My God is My HERO … !

Super Capacitor

Electronic based on polymeric materials project

of Hamed Fooladvand

Supervised by Dr. Kiyani

The School of Engineering Emerging Technologies – NANO Electronic Engineering Group
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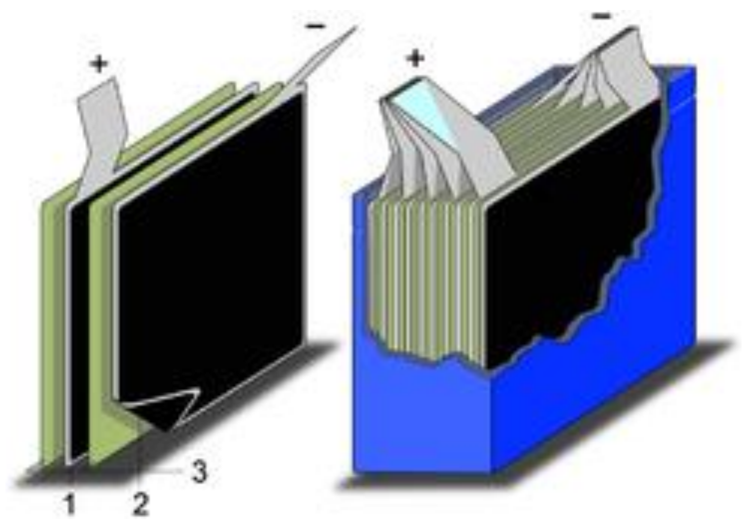
Transparent, flexible super-capacitors from Nano-engineered carbon films

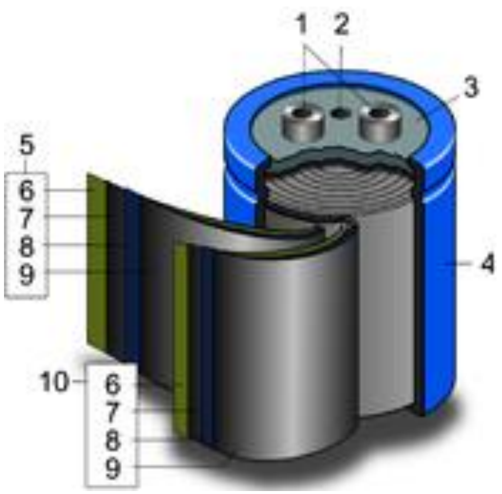
RECOMMENDS RESEARCH

INTRODUCTION

Electrical double-layer capacitors (EDLC) are, together with pseudo-capacitors, part of a new type of electrochemical capacitors called **super-capacitors** or **ultra-capacitors**.

Styles of super-capacitors with activated carbon electrodes

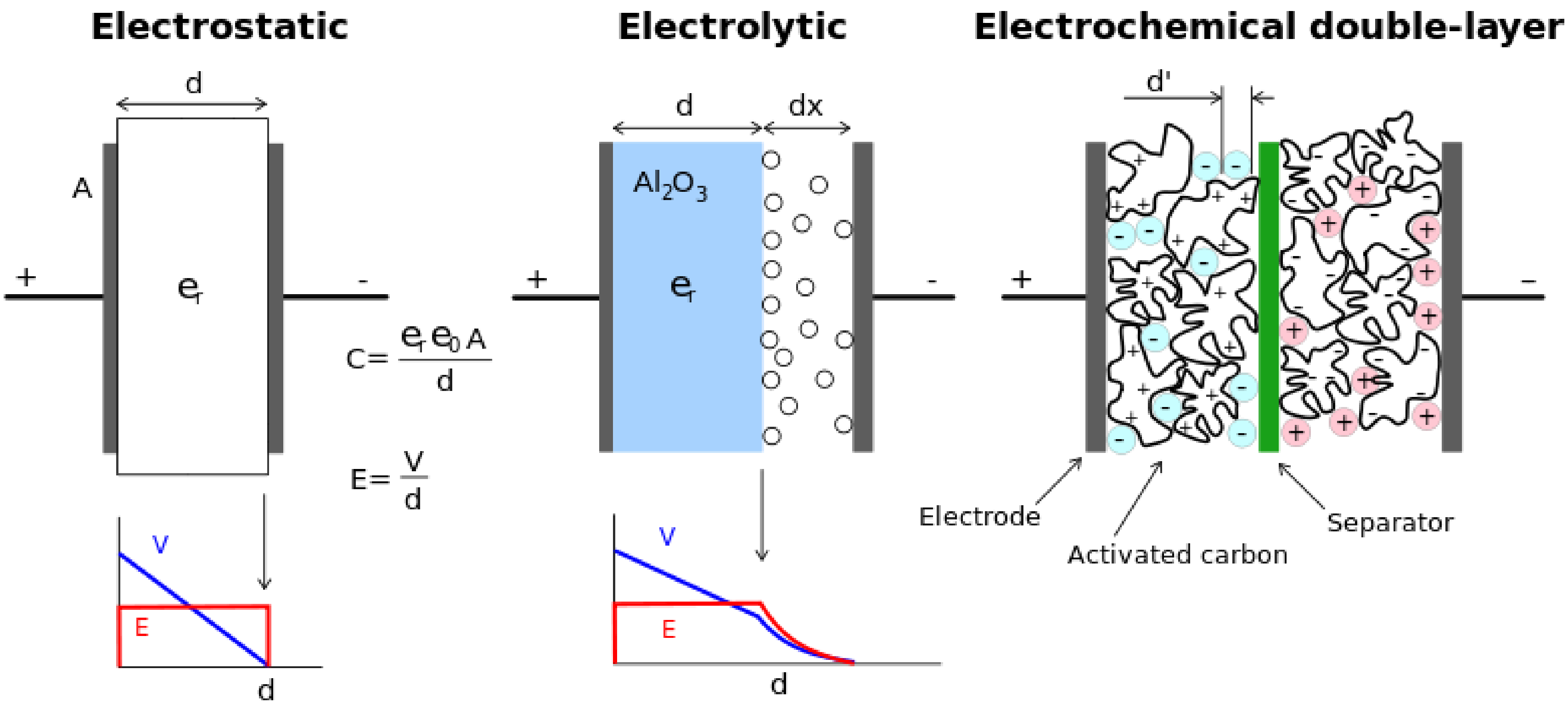




Schematic construction of a super-capacitor with stacked electrodes
1.Positive electrode, 2.Negative electrode, 3.Separator

Schematic construction of a wound super-capacitor
1.Terminals, 2.Safety vent, 3.Sealing disc, 4.Aluminum can, 5.Positive pole, 6.Separator, 7.Carbon electrode, 8.Collector, 9.Carbon electrode, 10.Negative pole

INTRODUCTION



comparison of construction diagrams of three capacitors.

Left: a normal capacitor,

middle: a electrolytic capacitor,

right: electric double-layer capacitor (super-capacitor).

INTRODUCTION

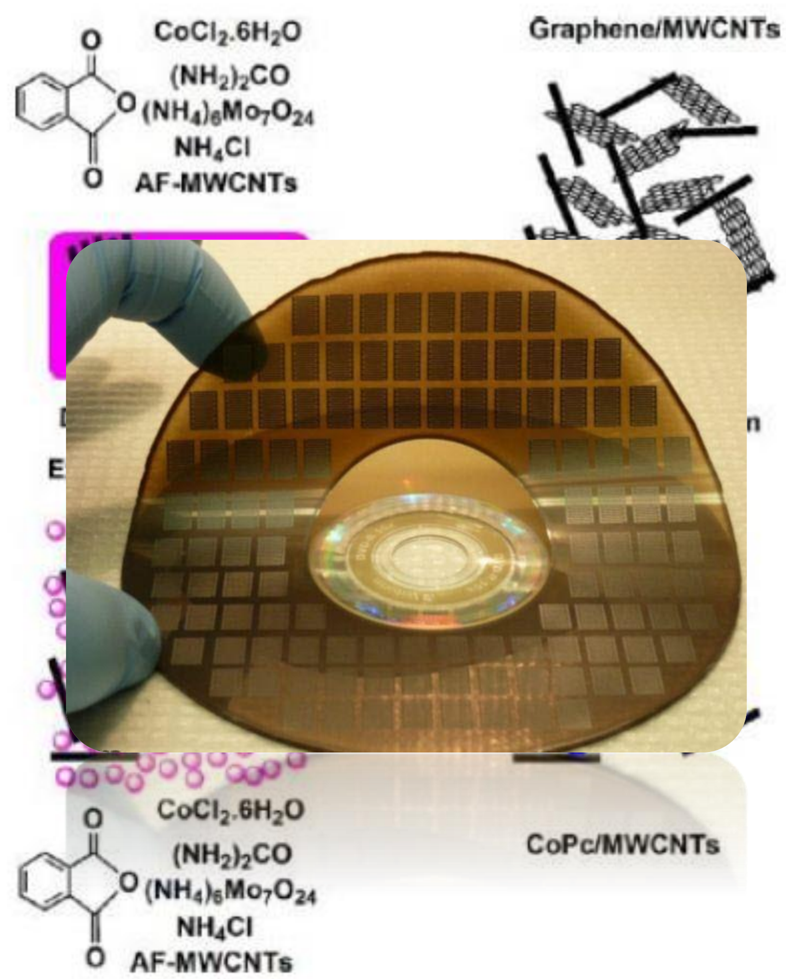
A Brief History

- The first super-capacitor based on a double layer mechanism was developed in 1957 by General Electric Company using a porous carbon electrode.
- In 1966 researchers at Standard Oil of Ohio developed the modern version of the device. Standard Oil did not commercialize their invention, licensing the technology to NEC, who finally marketed the results as “super-capacitors” in 1978, to provide backup power for maintaining computer memory.
- As of 2007 solid state micrometer-scale electric double-layer capacitors based on advanced super-ionic conductors were employed for low-voltage electronics such as deep-sub-voltage nanoelectronics and related technologies (the 22 nm technological node of CMOS and beyond).
- As of 2010 multi-voltage 5.3 W EDLC power supply for medical equipment produced a total of 55 F of capacitance, charged in about 150 seconds and ran for about 60 seconds.

INTRODUCTION

Materials

In general, EDLCs improve storage density through the use of a nanoporous material, typically activated charcoal[1], in place of the conventional insulating dielectric barrier.



[1] . Activated charcoal is an extremely porous, "spongy" form of carbon with an extraordinarily high specific surface area a common approximation is that 1 gram (a pencil-eraser-sized amount) has a surface area of roughly 250 square metres (2,700 sq ft) about the size of a tennis court.

INTRODUCTION

Research Materials

Material	Energy density/power density	Notes
Graphene	85.6 W·h/kg at room temperature and 136 W·h/kg at 80 °C at a current density of 1 A/g comparable to that of nickel metal hydride batteries	The device uses curved graphene sheets that do not restack face-to-face. The curved shape enables the formation of mesopores accessible to and wettable by environmentally benign ionic liquids capable of operating at a voltage over 4 V. These devices fully use the surface capacitance and specific surface area of single-layer graphene.
Carbon nanotubes	?	Allow polymer to sit in the tube and act as a dielectric. Carbon nanotubes can store about the same charge as charcoal (which is almost pure carbon) per unit surface area, but nanotubes can be arranged in a more regular pattern that exposes greater suitable surface area. The high surface area and conductivity of single-wall carbon nanotubes further increase energy density. Multi-walled carbon nanotubes have mesopores that allow for easy access of ions at the electrode/electrolyte interface. Adding multi-walled nanotubes lowers resistance. Capacitors with multi-walled nanotube fibers had higher electron and electrolyte-ion conductivities than others. Improved power density.
Poly-acenes and conducting polymers	?	redox (reduction-oxidation) storage mechanism along with a high surface area
Tunable nano-porous carbon (carbide-derived carbon)	?	exhibit high surface areas and tunable pore diameters to maximize ion confinement, increasing specific capacitance and energy densities above those offered by similar endohedral carbon allotropes. H_2 adsorption treatment can increase energy density by as much as 75% over 2005-era commercial products.
Carbon aerogel	90 W·h/kg energy density and 20 W/g power density	Gravimetric densities of about 400–1000 m²/g. Electrodes are a composite material usually made of non-woven paper made from carbon fibers and coated with organic aerogel, which then undergoes pyrolysis. The carbon fibers provide structural integrity and the aerogel provides the surface area. Small aerogel supercapacitors are used as backup electricity storage in microelectronics. Aerogel capacitors can only work at a few volts; higher voltages ionize the carbon and damage the capacitor.
Solid activated carbon or consolidated amorphous carbon (CAC)	?	Surface area exceeding 2,800 m^2/g
Mineral-based carbon	10 Wh/kg energy density and 50 kW/kg power density of devices	nonactivated carbon, synthesised from metal or metalloid carbides, e.g. SiC, TiC,Al_4C_3. The synthesised nanostructured porous carbon, often called Carbide Derived Carbon (CDC), has a surface area of about400 m^2/g to 2,000 m^2/g with a specific capacitance of up to100 F/mL (in organic electrolyte). As of 2006 this material was used in a supercapacitor with a volume of 135 mL and 200 g weight having 1.6 kF capacitance.
Bacitor	?	biodegradable paper battery with aligned carbon nanotubes, designed to function as both a lithium-ion battery and capacitor. The device employed an ionic liquid, essentially a liquid salt, as the electrolyte. The paper sheets can be rolled, twisted, folded, or cut with no loss of integrity or efficiency, or stacked, like ordinary paper (or a voltaic pile), to boost total output. They can be made in a variety of sizes, from postage stamp to broadsheet. Their light weight and low cost.
Poly-pyrrole and nanotube-impregnated papers.	?	Research

INTRODUCTION

Advantages of super-capacitors

1. Long life, with little degradation over hundreds of thousands of charge cycles.
2. Low cost *per cycle*
3. Good reversibility
4. Fast charge and discharge.
5. Low internal resistance Low ESR and consequent high cycle efficiency
6. Low heating levels during charge and discharge
7. High output power
8. High specific power/power density the specific power of electric double-layer capacitors can exceed 6 kW/kg at 95% efficiency.
9. Improved safety Uses non-corrosive electrolytes and low material toxicity.
10. Simple charge methods no danger of overcharging, thus no need for full-charge detection.
11. In conjunction with rechargeable batteries, some applications use EDLC to supply energy directly, reducing battery cycling and extending life

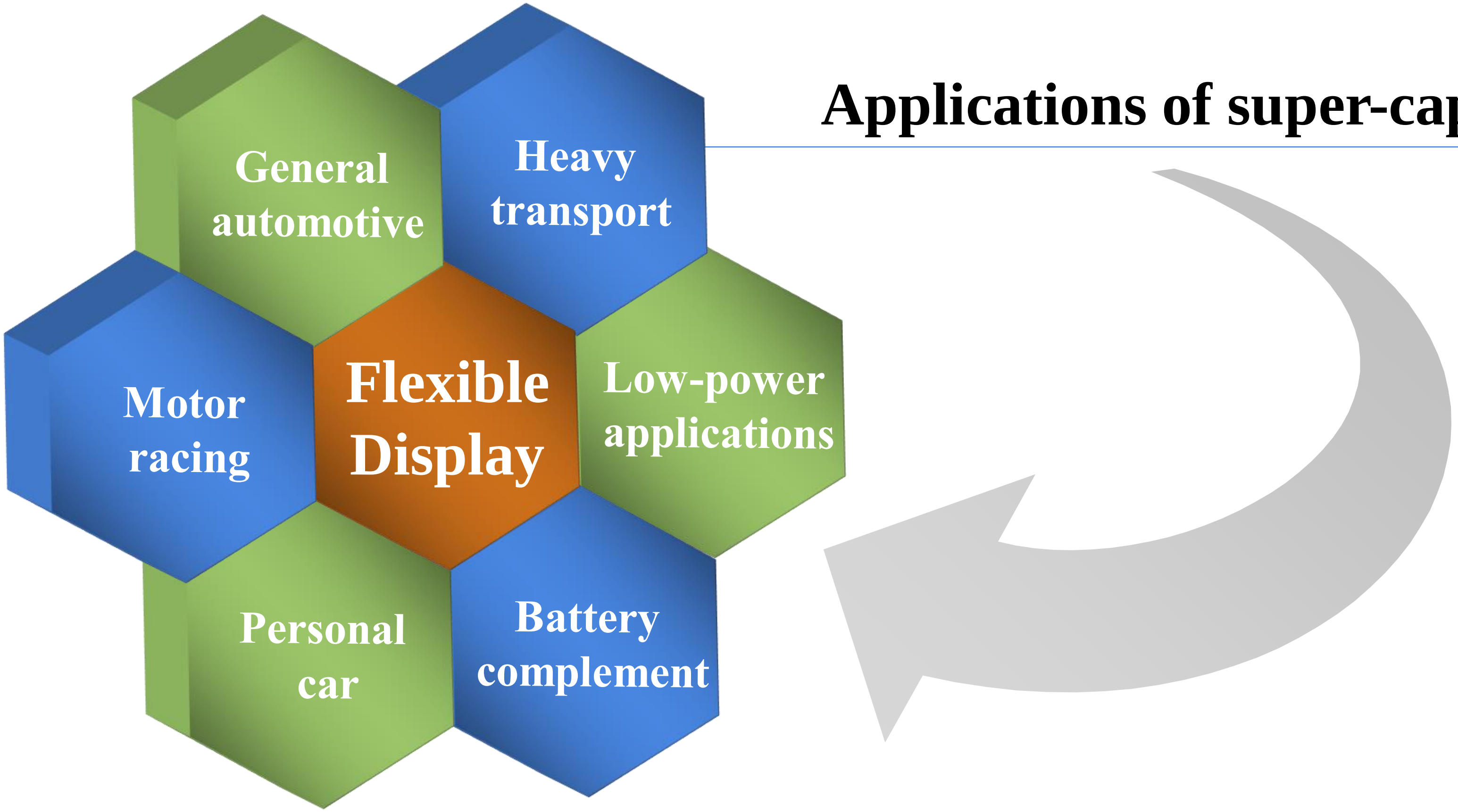
INTRODUCTION

Disadvantages of super-capacitors

1. Low energy density The amount of energy stored per unit weight is generally lower than that of electrochemical batteries (3 to 5 W·h/kg, although 85 W·h/kg has been achieved in the lab as of 2010 compared to 30 to 40 W·h/kg for a lead acid battery, 100 to 250 W·h/kg for a lithium-ion battery and about 0.1% of the volumetric energy density of gasoline).
2. High dielectric absorption highest of any type of capacitor.
3. High self-discharge the rate is considerably higher than that of an electrochemical battery.
4. Low maximum voltage series connections are needed to obtain higher voltages and voltage balancing may be required.
5. Rapid voltage drop Unlike batteries, the voltage across any capacitor drops significantly as it discharges. Effective energy recovery requires complex electronic control and switching equipment, with consequent energy loss.
6. Spark hazard Low internal resistance allows extremely rapid discharge when shorted, resulting in a spark hazard generally much greater than with batteries.

INTRODUCTION

Applications of super-capacitors



NEW CHALLENGE
(paper explain)

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Transparent, flexible super-capacitors fron Nano-engineered carbon films

SCIENTIFIC REPORTS (Nature Journal)

Hyun Young Jung[1]
Majid B. Karimi[1]
Myung Gwan Hahm[2]
Pulickel M. Ajayan[2]
Yung Joon Jung[1]

[1]Northeastern University, Boston , [2]Rice University, Houston, Texas

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INTRODUCTION

- Recently there has been significant interest in using carbon based nano-materials as super-capacitor electrodes due to several advantages of carbon such as light weight, high electrical conductivity and electrochemical surface area 1-20.
- Here, we demonstrate the design and fabrication of flexible and transparent super-capacitors using a highly structured carbon thin film, structured inside porous templates by Chemical Vapor Deposition (CVD).
- CNCs are architectures precisely engineered from graphitic carbon, within porous templates, having up to 105 times smaller length/diameter (L/D) ratios compared to conventional nanotubes, and have unique nanoscale cup morphology.

INTRODUCTION

- Our CNC films polymer electrolyte composites have three remarkable features for the use as a solid state, thin-film super-capacitor device :

- First, a CNC film has the high surface area offered by arrays of controlled nano-scale cup structures and highly disordered graphitic layers that are keys for the effective permeation of the polymer electrolyte in super-capacitors.

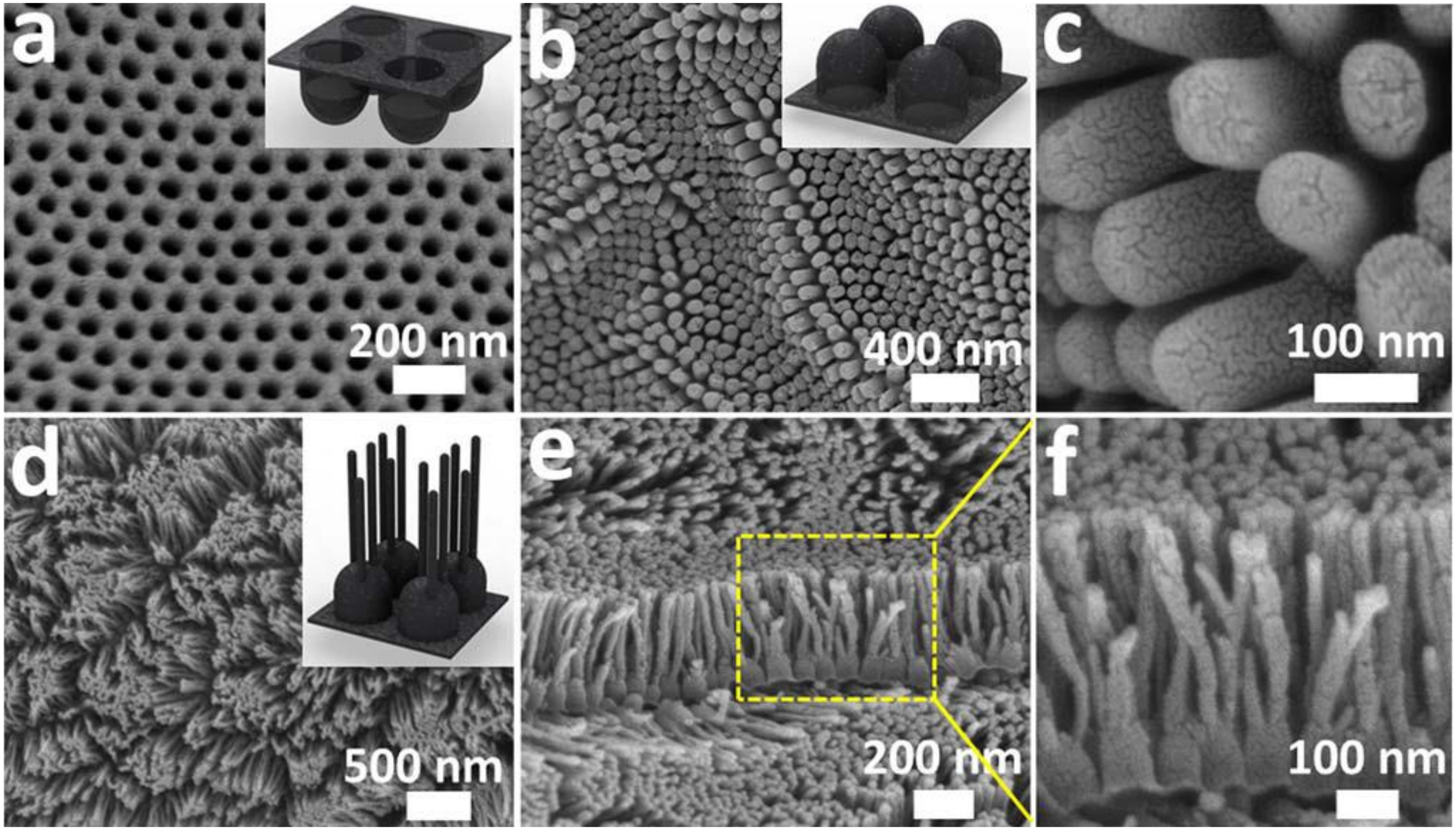
- Second, unique nano-scale structural and morphological features of CNC films enable the easy access and faster transport of ions at the electrode/electrolyte interface resulting in higher power capability.

- Finally, high current carrying capability, substantial mechanical strength, and small effective electrode thickness (10 nm) allow us to build multifunctional (optically transparent and mechanically flexible) reliable thin-film energy storage devices.

Fabrications of nano-engineered carbon films

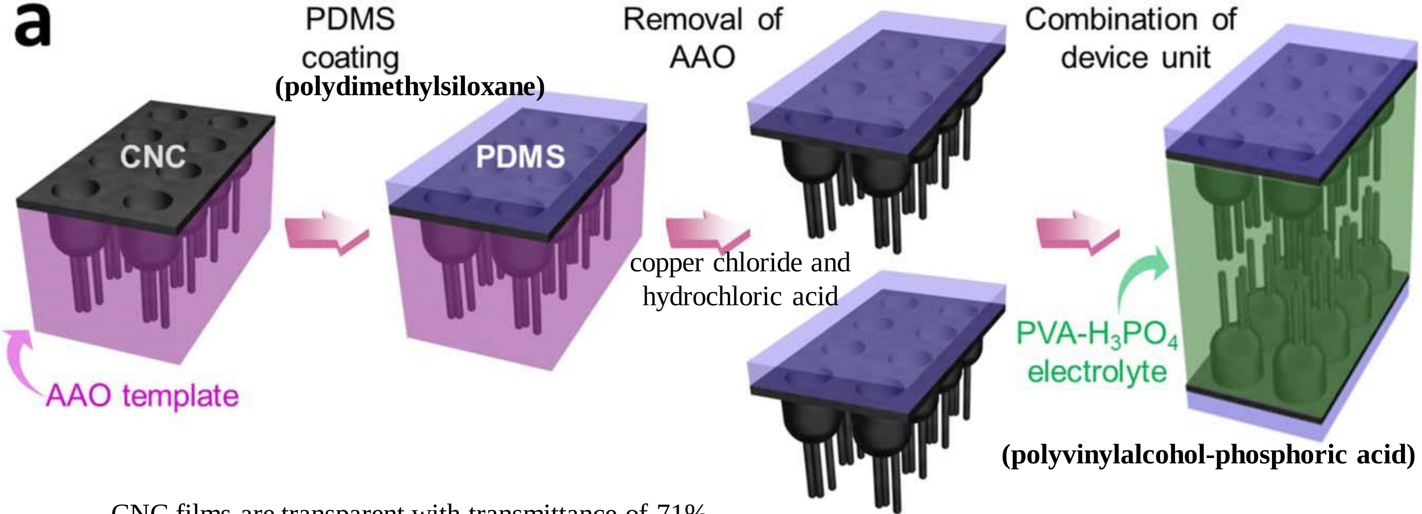
SEM images of CNCs

anodic aluminum oxide (AAO) templates

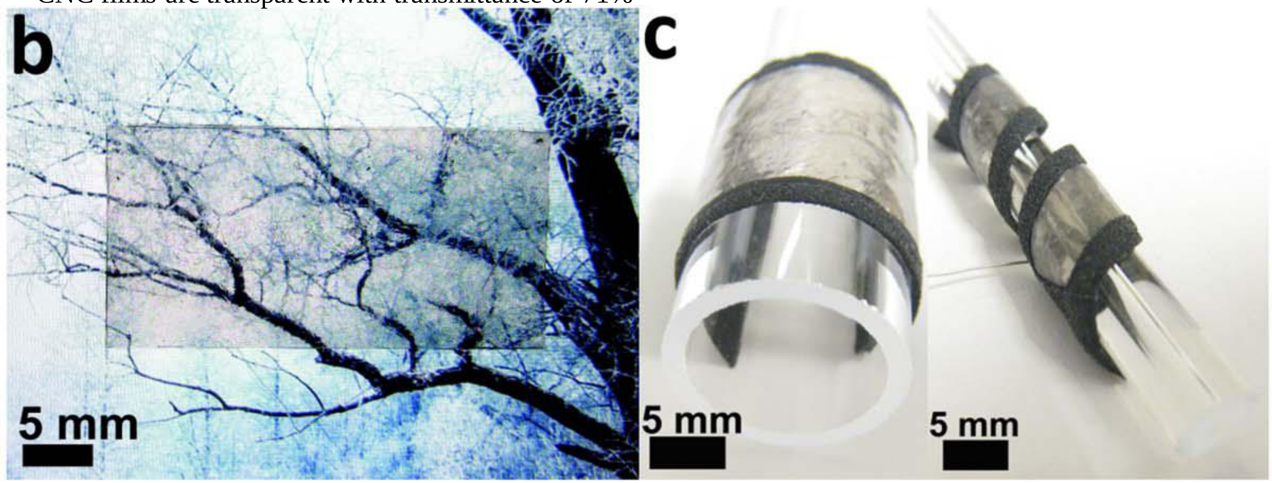


Note that the thickness of CNCs film can be controlled by changing carbon deposition time or carbon concentration during a CVD process.

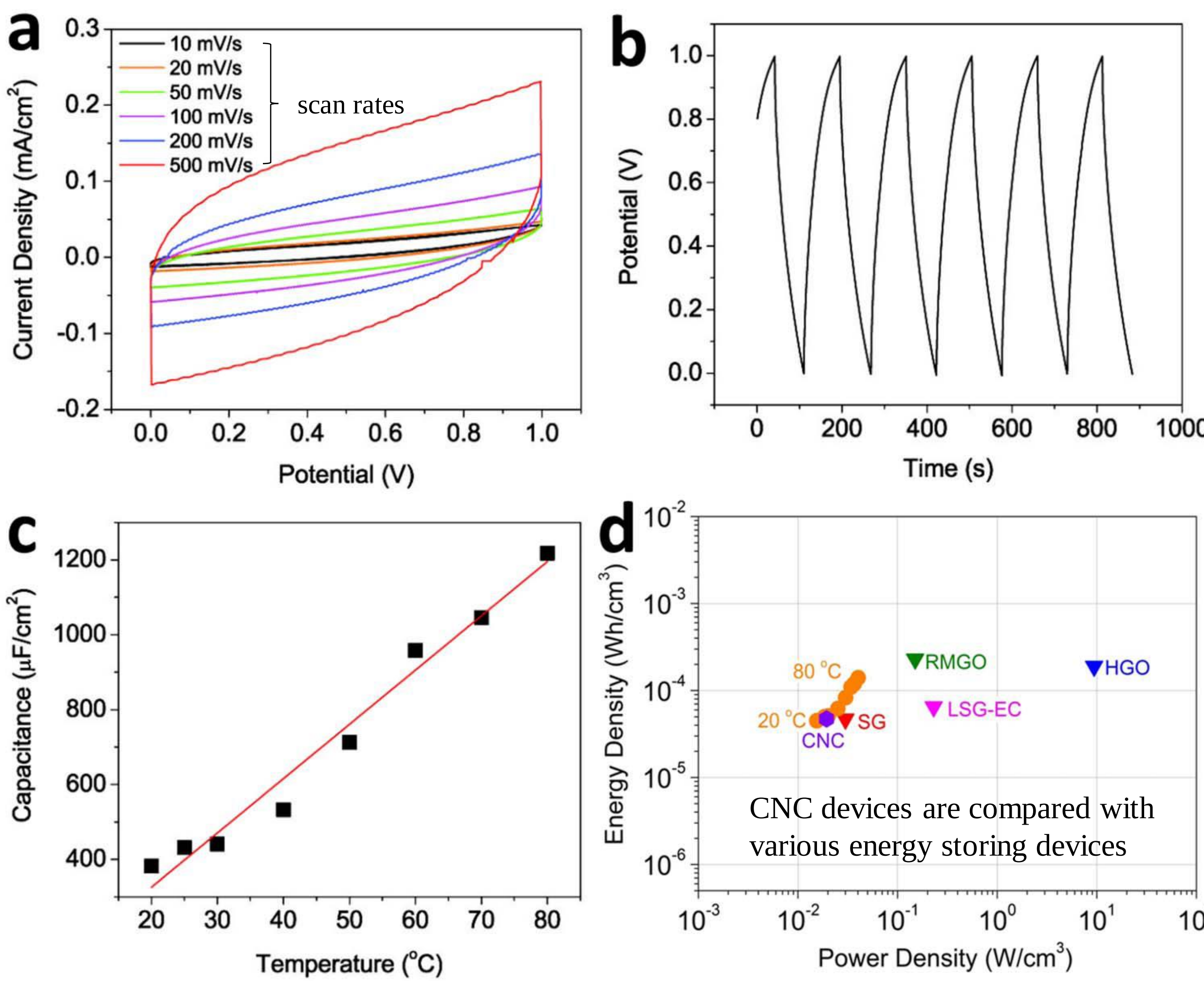
Schematics of the fabrication process of a branched CNC based super-capacitor



CNC films are transparent with transmittance of 71%



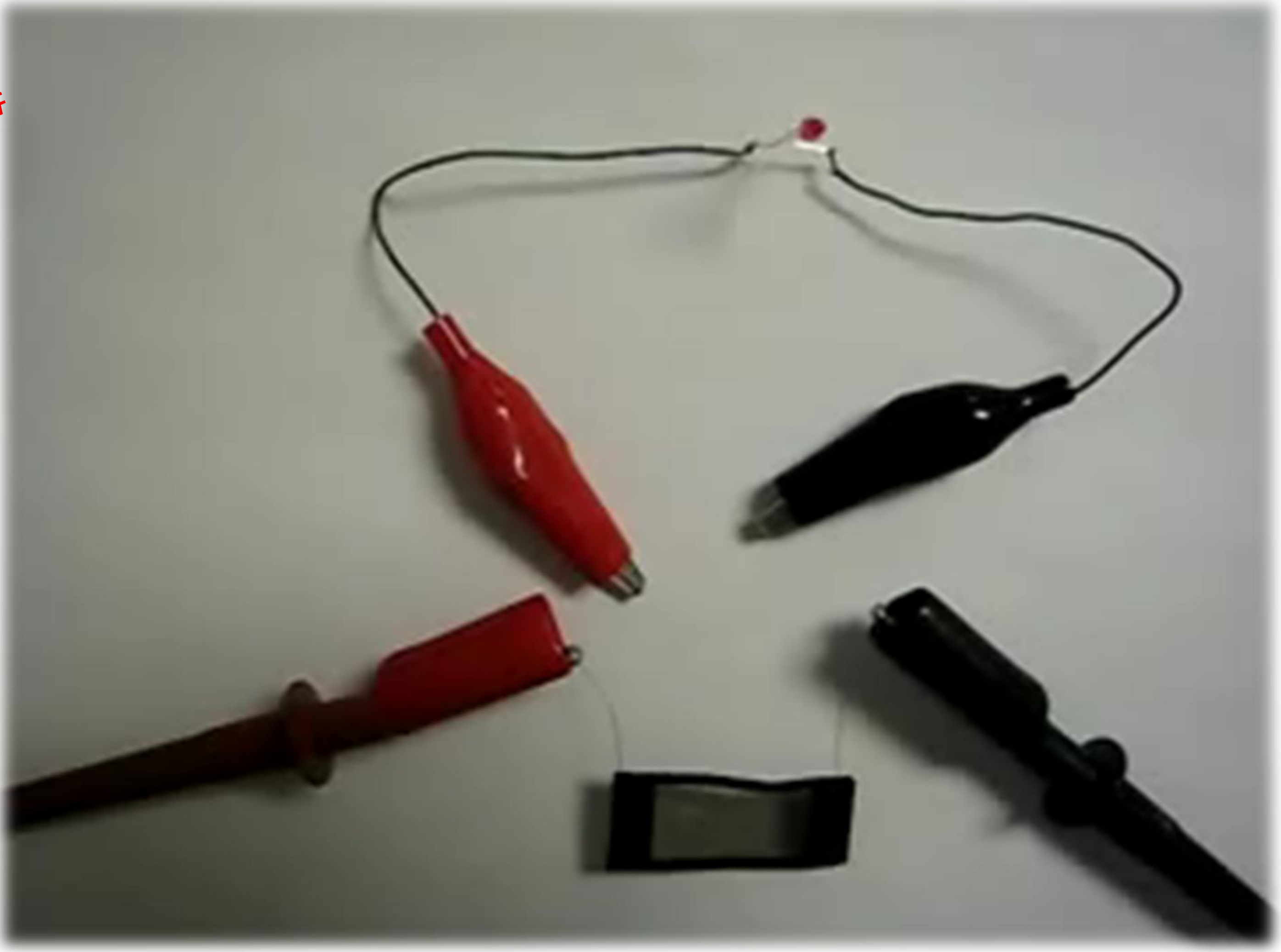
Electrochemical properties of branched CNC super-capacitor devices



(Galvanostatic CD) results measured at a constant current density

How do work CNC based super-capacitor?

Video 1#



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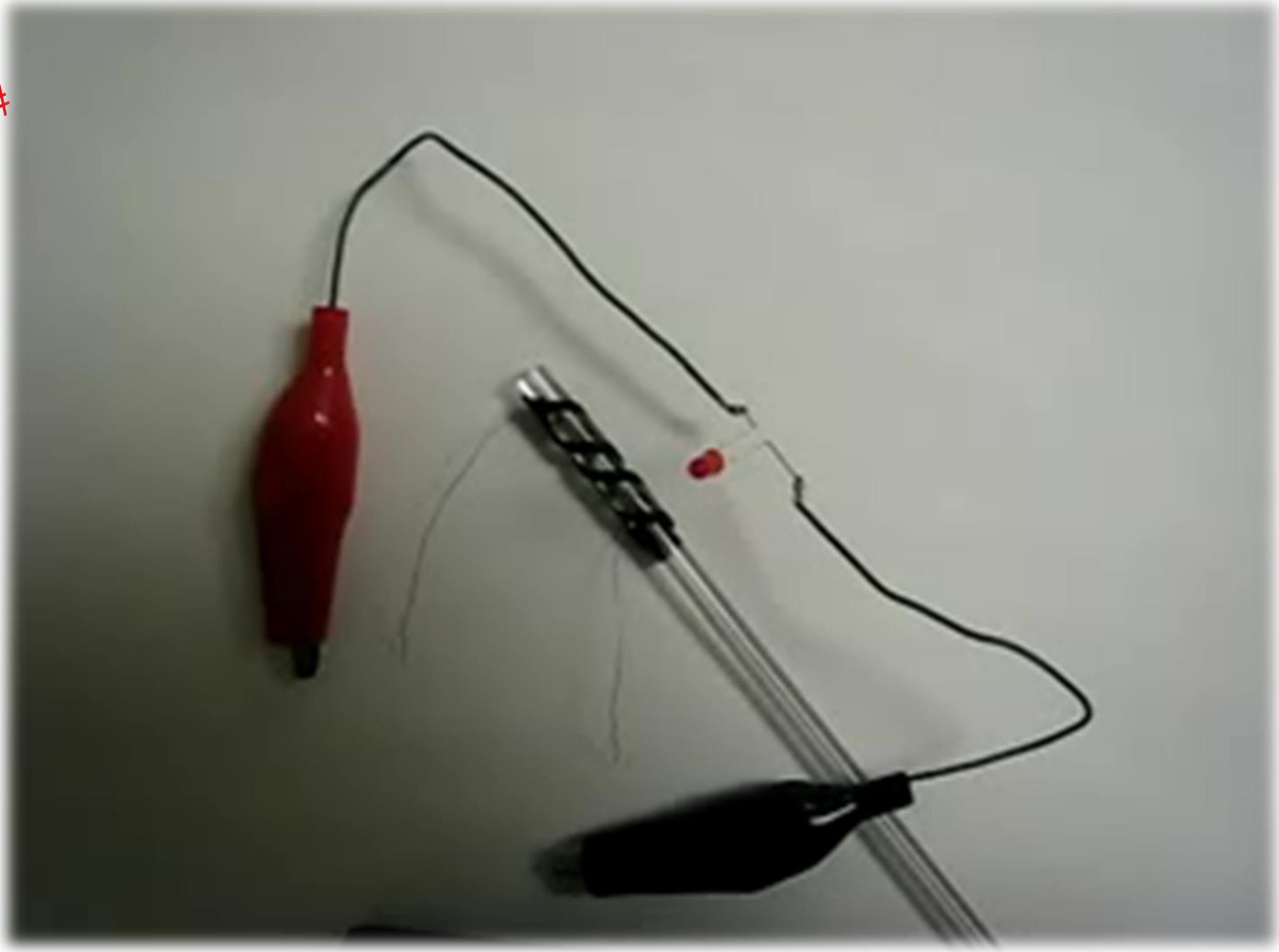
How do work CNC based super-capacitor?

Video 2#



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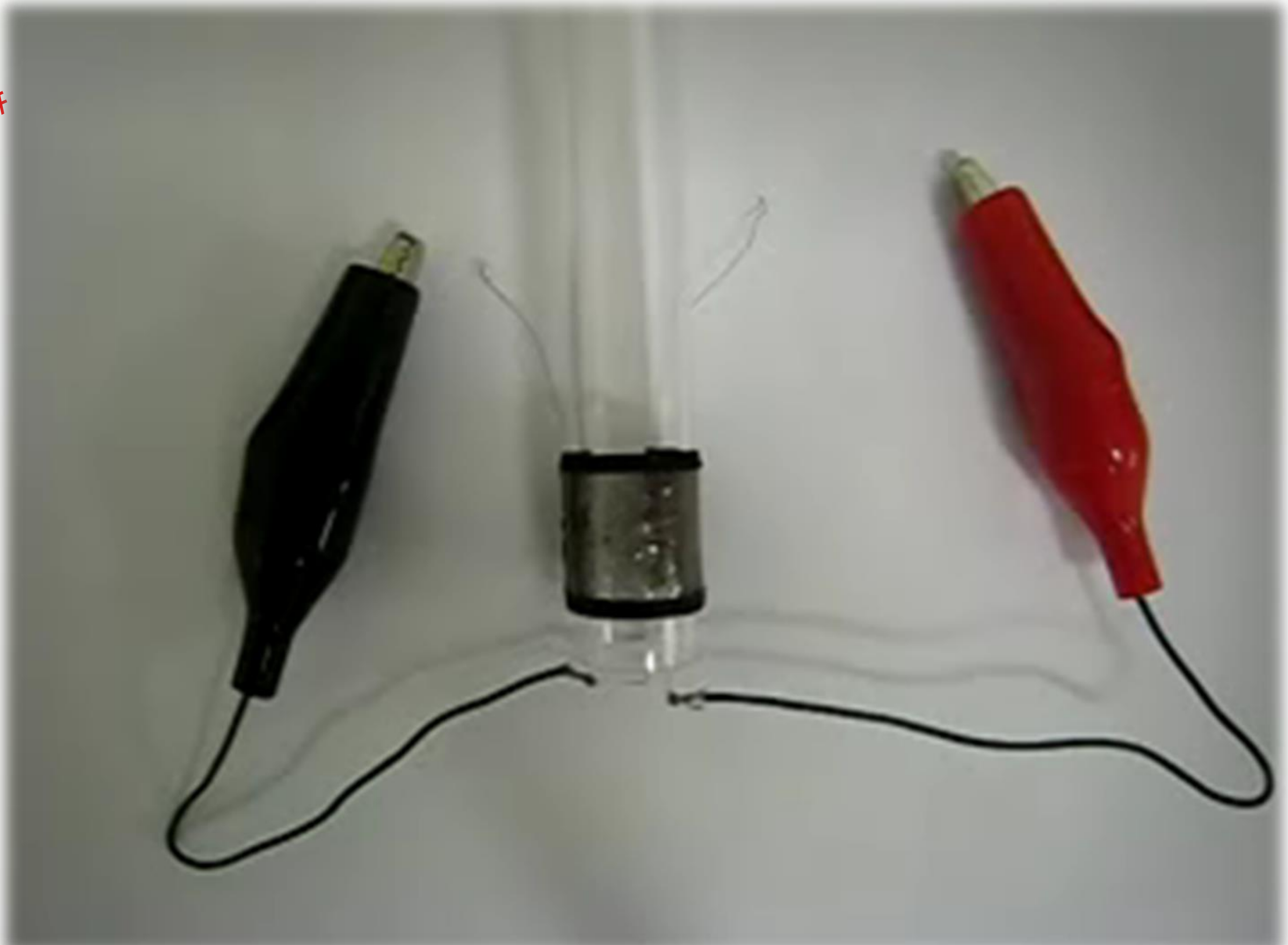
How do work CNC based super-capacitor?

Video 3#



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Research Recommends

- Super-Capacitor in the Flexible Display Application
- Super-Capacitor in the Smart Windows Application
- Solving depending on the mechanical state
- Improving how connections electrodes in super-capacitors

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WITHOUT HIM THIS WORLD WOULD BE EMPTY …

Thank You !

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