ALIGNED CARBON NANOTUBE FORESTS AS SUPERCAPACITOR ELECTRODES

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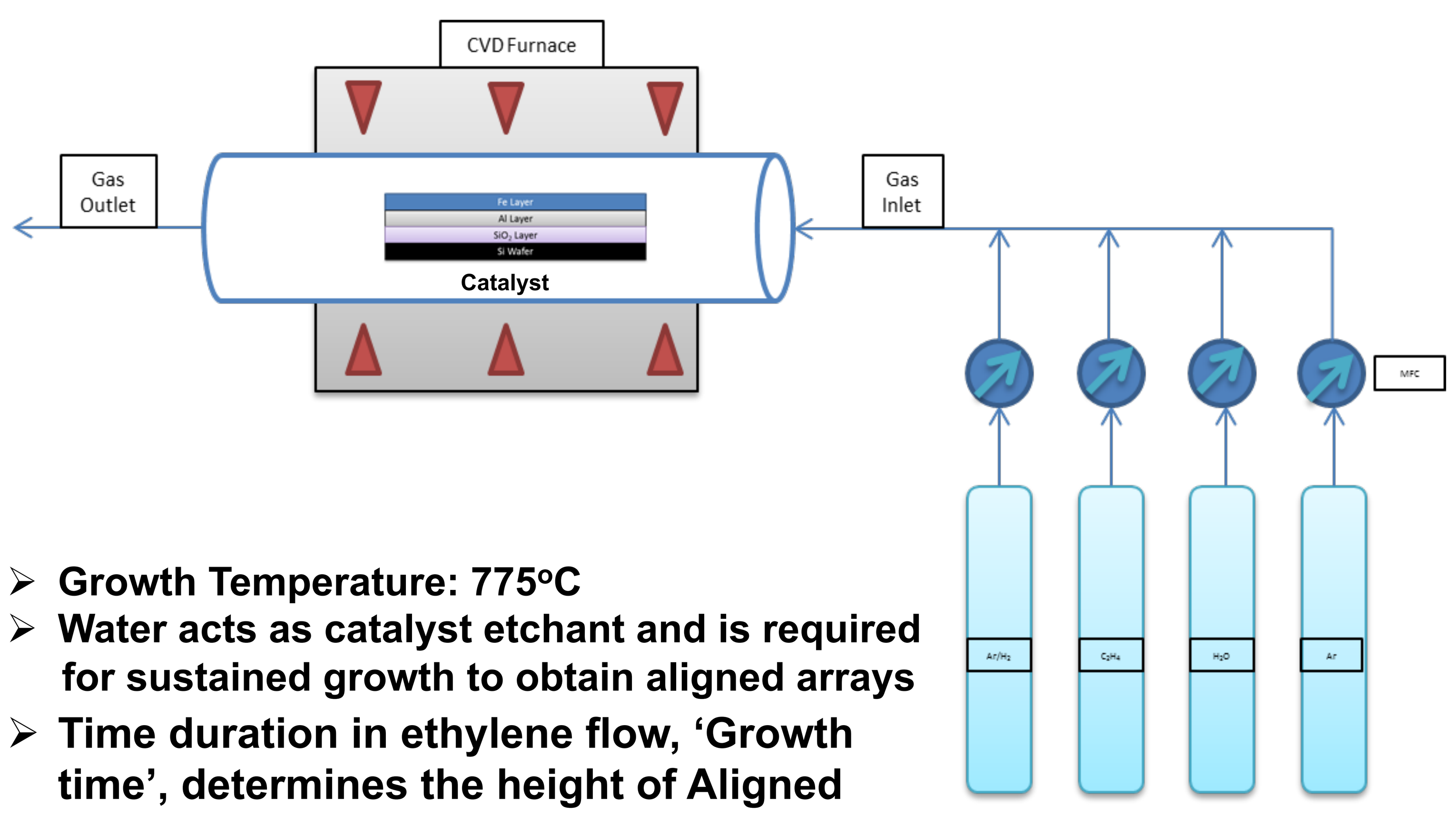
Abstract

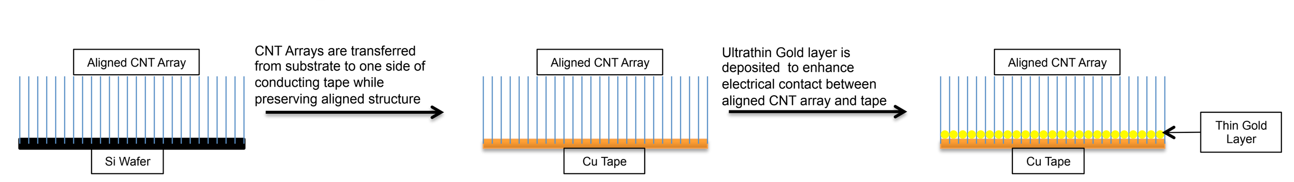
Supercapacitors, as energy storage devices, bridge the gap between conventional capacitors and rechargeable batteries. They combine the high energy storage capability of batteries with the high power delivery capability of capacitors. Carbon Nanotubes (CNTs) are desirable for making supercapacitor electrodes because of their good electrical conductivity, high porosity and high electrolyte accessibility. In addition to these properties, carbon nanotubes (CNT) are very light and are capable of high and rapid charge transport when properly stacked. Aligned CNT electrodes are predicted to have better charge storage and transport properties than entangled CNTs as a result of higher pore structure regularity. In the present study, aligned CNT arrays are fabricated at varying heights and used as electrodes in supercapacitors with electrolytes consisting of an ionic liquid in an organic solvent. Galvanic Cycle and Cyclic Voltammogran measurements were used to characterize our CNT supercapacitor electrodes.

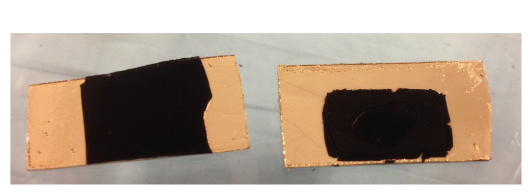
CVD Growth of Carbon Nanotubes



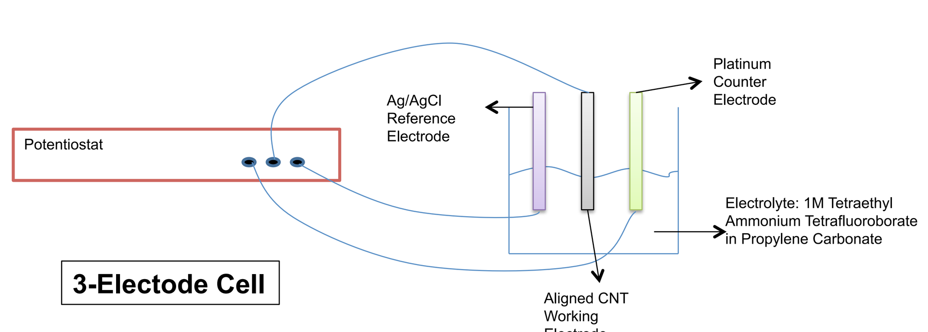
- **Growth Temperature: 775ºC**
- **Water acts as catalyst etchant and is required for sustained growth to obtain aligned arrays**
- **Time duration in ethylene flow, 'Growth time', determines the height of Aligned CNTs.**

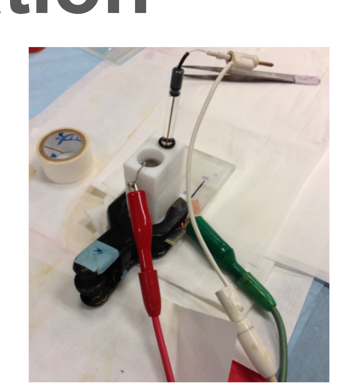
Preparation of Electrodes



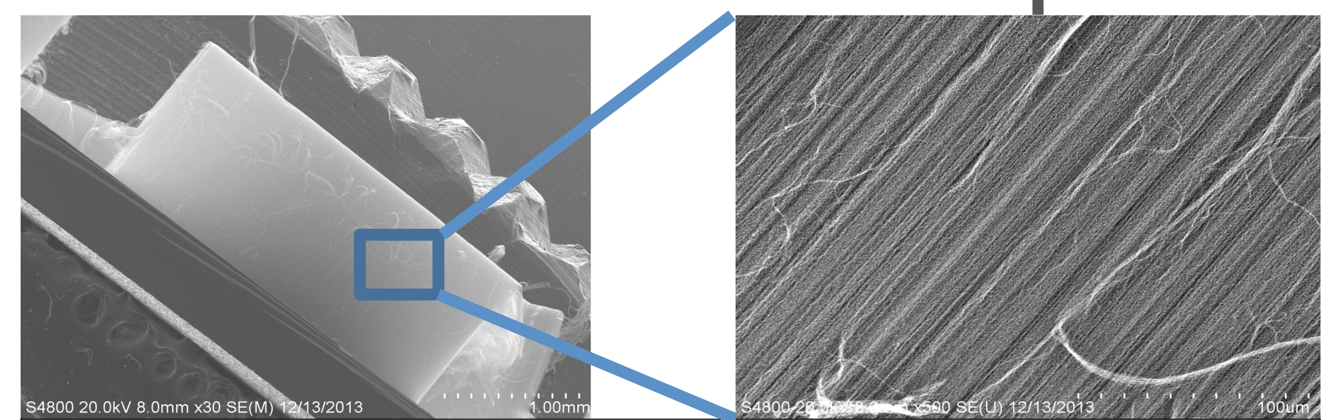


Electrical Characterization

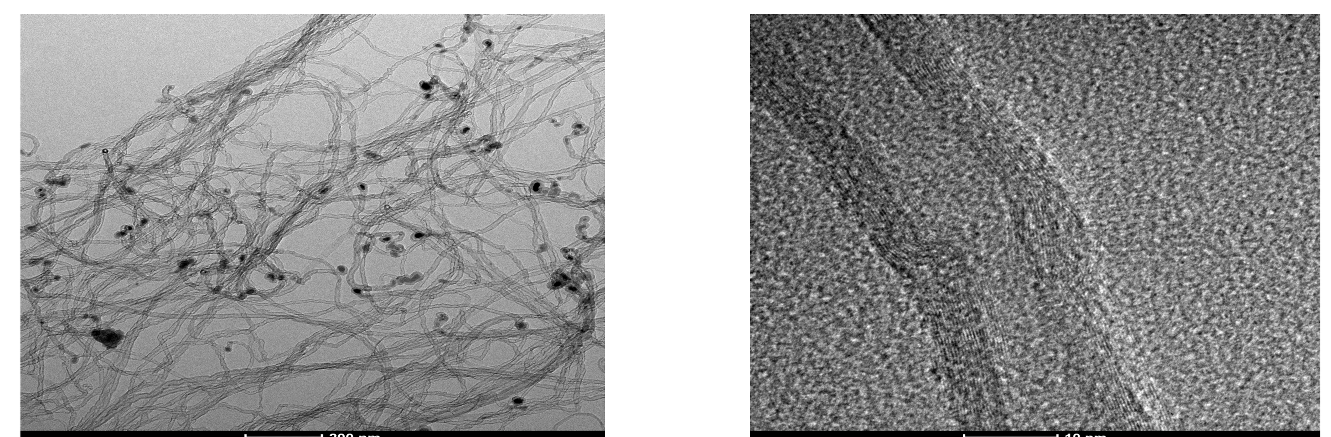




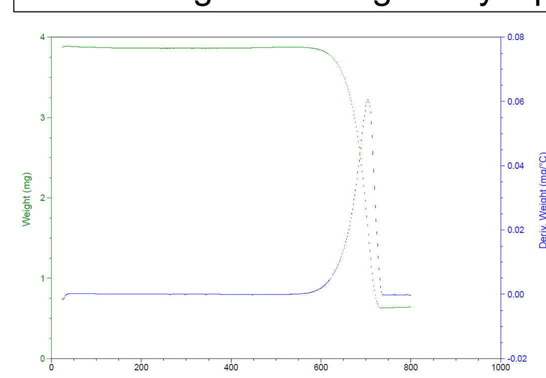
Carbon Nanotube Properties



SEM Micrographs showing alignment of Carbon Nanotubes



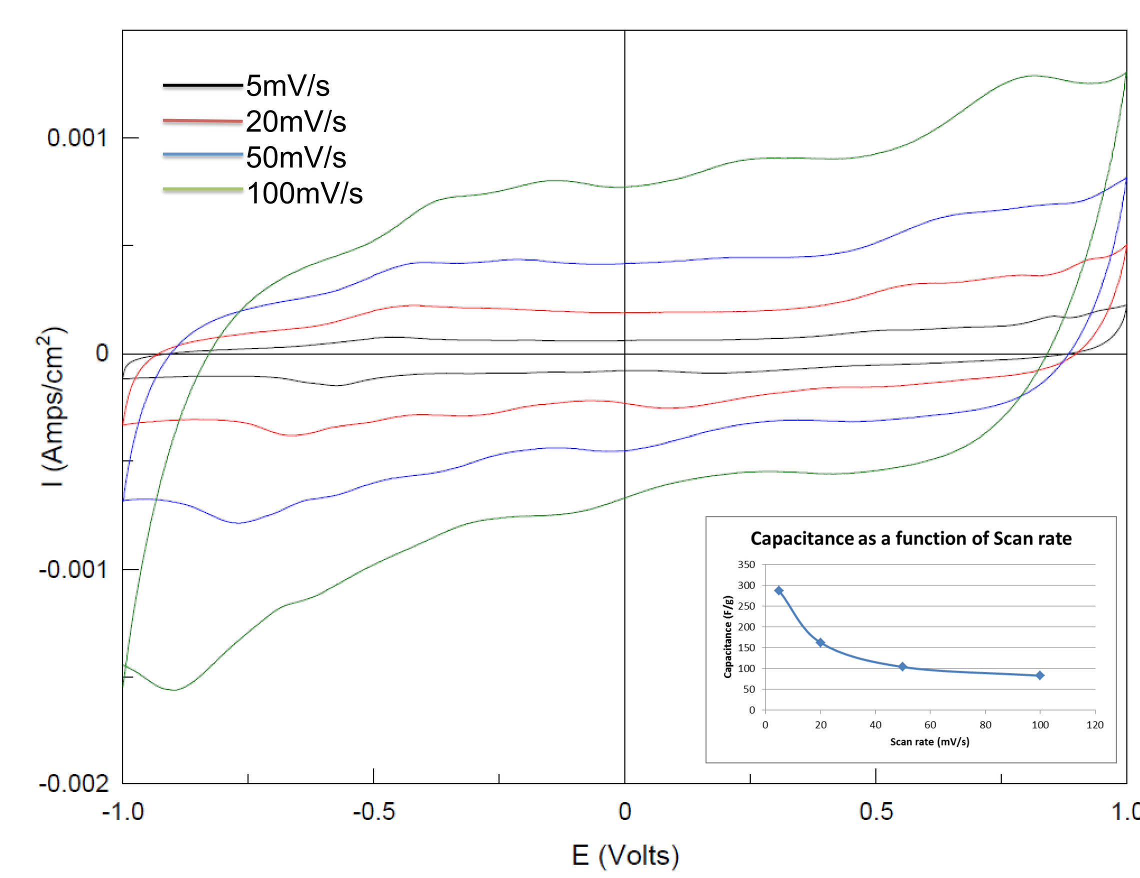
TEM Images showing catalyst particles embedded in CNTs and walls of CNTs



TGA of CNTs

: Multi Walled CNTs

Cyclic Voltammetry

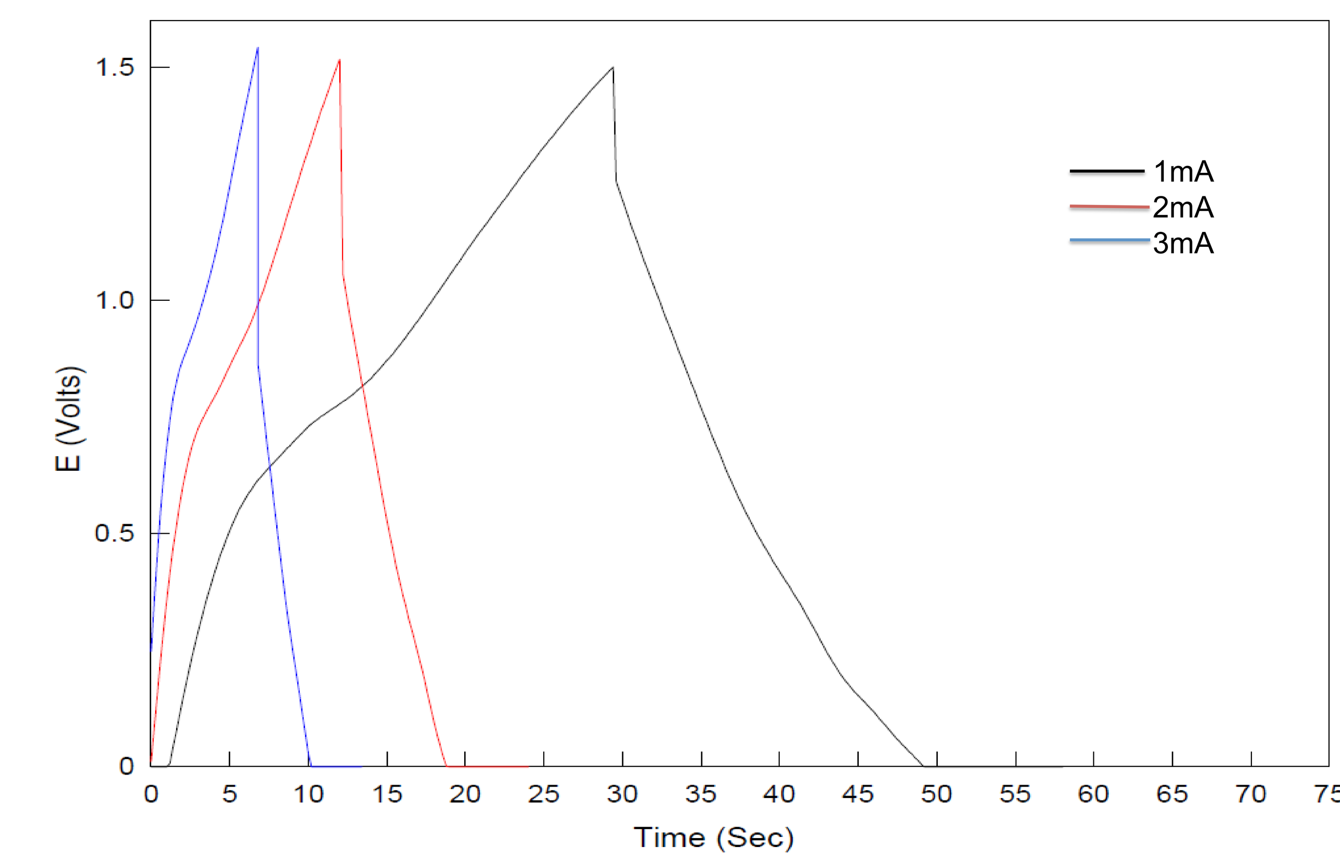


Cyclic Voltammetry (CV) scans at scan rates of 5, 20, 50 and 100mV/s.
Inset: Variation of capacitance with scan rate.

- Observed variation is indicative of resistance to diffusion of ionic liquid electrolyte in and out of the pore spaces within the walls of the CNT array

Mass of CNT in electrode per cm² (mg)	Height of CNT array (µm)	Capacitance from CV scans (F/g) @100mv/s
0.157	200	97.3

Charge-Discharge Characteristics



Charging and Discharging at constant currents of 1, 2 and 3mA between 0 and 1.5V.

Mass of CNT in electrode per cm² (mg)	Height of CNT array (µm)	Capacitance from Charge-Discharge (F/g) @ 100 mv/s
0.157	200	99.5

Future Work

- **Optimization of CNT array height to minimize diffusion resistance.**
- **Increasing the density of our CNT's to further increase capacitance.**
- **Creating similar electrodes using Single Walled Carbon Nanotubes to compare to our current Multi Walled Carbon Naotubes.**
- **Introduction of pseudocapacitance via functionalization of nanotubes or decoration of nanotube array with transition metal oxides**
- **Remove Silicon wafer and replace with conductive substrate for growth of Carbon Nanotubes such as Inconel.**

Acknowledgements

This material is based upon work supported by the National Science Foundation under the NSF EPSCoR Cooperative Agreement No. EPS-1003897 with additional support from the Louisiana Board of Regents.