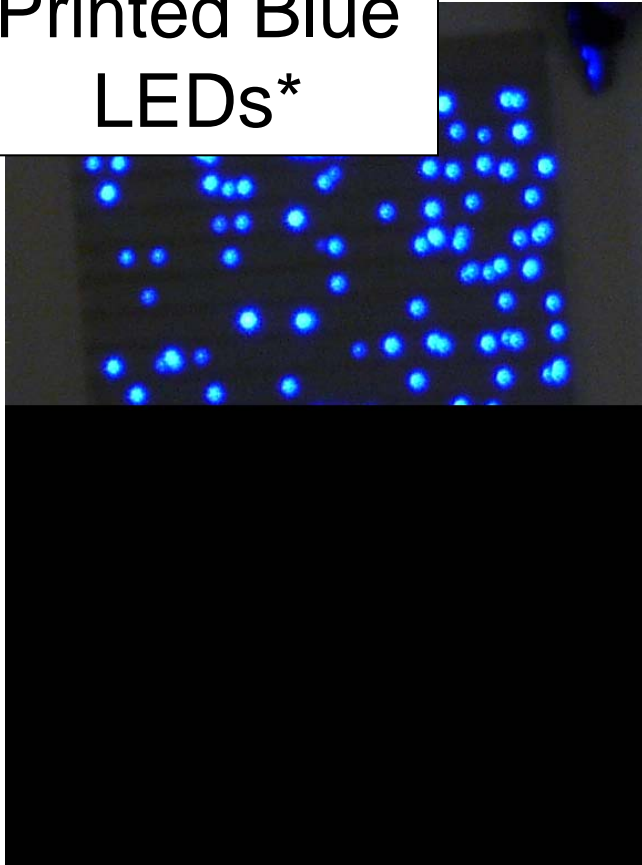
# Printed LED Lighting



\* Courtesy of SWeNT Collaboration Partner

# Prototype LED Lights

Printed Blue  
LEDs\*

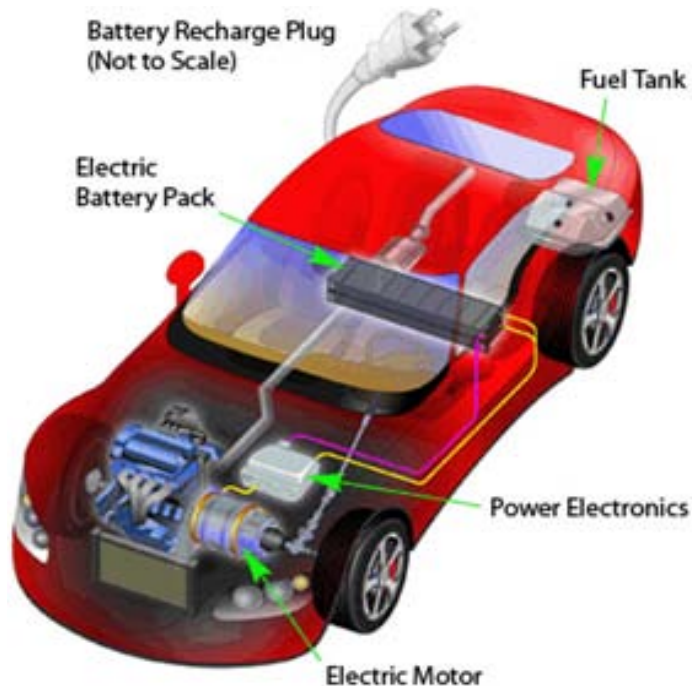


Printed LEDs  
with Phosphor  
Shift to White\*

\* Courtesy of SWeNT Collaboration Partner

# Li-ion Batteries

## Hybrid Electric Vehicles



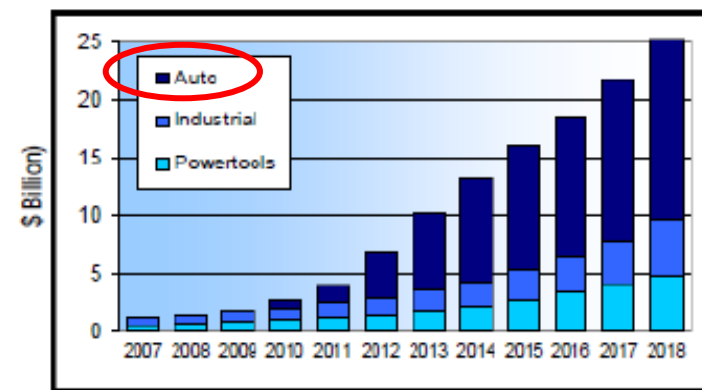
## Li-ion Battery Requirements (DOE)

Characteristics at the End of Life		High Power/Energy Ratio Battery	High Energy/Power Ratio Battery
Reference Equivalent Electric Range	miles	10	40
Peak Pulse Discharge Power (2 sec/10 sec)	kW	50/45	46/38

## New Electrode Materials Needed → CNTs

Available Energy in Charge Sustaining (CS) Mode	kWh	0.5	0.3
CD Life	Cycles	5,000	5,000
CS HEV Cycle Life, 50 Wh Profile	Cycles	300,000	300,000
Calendar Life, 35°C	year	15	15
Maximum System Weight	kg	60	120
Maximum System Volume	Liter	40	80
System Recharge Rate at 30°C	kW	1.4 (120V/15A)	1.4 (120V/15A)
Unassisted Operating & Charging Temperature	°C	-30 to +52	-30 to +52
Maximum System Price @ 100k units/yr	\$	\$1,700	\$3,400

## Li-ion Battery Market



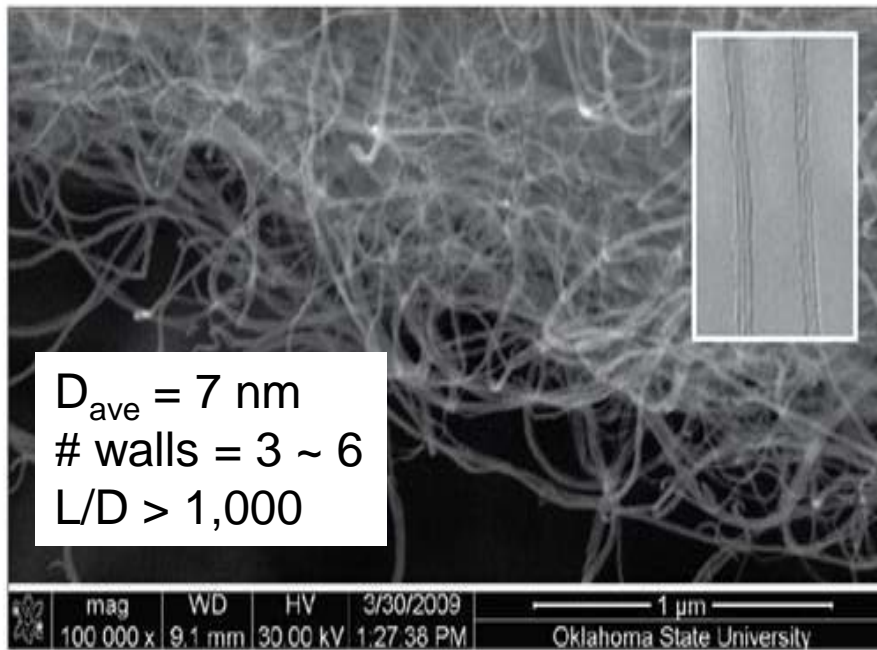
# CNT Enhanced Cathodes

## Why SMW™ CNTs are preferred?

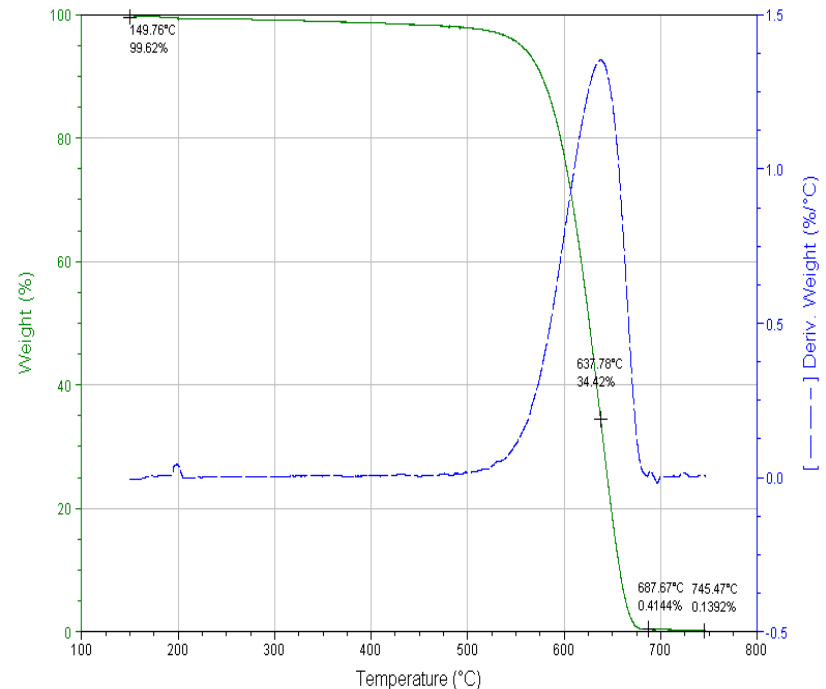


### Tube Structure

Small dia., Few walls, High L/D



### 99.9% Purity



Low Defects, Easy to Disperse, Scalability, Low Cost.

# CNT Enhanced Cathodes

## Promising Initial Results

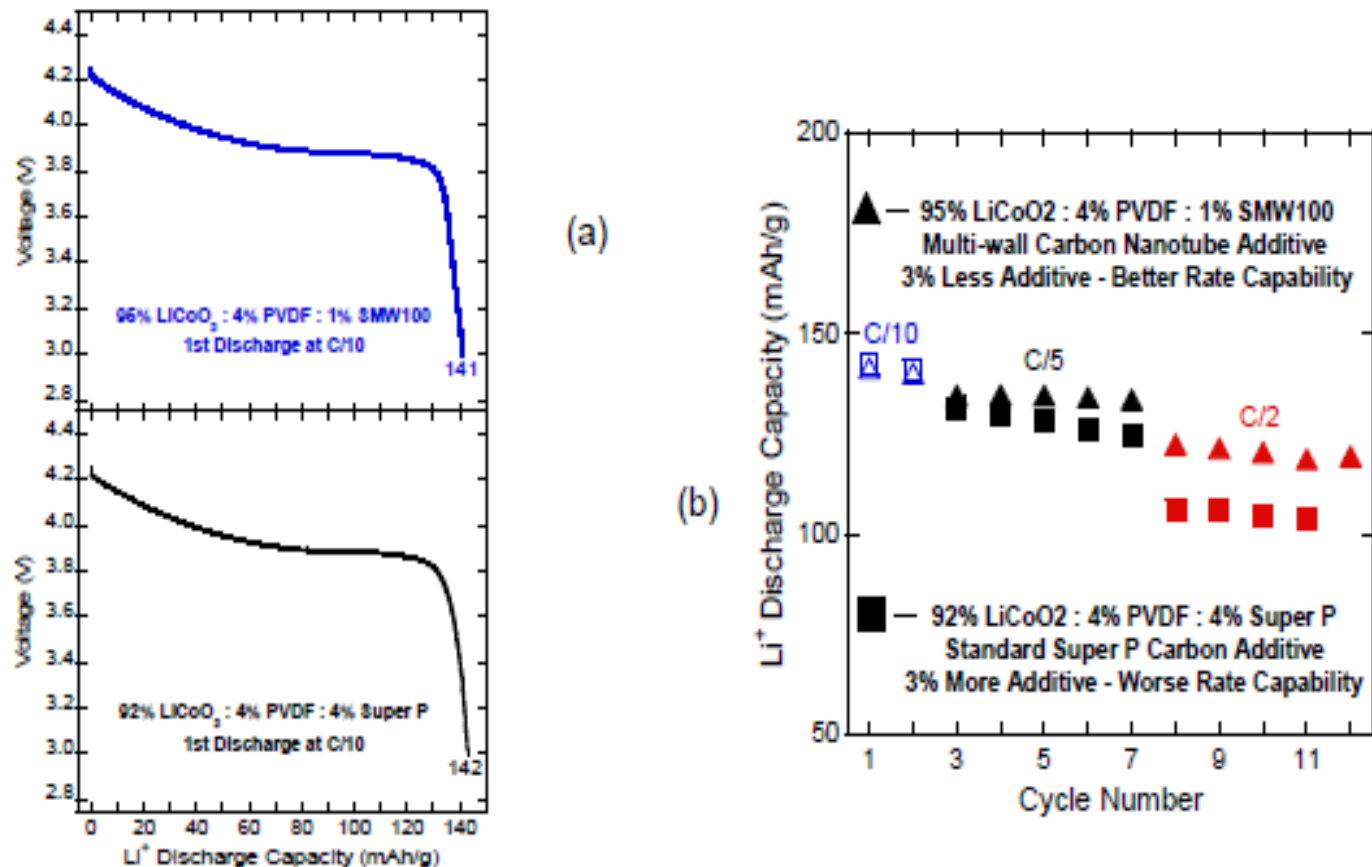


Figure 8: (a) First discharge voltage profiles for LiCoO<sub>2</sub> cathode with: (1) 4% Super P and (2) 1% SMW100 conductive additive. (b) Rate study for cathode half cells at C/10, C/5, and C/2 rates: Typical conductive additive (squares) and SMW100 (triangles)

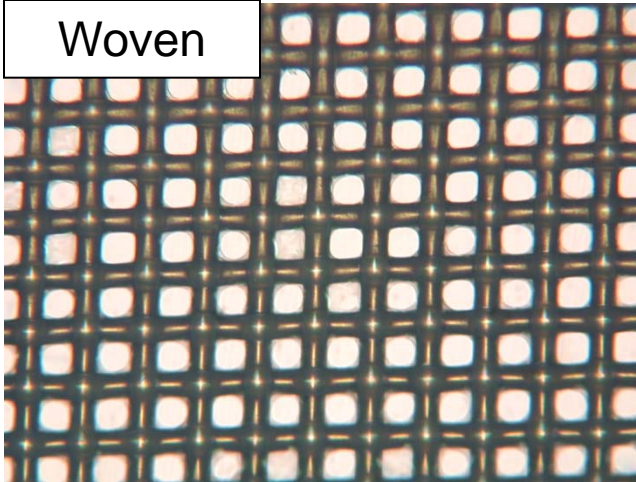


# nanoPly™ CNT Fabrics

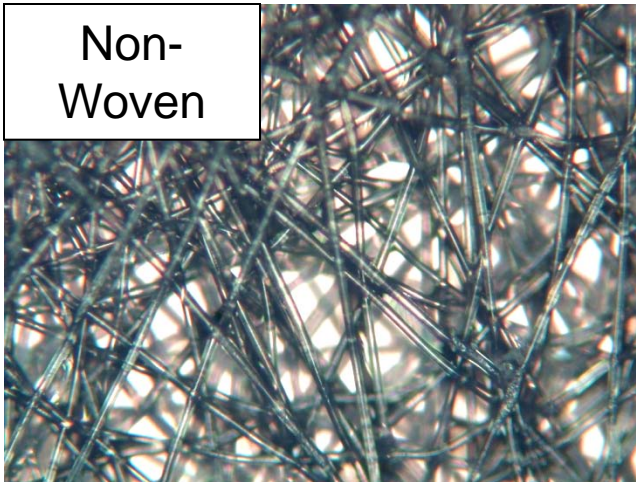
## Structural Sensors for FRP Composites



Woven



Non-Woven



Conductive!



# Bridge Repair

## Structural Sensors for FRP Composites



Lafayette, LA

Girder wrapped with FRP Composite containing nanoPly™ CNT Fabric

January 2010

*Thank you*

