2015年奈米技術與材料研討會

奈米材料科技在推展綠能方面的應用

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大葉大學

2015年11月13日

Outlines

I. Personal background

II. Nanomaterials vs. Green energy

III. Selected examples of applications

IV. Research outlook

V. Conclusion

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表面物理實驗室

* 主流(傳統)的表面物理：研究固體表面或介面的物理現象及其應用。

* 非典型(另類)的表面物理：善用表面或介面的物理知識，以開發新穎的科技領域。

一、電泳現象在微奈米尺度的原理及應用

「電泳」和「介電泳」的技術為奈微米尺度的研究和應用提供了以下的優勢：

低成本

無需貴重儀器設備

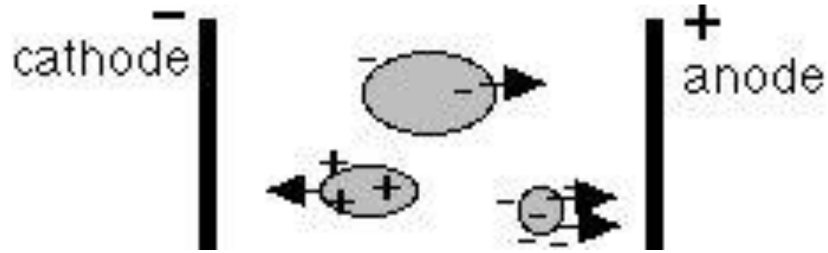
環保(少化學污染)

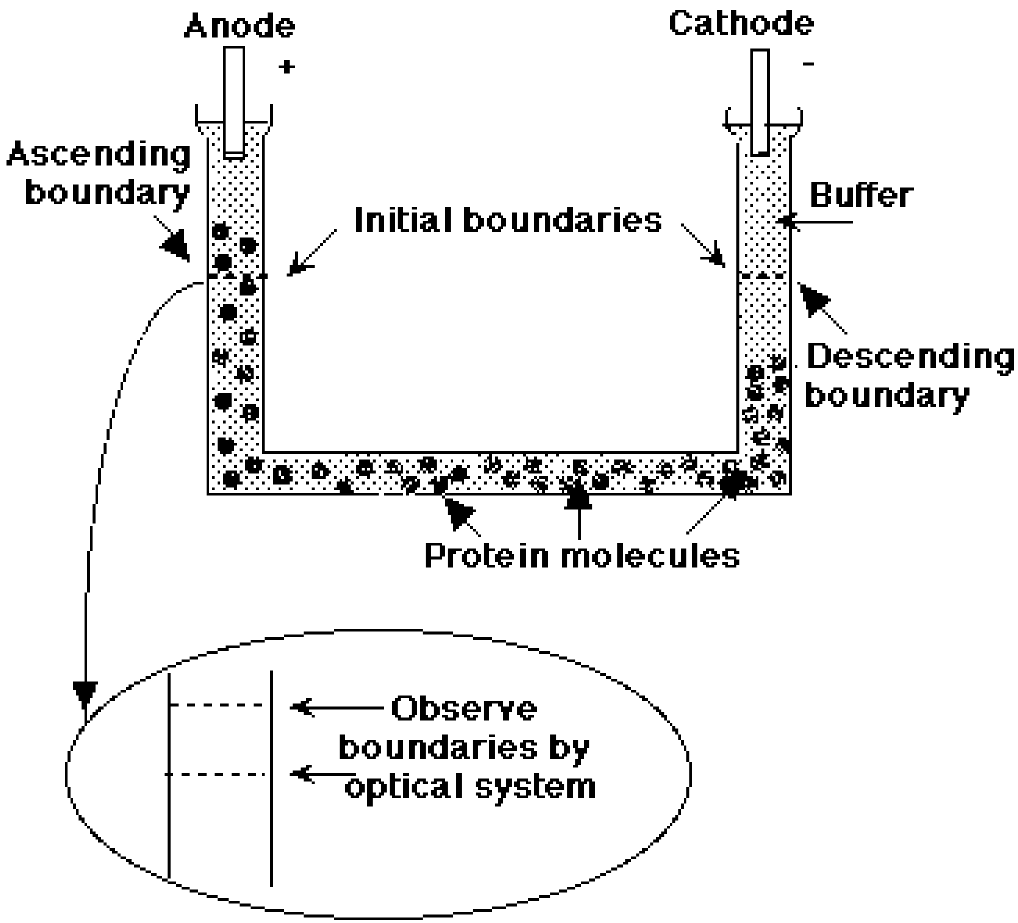
可量產化

多才多藝

•••••

何謂『電泳』？
(electrophoresis)

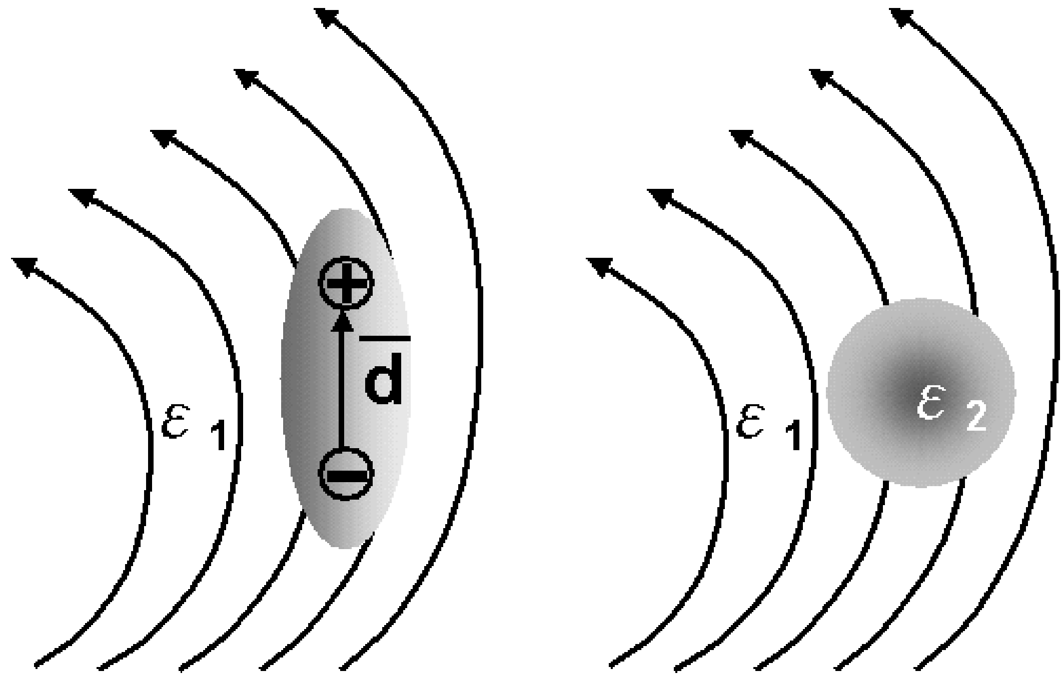




1948 諾貝爾化學獎
瑞典籍的生化學家
Arne Tiselius (1937)

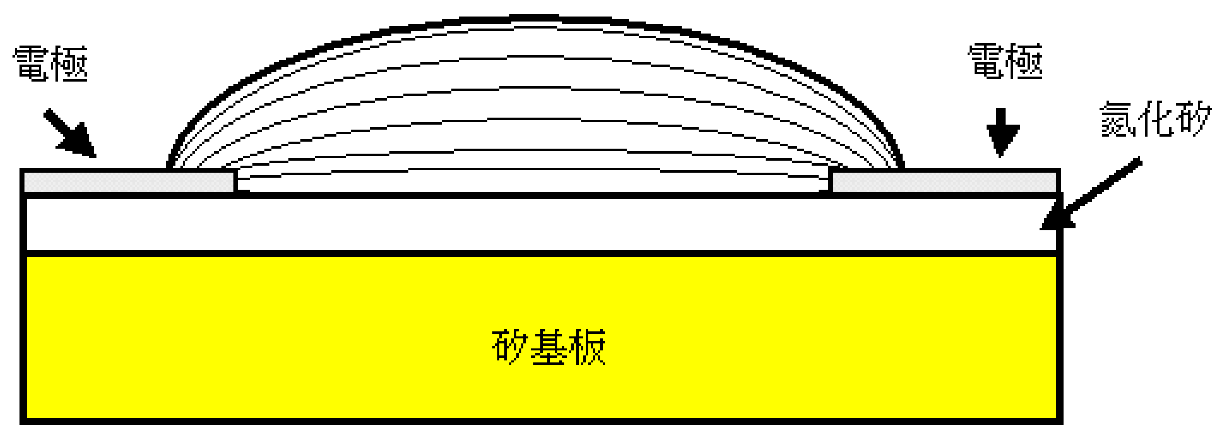
http://www.geocities.com/bioelectrochemistry/tiselius.htm

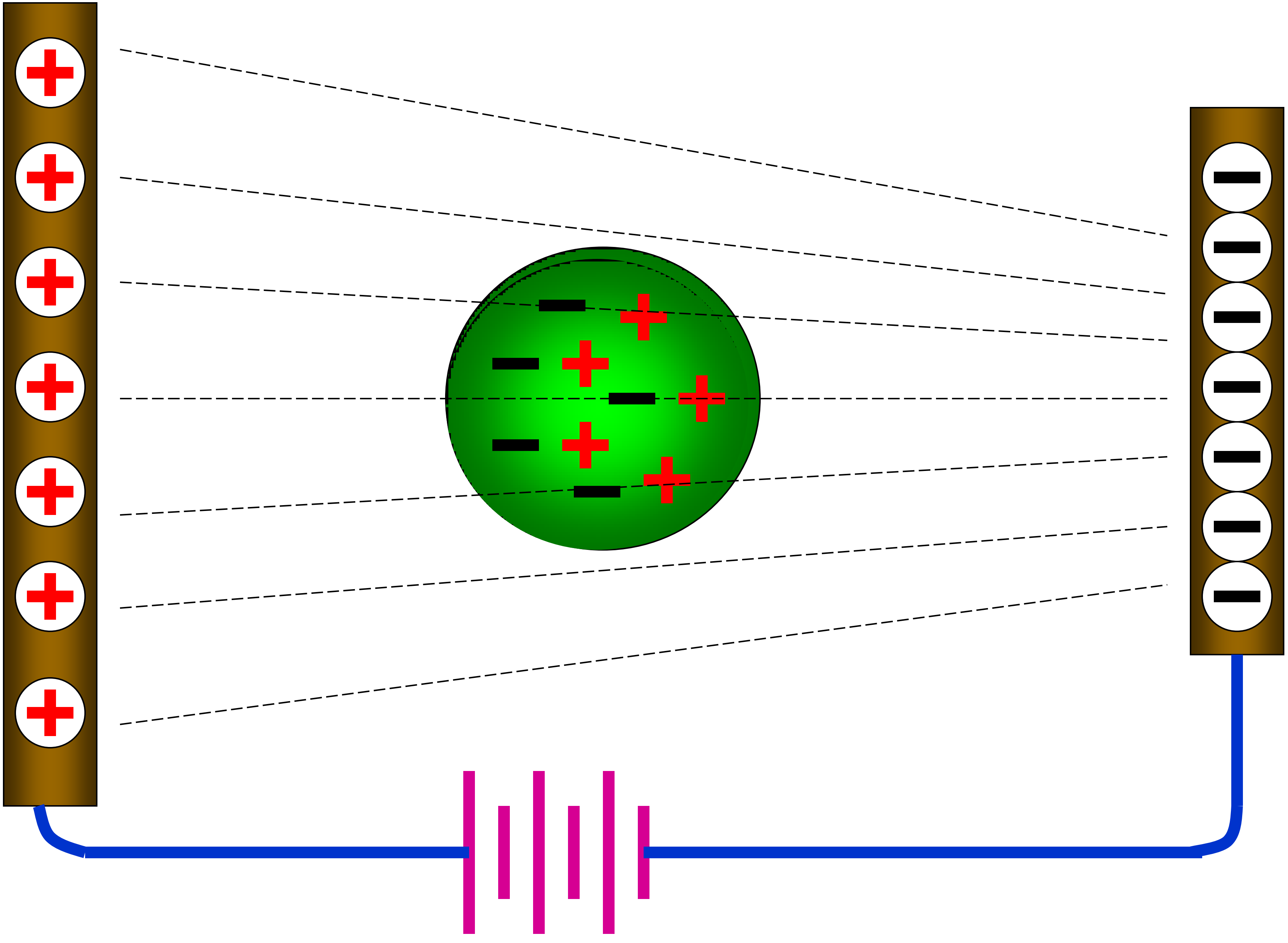
何謂『介電泳』？
(dielectrophoresis)

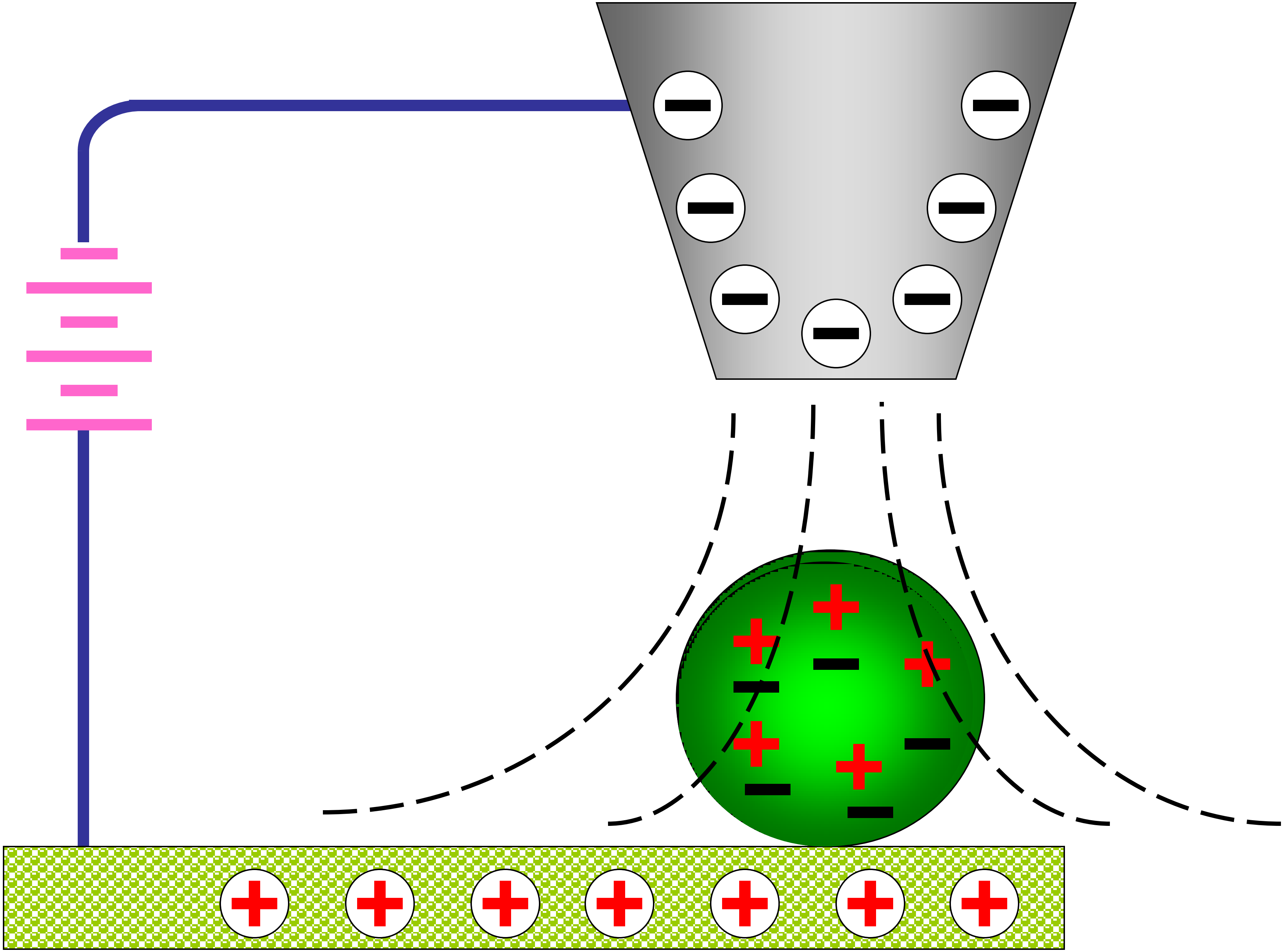


物理化學家
H. A. Pohl (1978)

Herbert A. Pohl,
Dielectrophoresis,
Cambridge University Press,
Cambridge, UK, 1978.

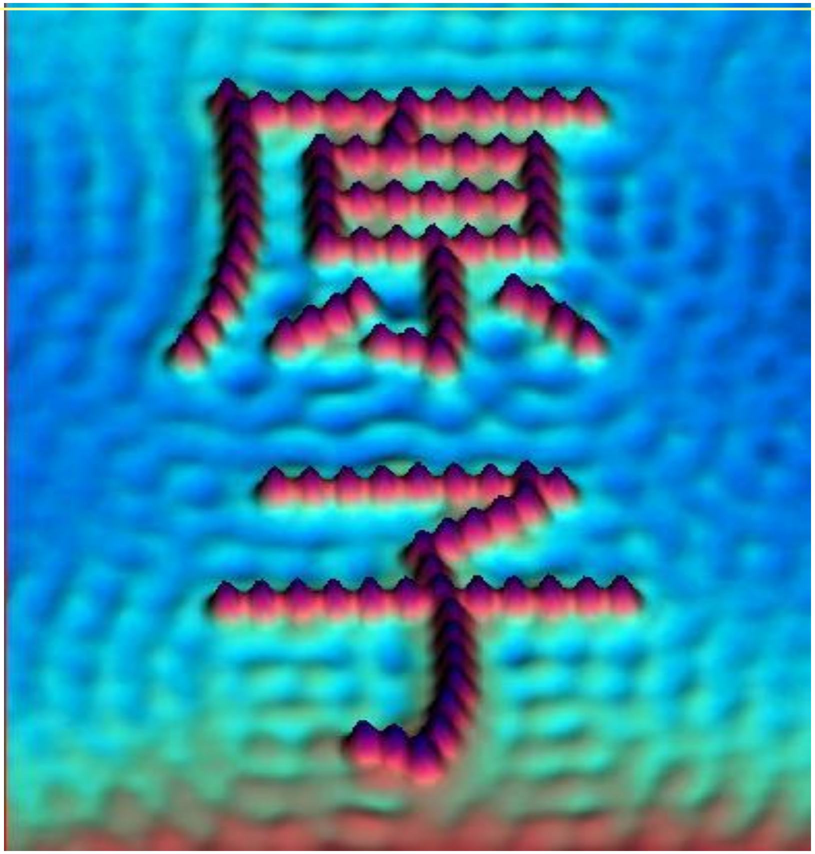






原子操控術

以原子為顏料的奈米風情畫



Title: Atom

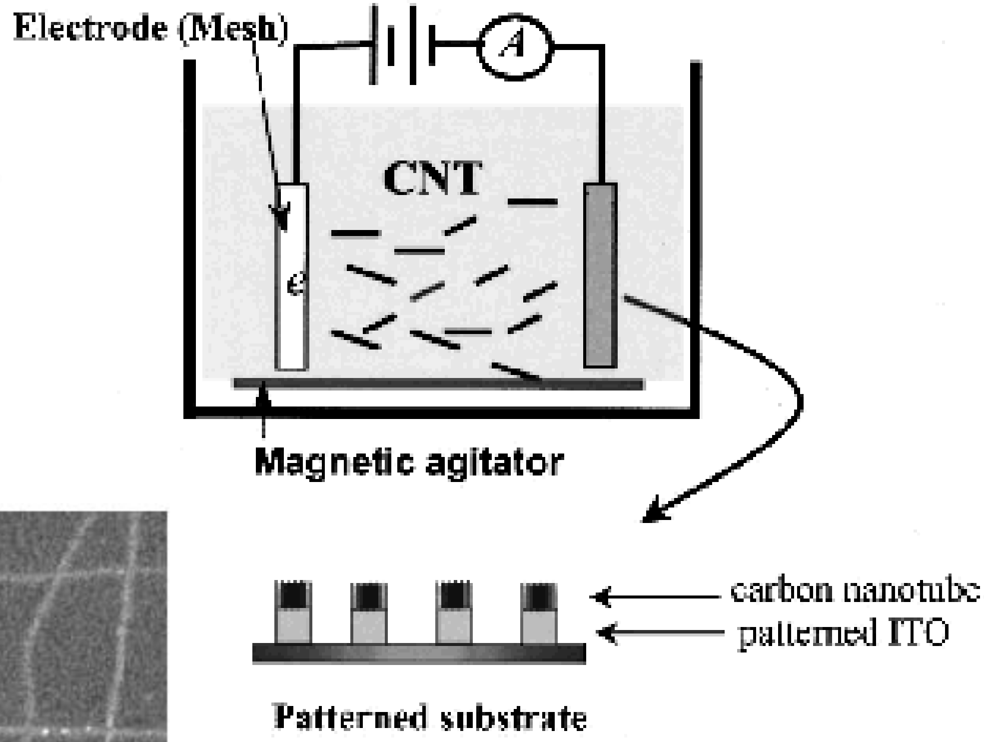
Media: Iron on Copper (111)

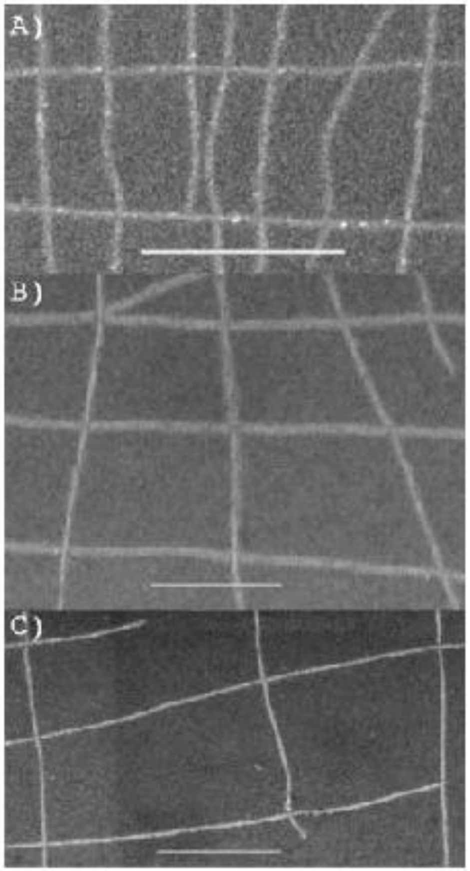
[Lutz & Eigler]

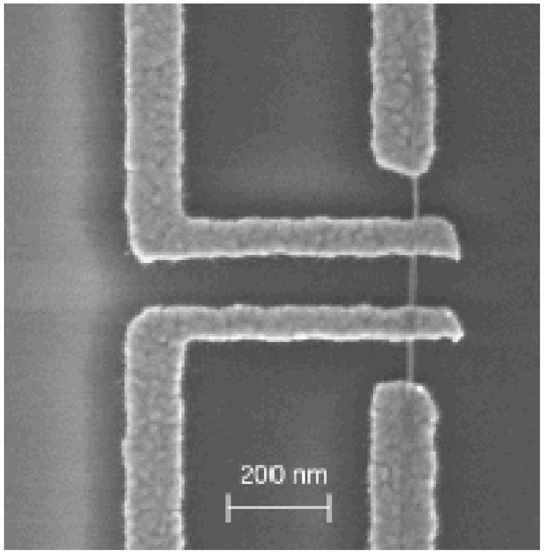
http://www.almaden.ibm.com/vis/stm/atomo.html#stm11

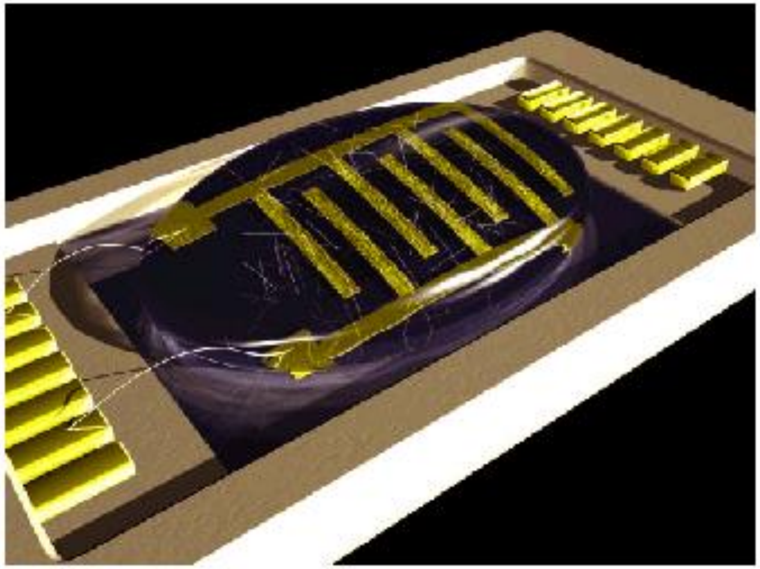
其他的碳管研究和應用

碳管場發射平面顯示器
四探針式碳管電性測量
碳管氣體偵測器
碳管場效電晶體
碳管電路網絡
碳管導電性篩選







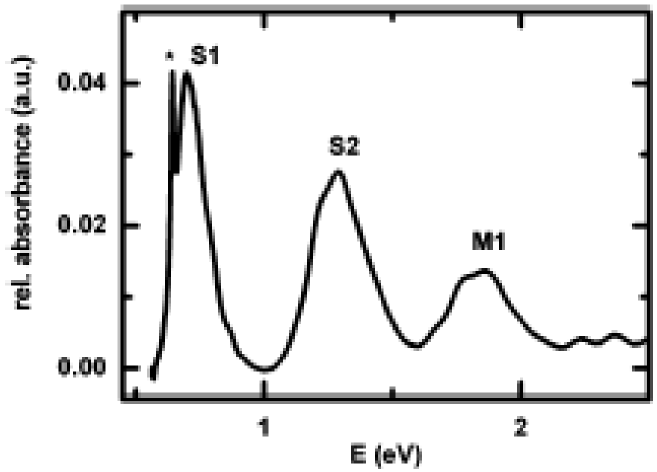


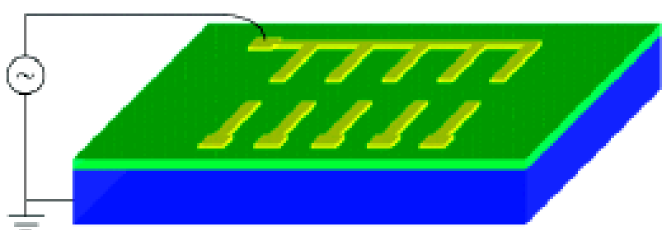
Simultaneous Deposition of Metallic Bundles of Single-walled Carbon Nanotubes Using Ac-dielectrophoresis

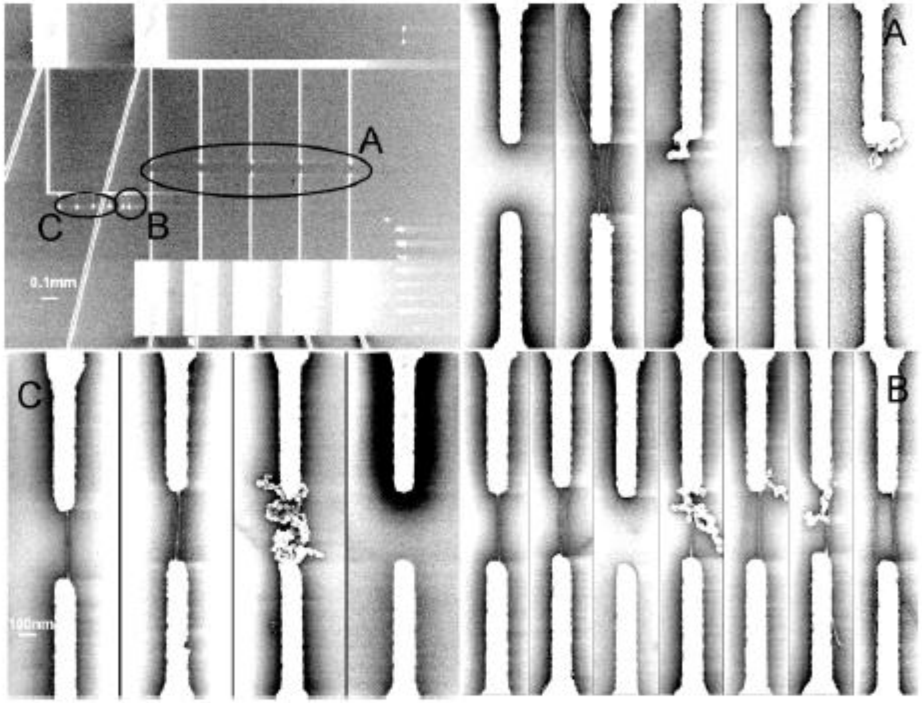
R. Krupke, F. Hennrich, H. B. Weber, M. M. Kappes, and H. v. Lo1hneysen|

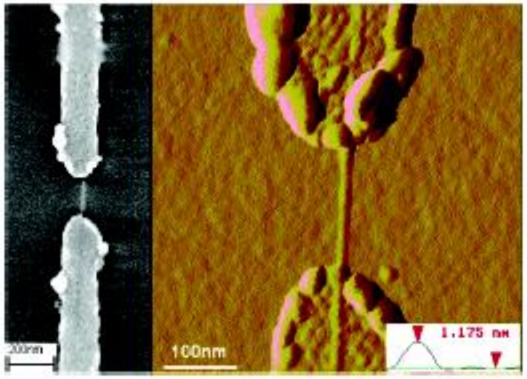
NANO LETTERS

2003
Vol. 3, No. 8
1019−1023





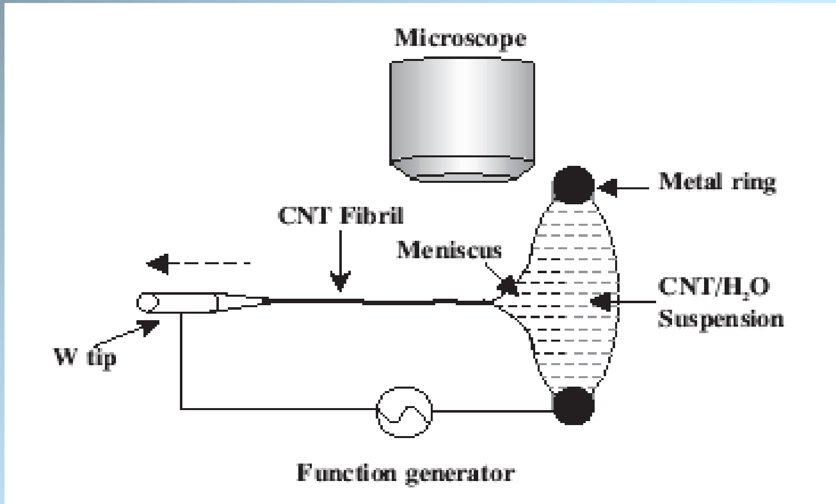


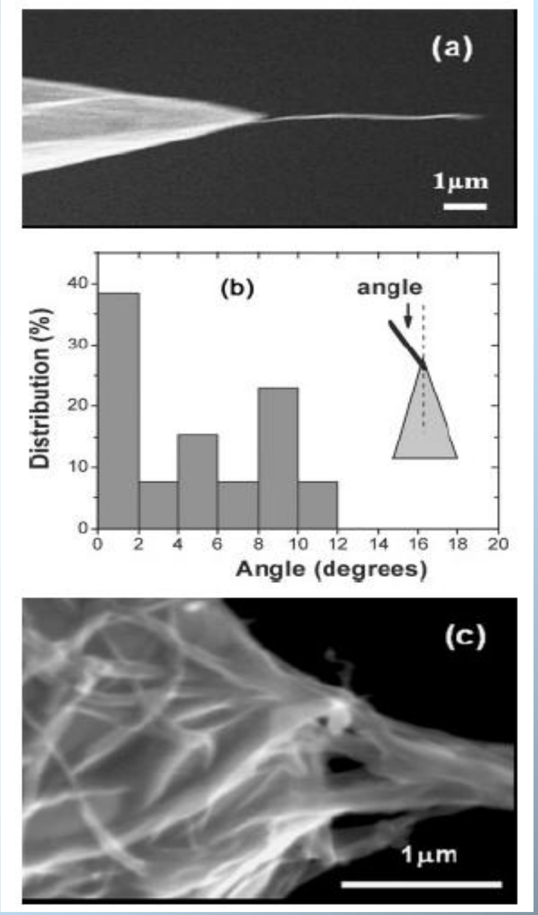


Efficient Fabrication of Carbon Nanotube Point Electron Sources by Dielectrophoresis

Jian Zhang, Jie Tang, Guang Yang, Qi Qiu, Lu-Chang Qin, and Otto Zhou

Adv. Mater. **2004**, *16*, p. 1219.





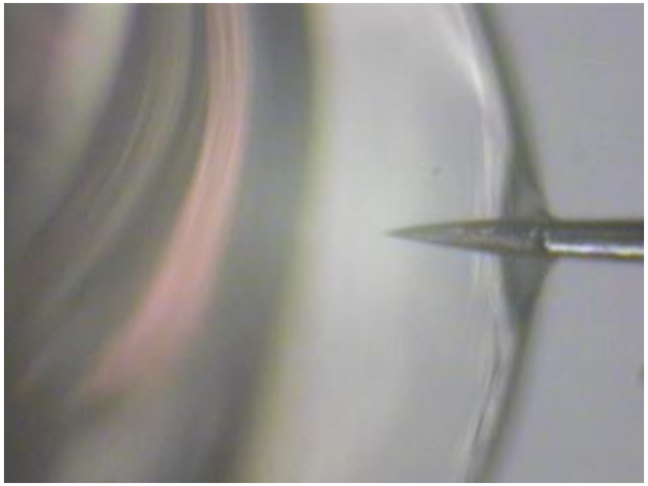
Assembly of 1D Nanostructures into Sub-micrometer Diameter Fibrils with Controlled and Variable Length by Dielectrophoresis

Jie Tang, Bao Gao, Huaizhi Geng, Orlin D. Velev, Lu-Chang Qin, and Otto Zhou

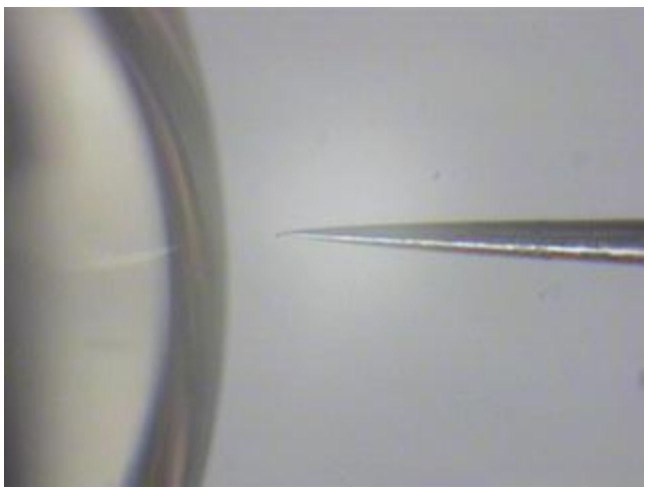
Adv. Mater. **2003**, *15*, p.1352.

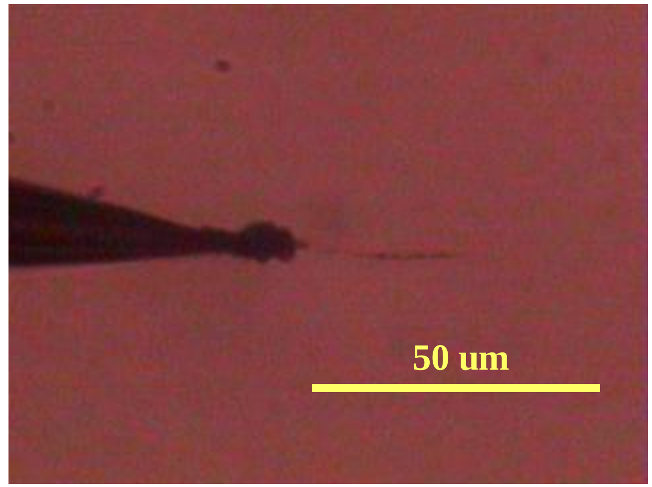
Our own results

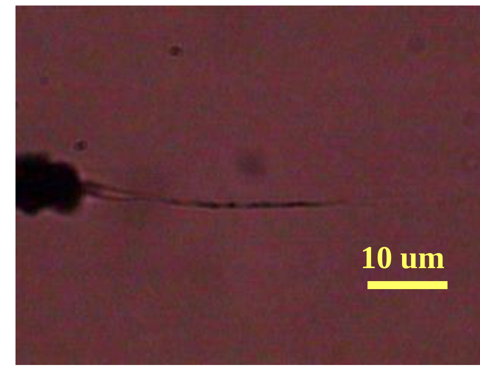
CNT-bundle / W-tip (by DEP)

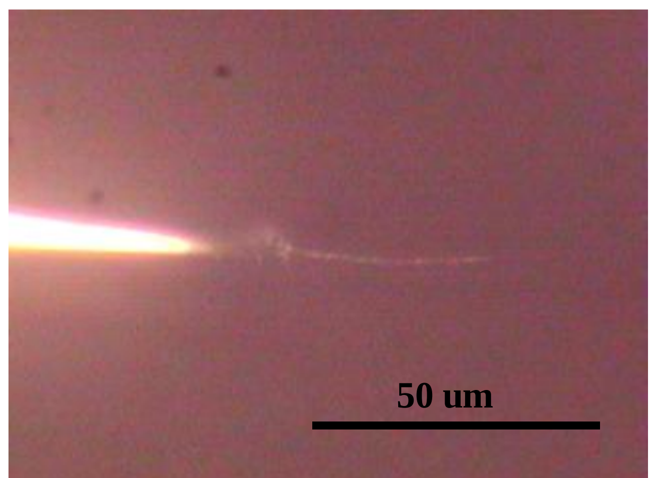


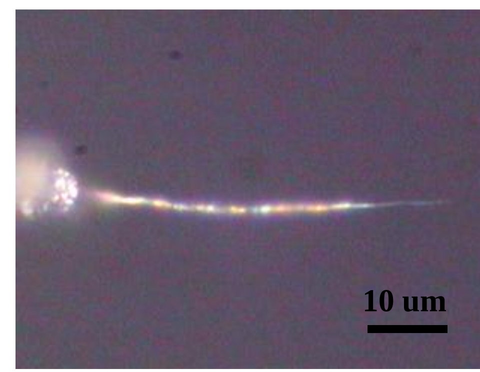
500 um











二、另類綠能科技的研發

(1) 新型的(超級)電容器 → 有效的電能儲存裝置

(2) 非電磁感應式的發電機制 → 有效汲取各種再生能源

(3) 箔式(非典型)的平價光電池 → 普及太陽能的接收利用

(4) 表面張力仲介的光能汲取裝置 → 開發新型的太陽能利用

(5) 地震的預測及其能量的採集 → 善用天然災害的可能性

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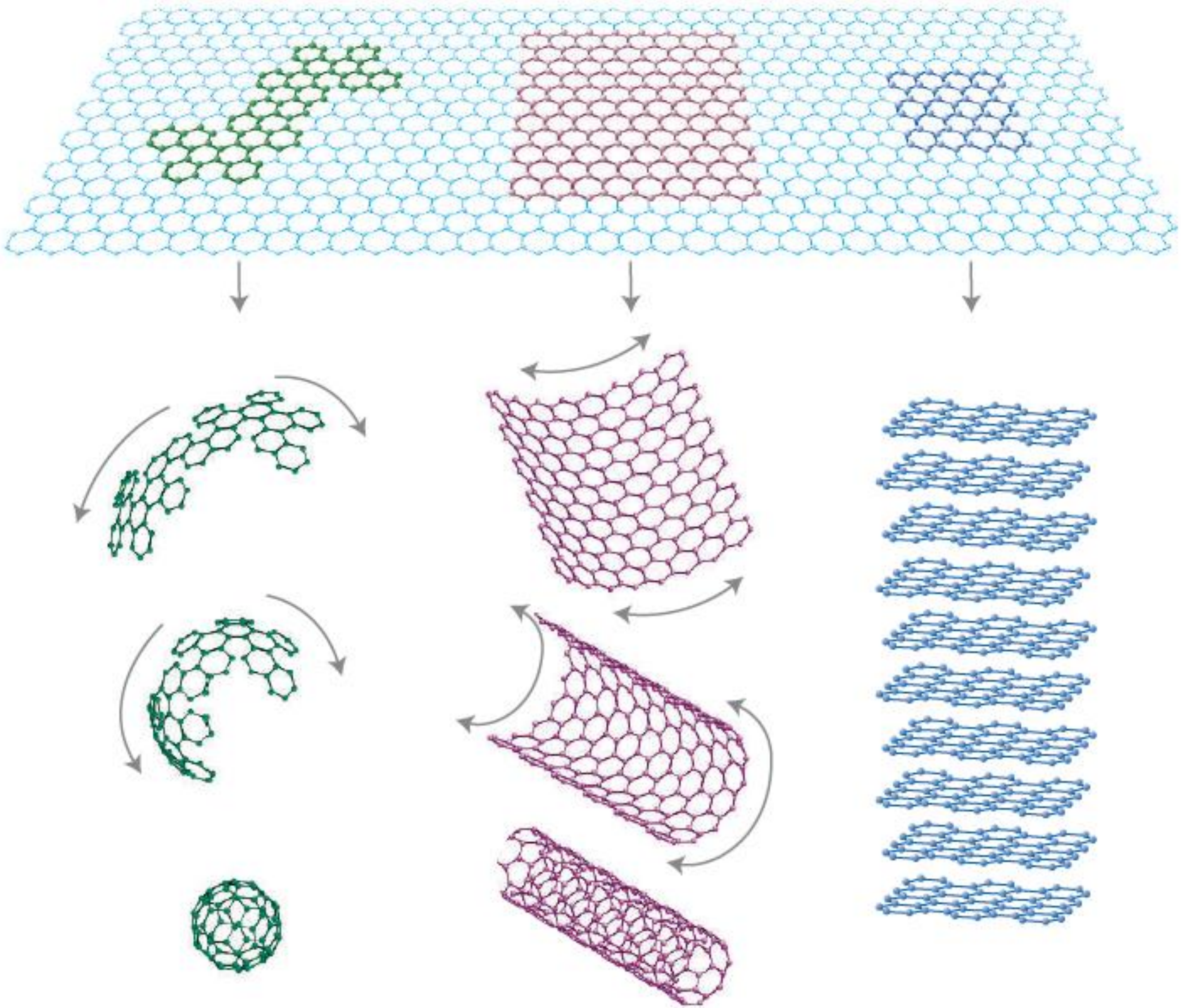


A. K. Geim and K. S. Novoselov, Nature Materials, 6 (2007) p. 183

Single-walled carbon nanotubes (SWNTs) vs. Graphene

表 1 單壁碳奈米管與石墨烯性質比較表[4]
Table 1. Properties of single wall carbon nanotubes and graphene[4]

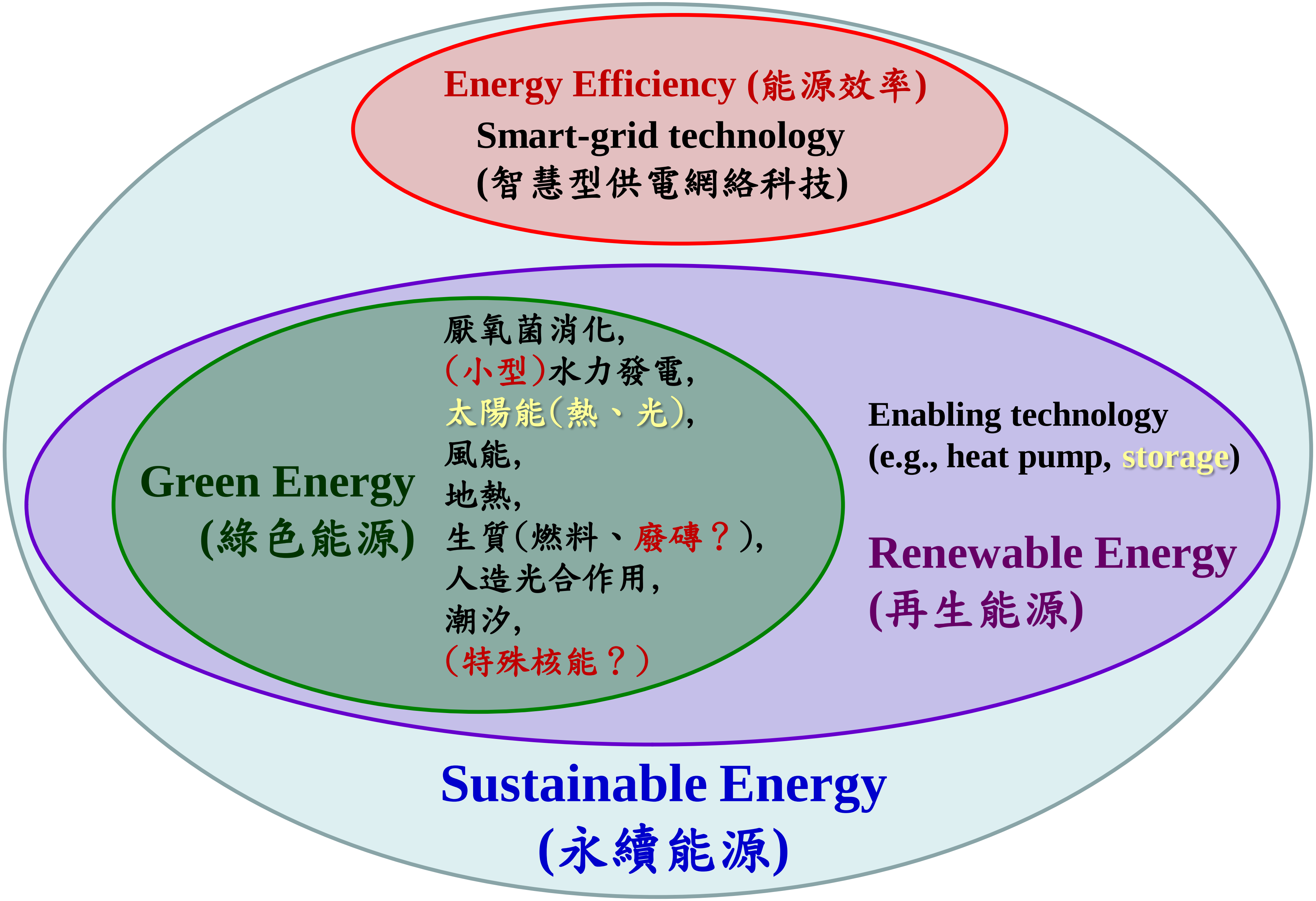
性質	單壁碳奈米管	石墨烯
比重 (g/cm^3)	1.2-1.4	~2.0
楊式模數 (T Pa)	1.0~1.7(軸向)	~1(平面)
抗張強度 (G Pa)	50-500	~100-400
線性電阻抗 (μΩ cm)	5-50	50
熱傳導係數 (Wm^{-1}K^{-1})	2,900	5,300(平面)；6-30(c 軸方向)
磁感受性 (emu/g)	22×10^6 (放射向) 0.5×10^6(軸向)	22×10^6(垂直平面) 0.5×10^6(平行平面)
熱膨脹係數 (K^{-1})	-1×10^{-6}	-1×10^{-6}(平面) 29×10^{-6}(c 軸方向)
熱穩定性 (℃)	＞700℃(空氣)	450-650℃(空氣)
比表面積 (m^2/g)	100-200 (最高至 1,300)	100-1000(最高＞2,600)
價格/磅 ($)	~500	~10

馬振基等人，台灣奈米會刊第**23**期**(99**年**12**月**)**第**47-59**頁

	奈米碳管	石墨烯
機械	極尖探針	
	(儲氫)	Supercapacitors
	抗應力複合材料	同左
機電	奈米秤、微鑷夾	超高頻電致振盪器
	奈米機電致動器	
電	場效電晶體、偵測器	同左
	場效型記憶體	
	量子化電阻器	室溫量子霍爾元件
	平面顯示器	
光電	可攜式X光機	
	場效微發光器	透明導電超薄膜
	微形光敏電阻	

Capacitors

(1) superb chemical stability,
(2) high conductivity,
(3) light mass,
(4) large surface area.



Based on http://en.wikipedia.org/wiki/Sustainable_energy

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Parallel-Plate Capacitor

small plate separation ➔ ignored fringing fields (fringe effects) at the ends

assume : uniform field ⇨ $V = E\,d$

$E = \sigma/\varepsilon_0 = Q/\varepsilon_0 A$ (surface charge density : $\sigma = Q / A$)

$C \equiv Q / V = \varepsilon_0 A / d$ permittivity : $\varepsilon_0 = 8.85 \times 10^{-12}$ (F/m)

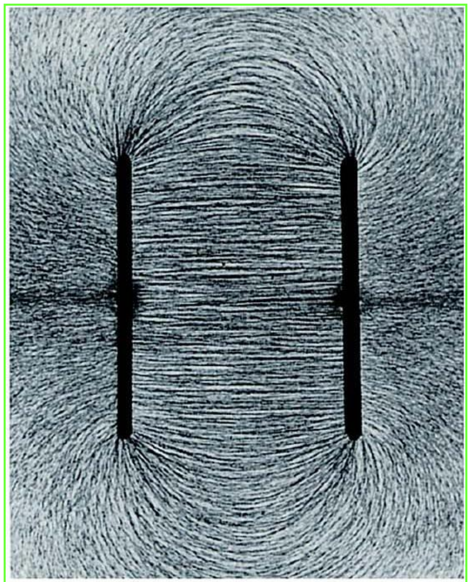


圖 26.3
兩塊電性相反且大小有限之平板，所造成的電場並不均勻。

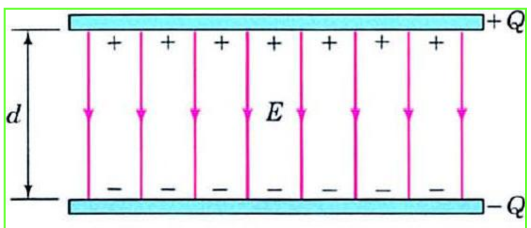


圖 26.4
當平板間距極小時，邊緣效應可被忽略，電場仍可被視為均勻的。

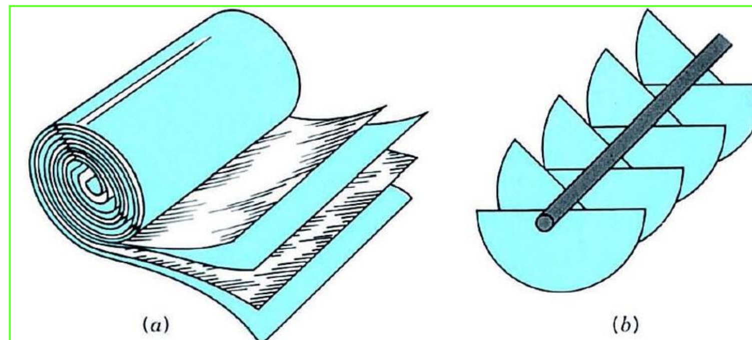
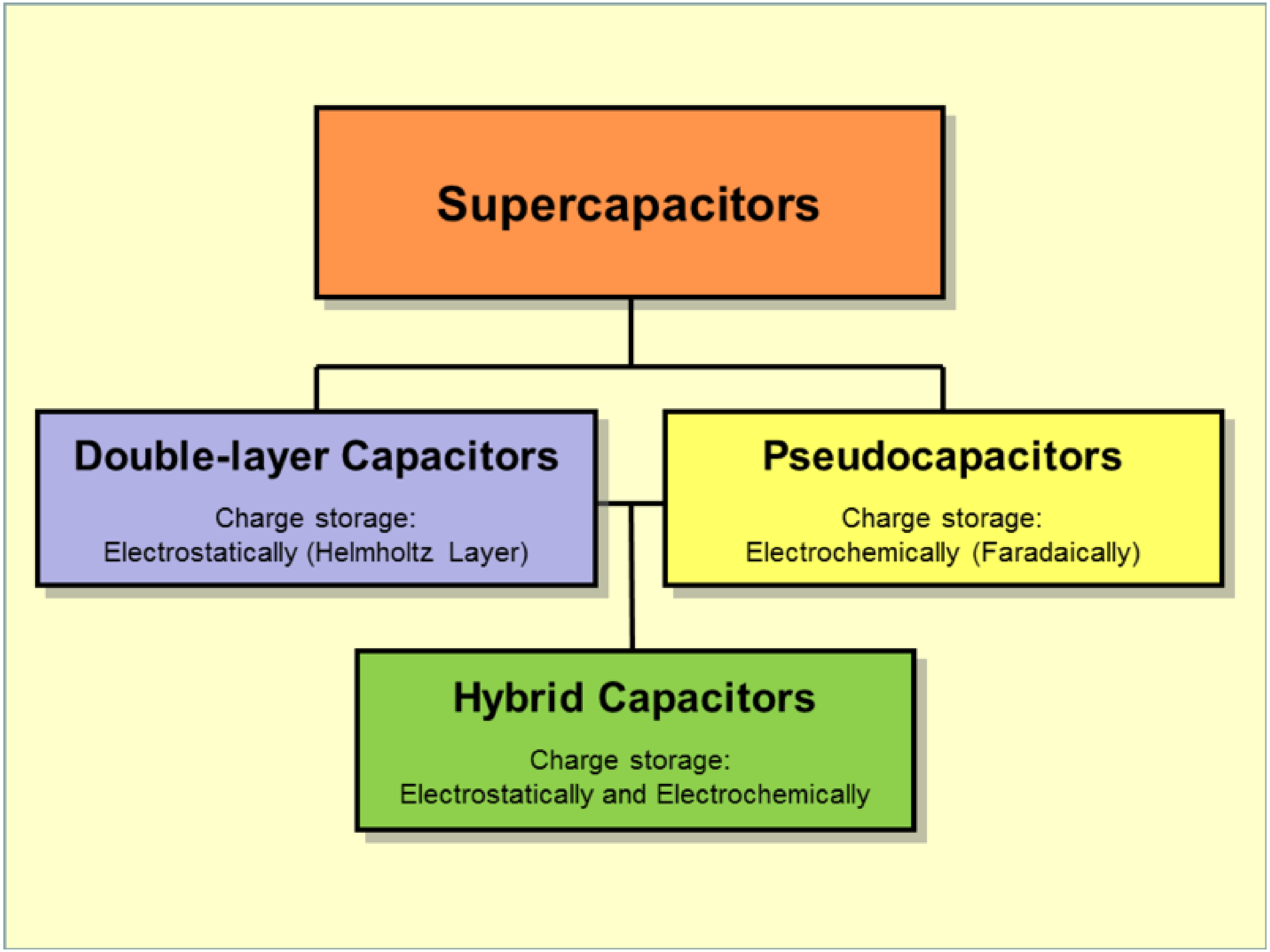


圖 26.5
(a) 將塑膠物質包入金屬箔片中而製成電容。
(b) 可變電容。電容大小視兩組板子間之重疊部份而定；一組板子固定，另一組可轉動。

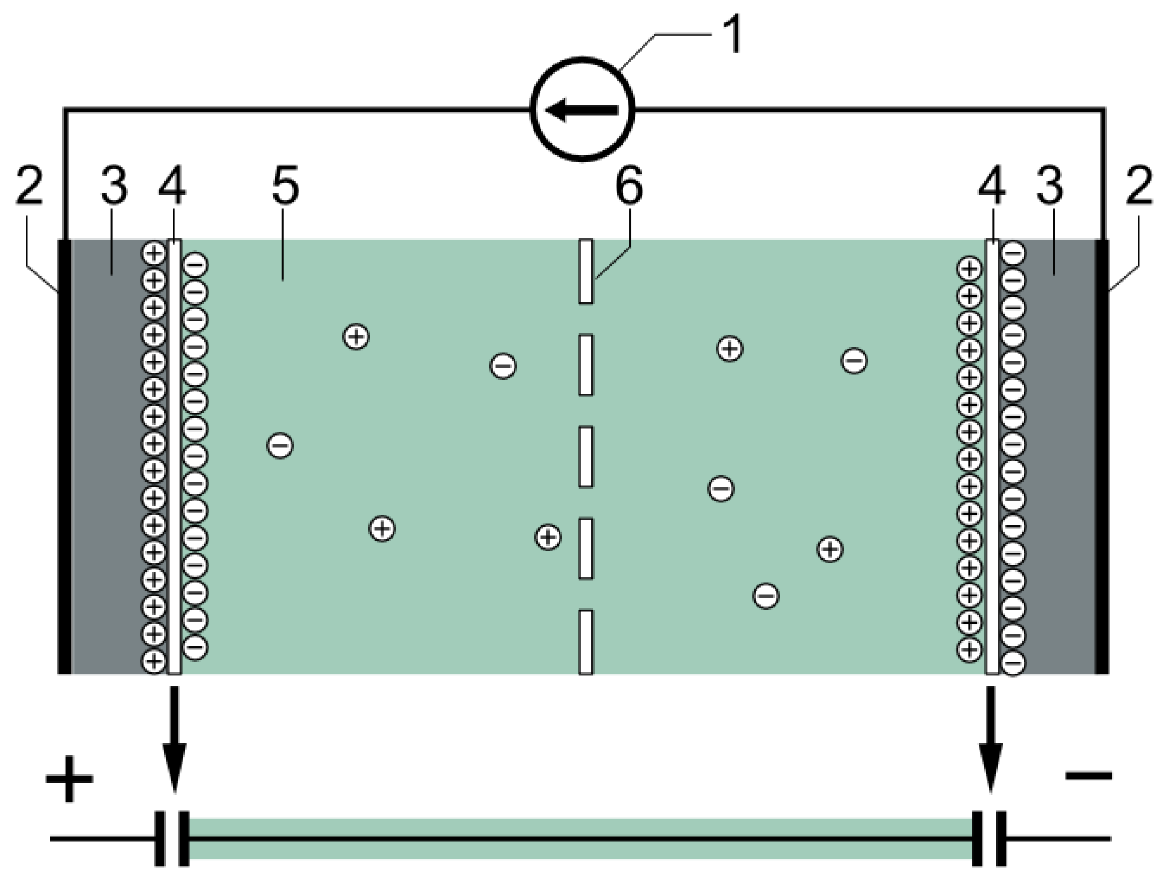
University Physics (revised edition) by Harris Benson
(John Wiley & Sons, Inc.) §26-1

http://en.wikipedia.org/wiki/Supercapacitor



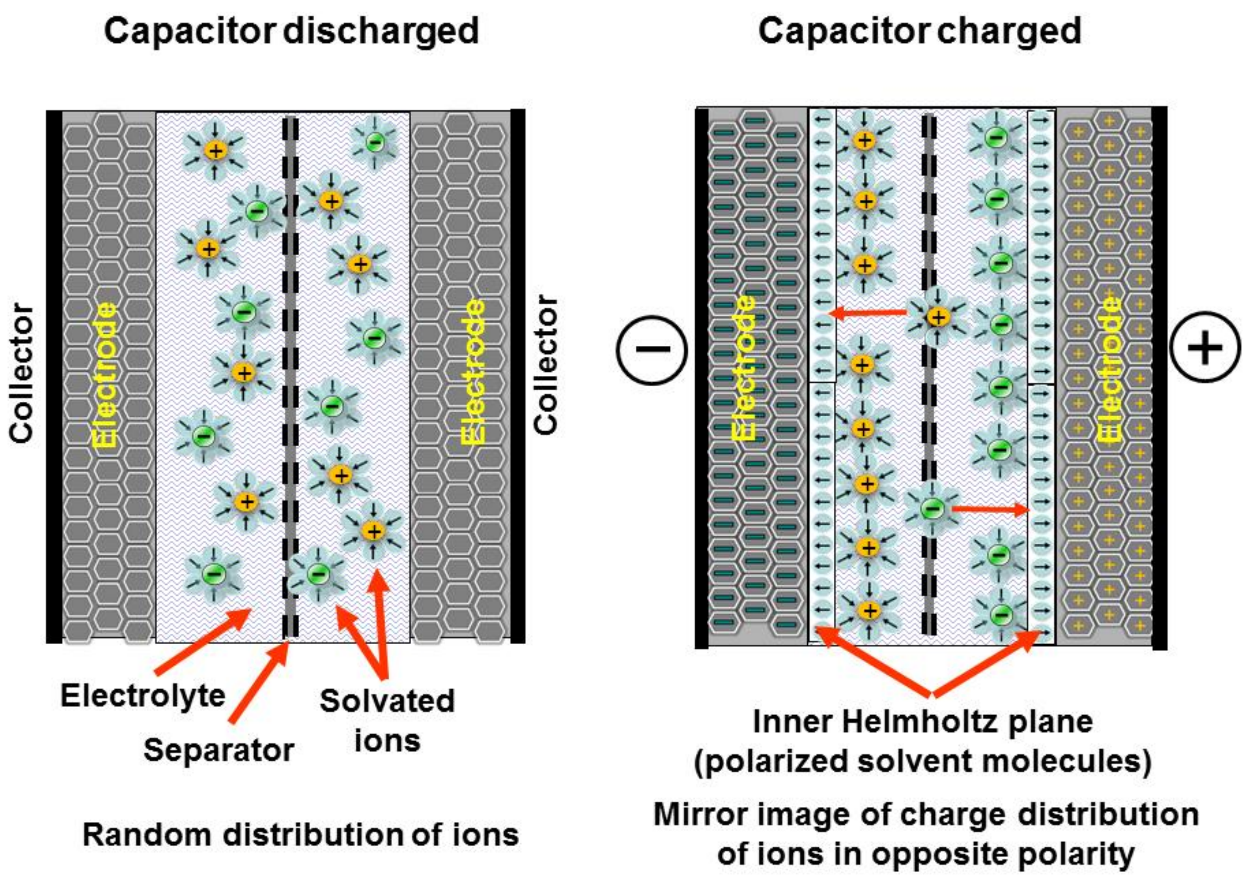
Hierarchical classification of supercapacitors and related types.

http://en.wikipedia.org/wiki/Supercapacitor



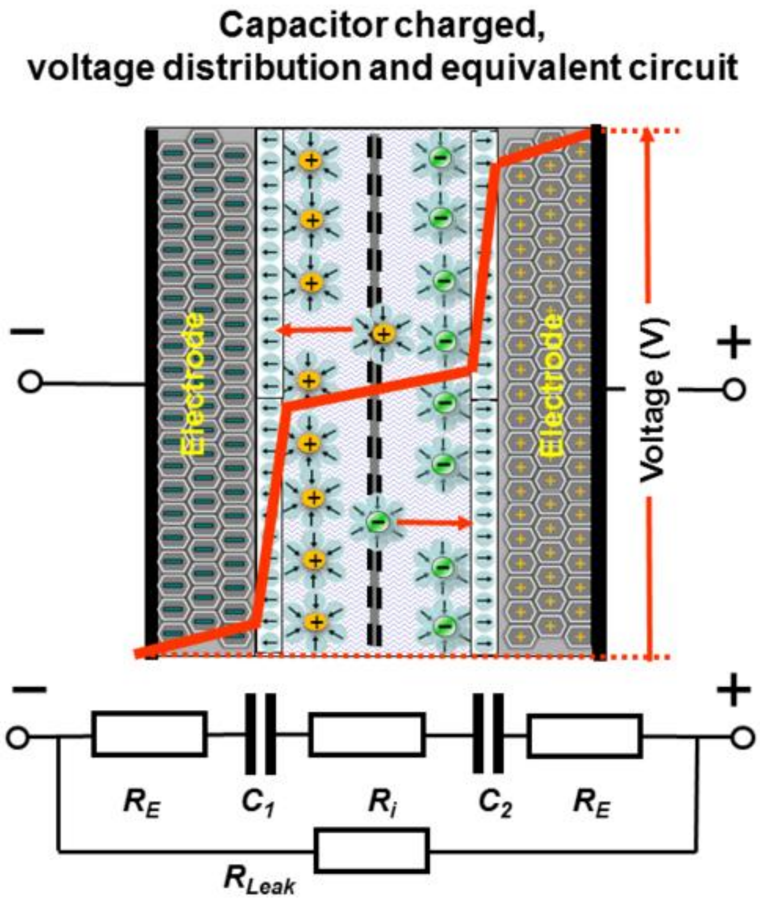
Principle construction of a supercapacitor; 1. power source, 2. collector, 3.polarized electrode, 4. Helmholtz double layer, 5. electrolyte having positive and negative ions, 6. Separator.

http://en.wikipedia.org/wiki/Supercapacitor



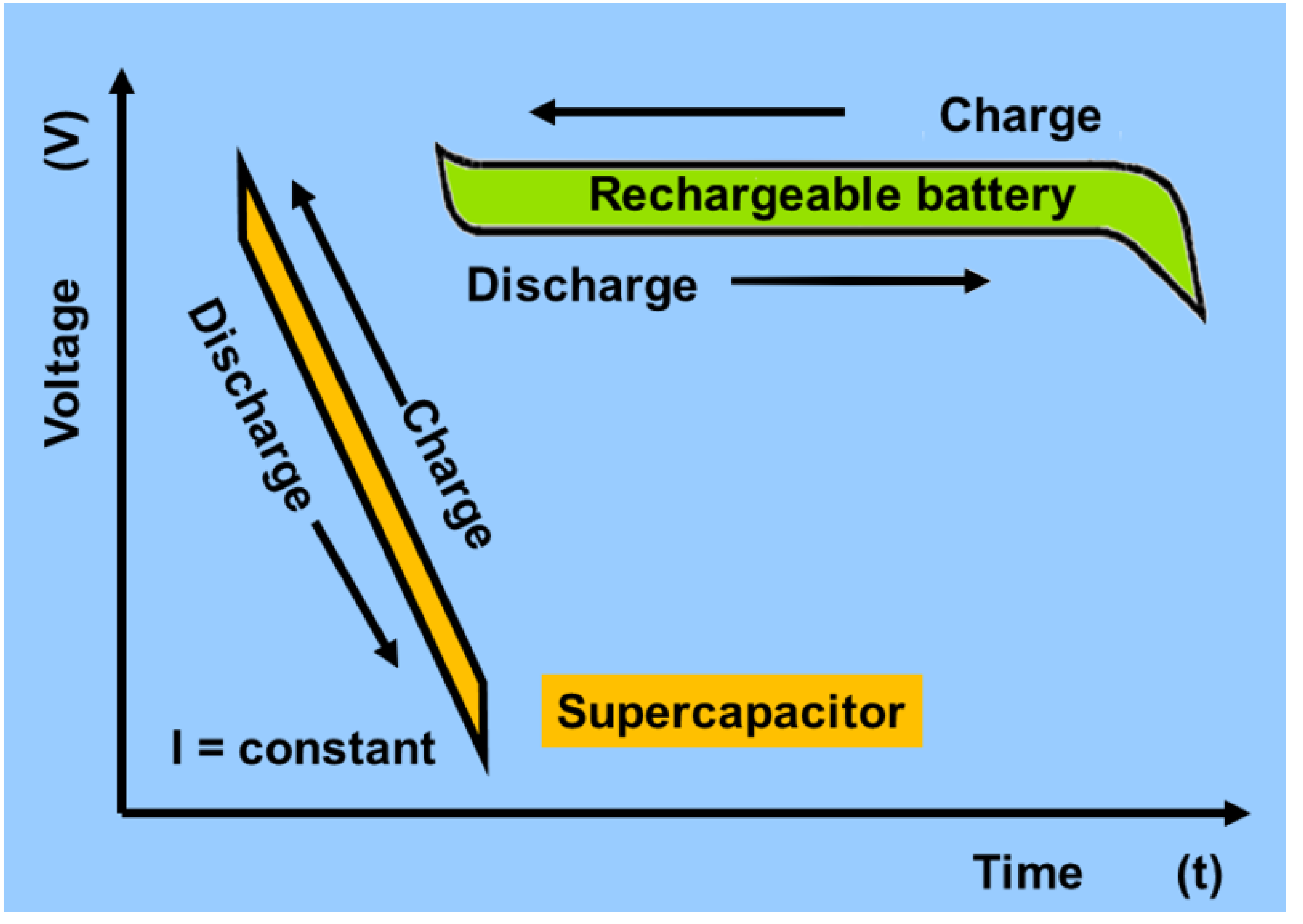
Structure and function of an ideal double-layer capacitor. Applying a voltage to the capacitor at both electrodes a Helmholtz double-layer will be formed separating the ions in the electrolyte in a mirror charge distribution of opposite polarity.

http://en.wikipedia.org/wiki/Supercapacitor



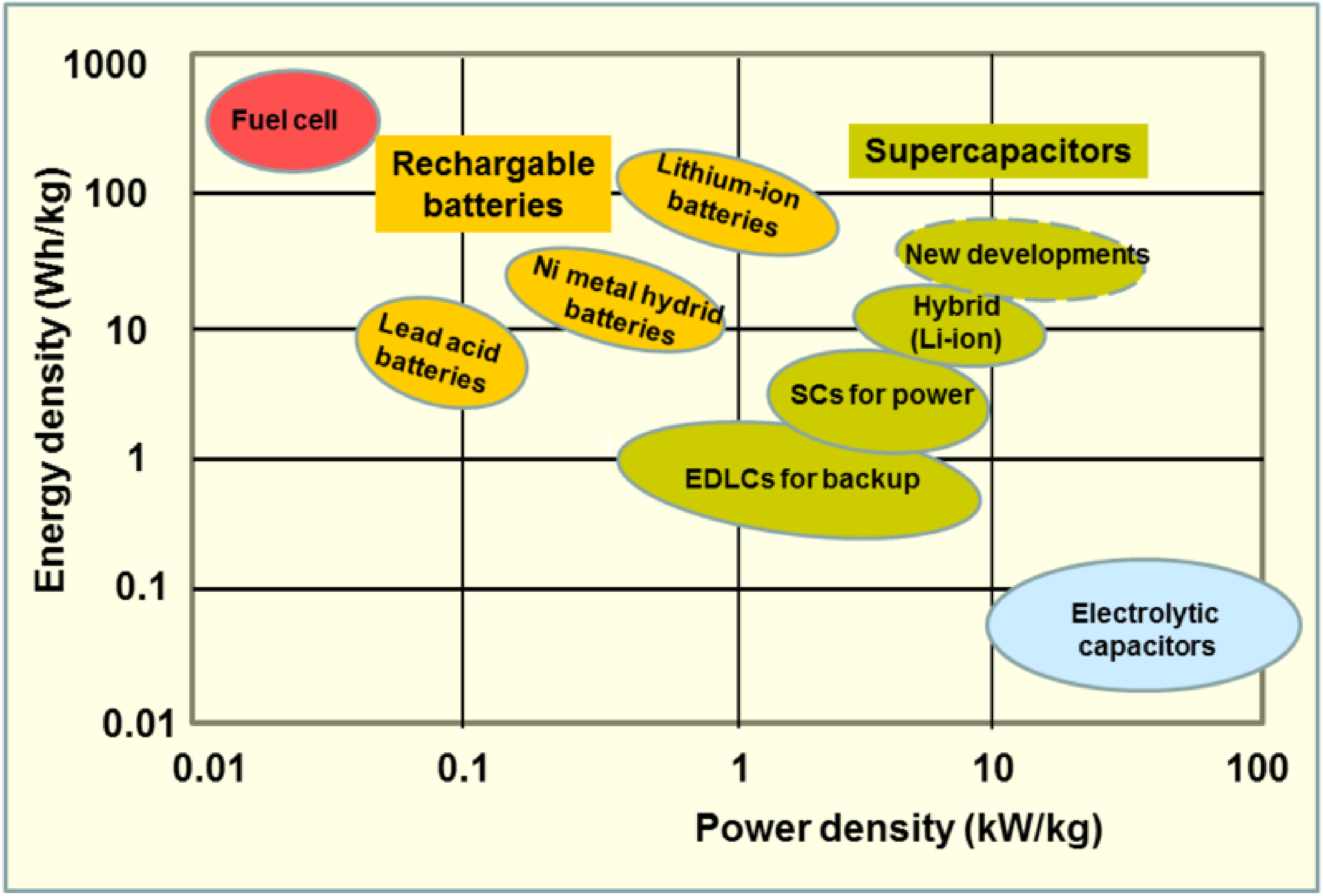
Basic illustration of the functionality of a supercapacitor, the voltage distribution inside of the capacitor and its simplified equivalent DC circuit.

http://en.wikipedia.org/wiki/Supercapacitor



The voltage behavior of supercapacitors and batteries during charging/discharging differs clearly.

http://en.wikipedia.org/wiki/Supercapacitor



Ragone chart showing power density vs. energy density of various capacitors and batteries

J. Phys. Chem. C **2009,** *113,* 13103–13107 **13103**

Supercapacitor Devices Based on Graphene Materials

Yan Wang,[†] Zhiqiang Shi,[‡] Yi Huang,[†] Yanfeng Ma,[†] Chengyang Wang,*[,‡] Mingming Chen,[‡] and Yongsheng Chen*[,†]

Key Laboratory of Functional Polymer Materials and Center for Nanoscale Science & Technology, Institute of Polymer Chemistry, College of Chemistry, Nankai University, Tianjin 300071, China, and Key Laboratory for Green Chemical Technology of State Education Ministry, School of Chemical Engineering and Technology,

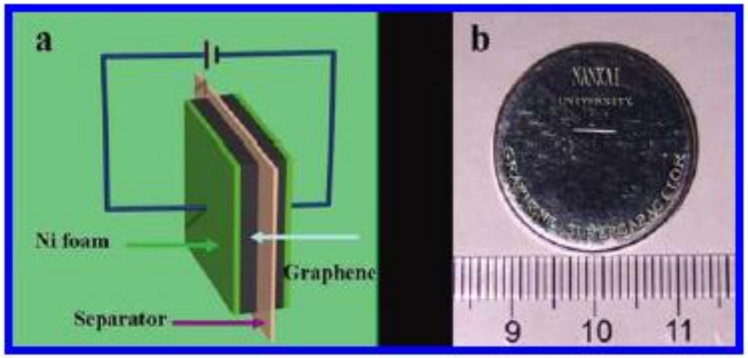


Figure 1. Graphene-based supercapacitor device. (a) Schematic diagram of graphene-based supercapacitor device. (b) An optical image of an industry-grade coin-shaped graphene-based supercapacitor device assembled in this study.

Received: May 3

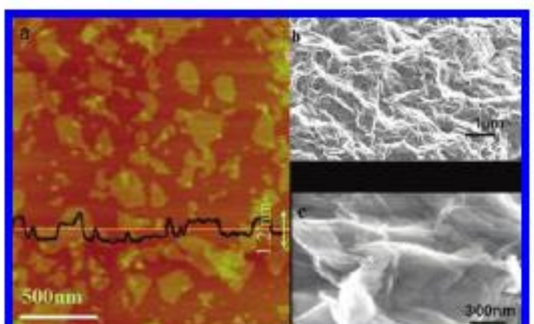


Figure 2. Morphology of graphene oxide and GMs. (a) Tapping-mode AFM image of graphene oxide and height profile plot showing the ~1.2 nm thickness for individual graphene oxide sheets. The sample was prepared by spin-coating the dilute graphene oxide dispersion (1.0 mg/mL) onto a freshly cleaved mica surface. (b, c) Scanning electron microscopy (SEM) images of GM-A with different scale bars.

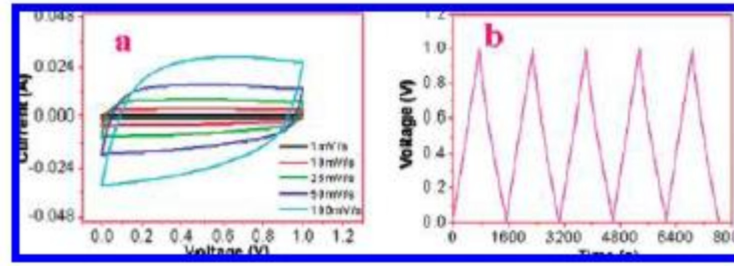
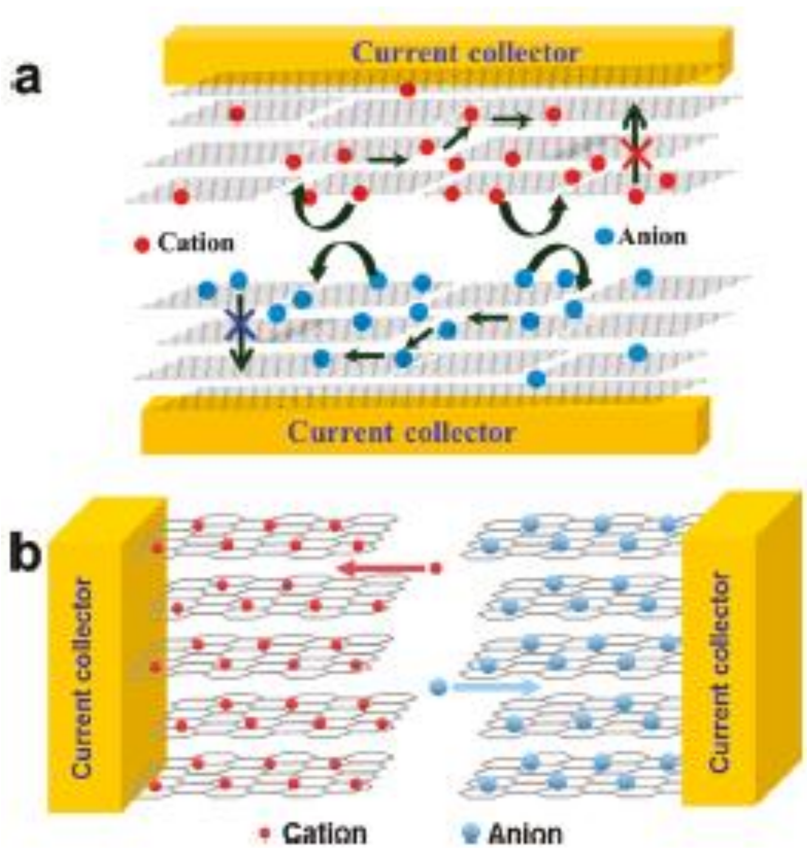


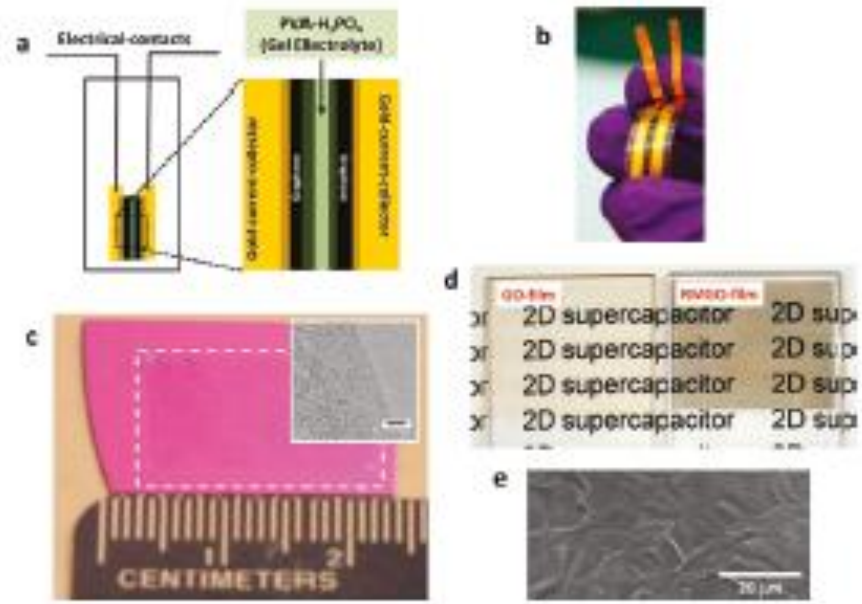
Figure 3. (a) Cyclic voltammograms (CV) for GM-A electrodes at different scan rates using 30 wt % KOH aqueous electrolyte. CV at high 100 mV/s still shows a rectangular-like curve, indicating a good capacitor behavior. (b) Galvanostatic charge−discharge curve of GMs electrode at a constant current density of 100 mA/g, using 30 wt % KOH electrolyte.

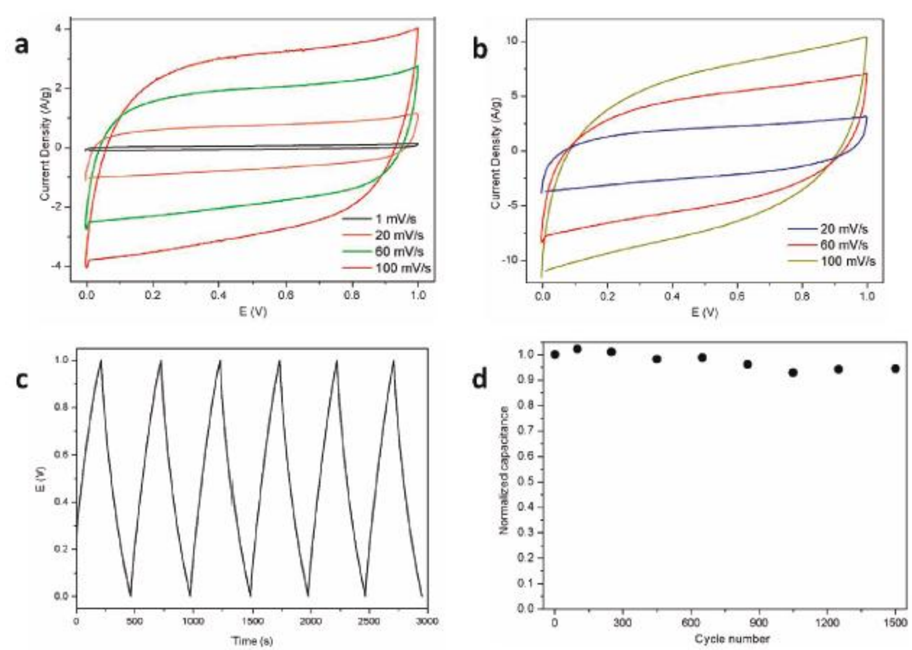
Jung Joon Yoo, *et. al.*,

Nano Letters 11 (2011) p. 1423

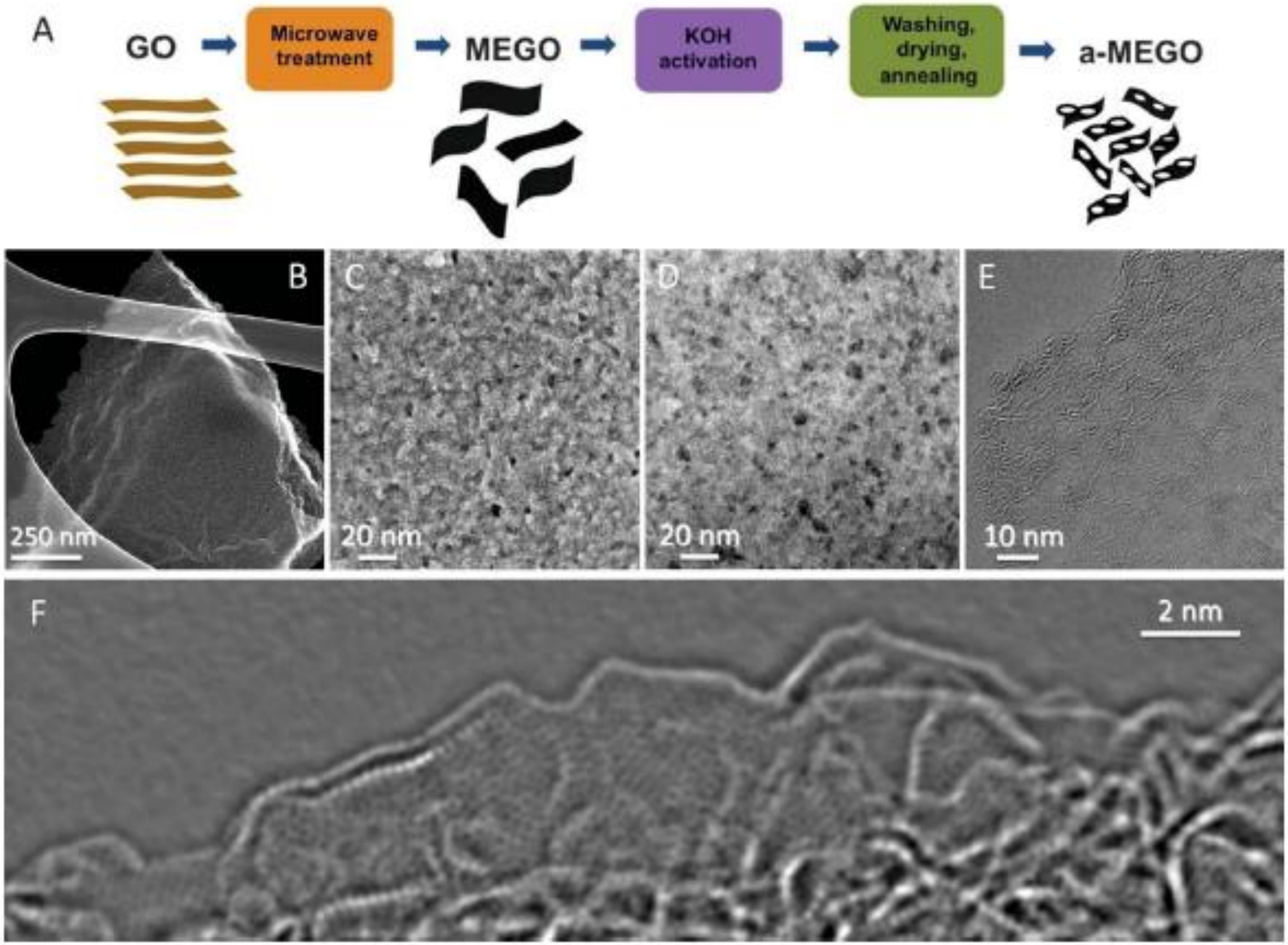
Ultrathin Planar Graphene Supercapacitors







Carbon-Based Supercapacitors Produced by Activation of Graphene
Yanwu Zhu, *et al.*
Science **332**, 1537 (2011);
DOI: 10.1126/science.1200770



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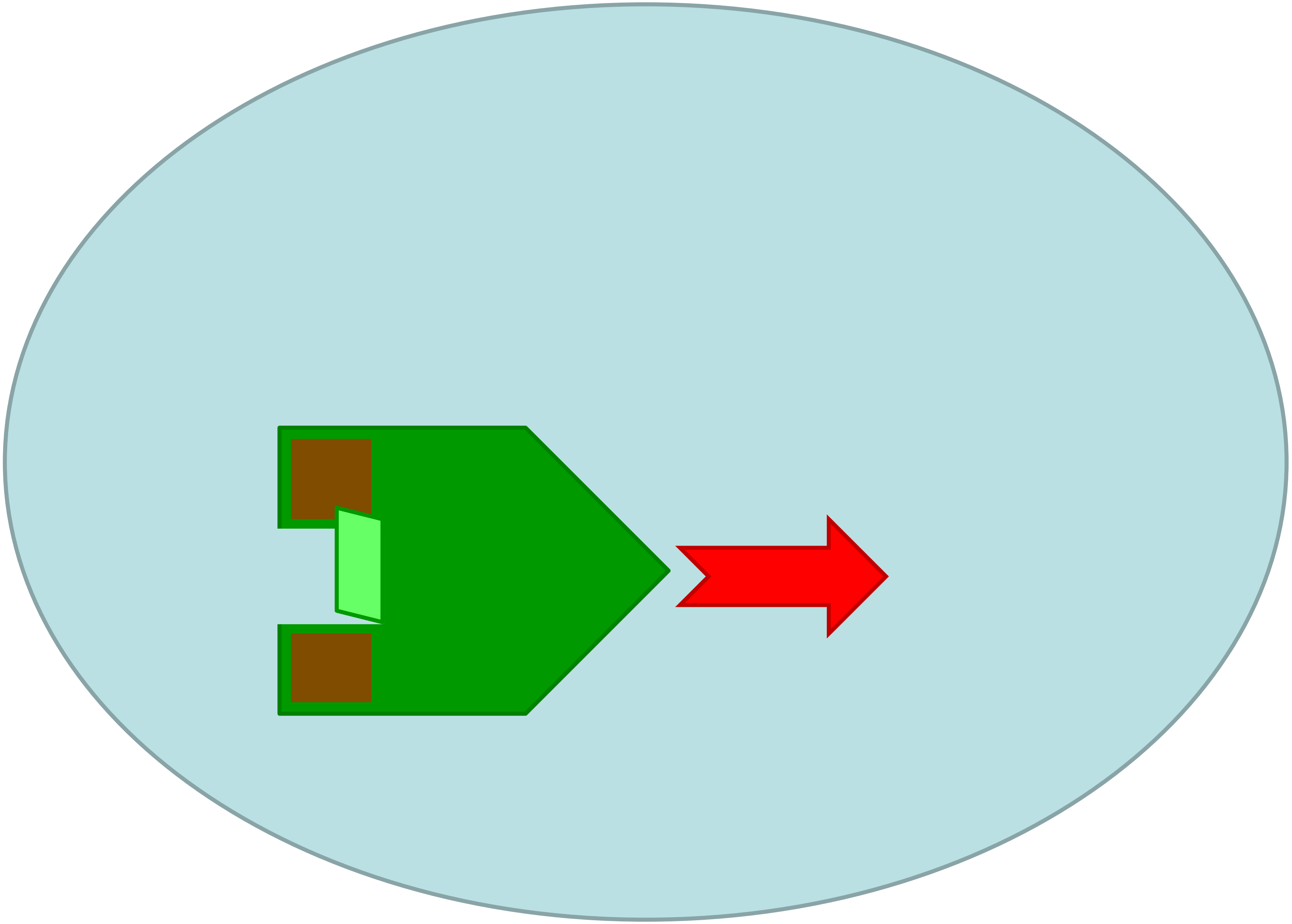
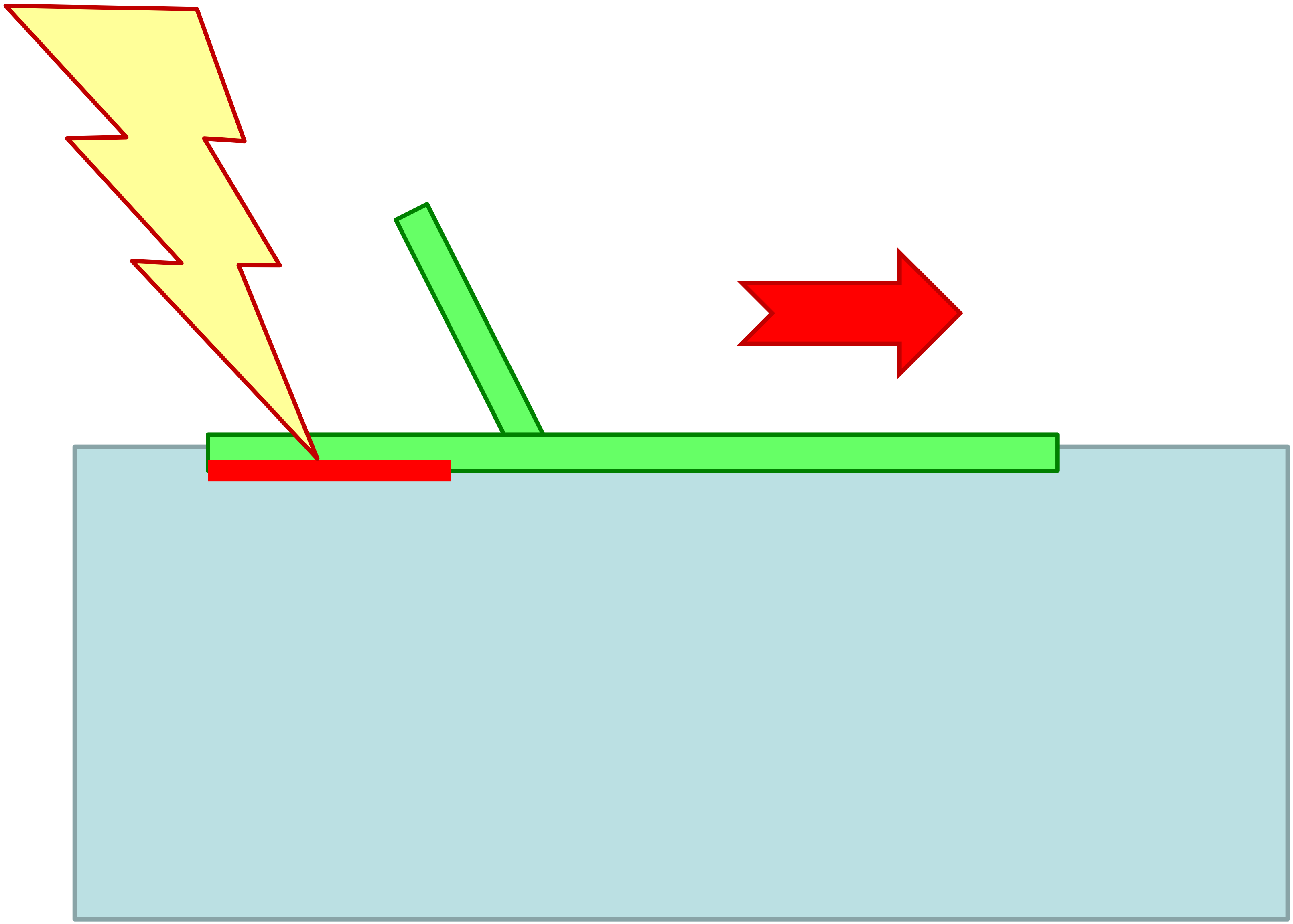
(5) 地震的預測及其能量的採集 ➔ 善用天然災害的可能性





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Published on Web 03/27/2009

Surface Tension Mediated Conversion of Light to Work

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Received January 7, 2009; E-mail: frechet@berkeley.edu

Ⓦ This paper contains enhanced objects available on the Internet at http://pubs.acs.org/jacs.

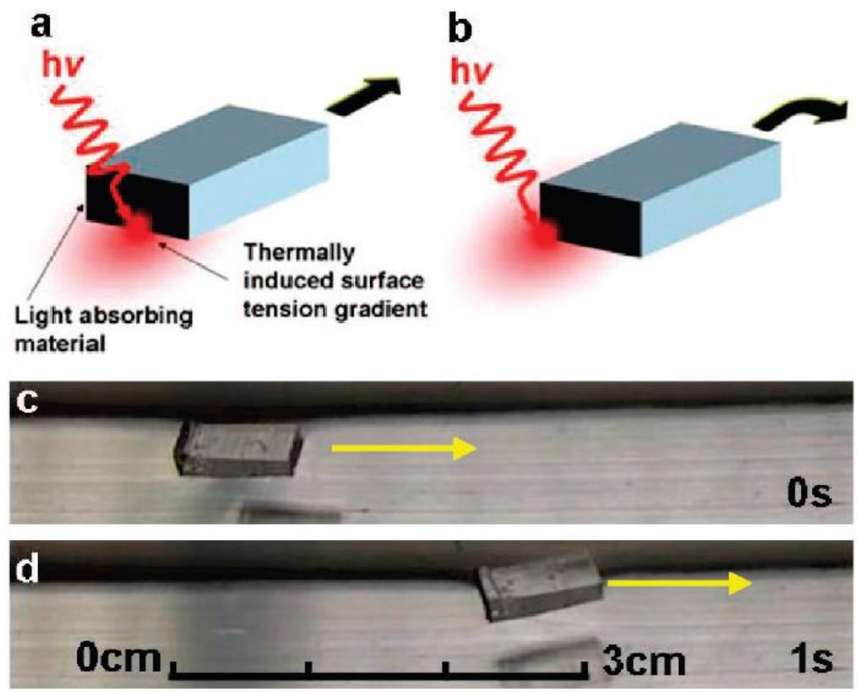

Figure 1. Light-based control of VANT-PDMS objects on water. When illuminated, as in (a), the retarding surface tension force diminishes and the object is pulled forward. Alternatively, when the back-left side is heated (b), an asymmetry of forces is created, resulting in forward and right turning propulsion. Such selective irradiation can be used to produce and remotely control motion. Optical images (c−d) of a VANT-PDMS composite in a water filled trough show the linear propulsion described in (a). The VANT-PDMS object is briefly irradiated at time zero with focused near-IR light (450 mW) just right of center on the back, absorbing face of the object. The laser source is roughly 13 cm away, with the beam nearly grazing the surface of the water and the focus set to coincide with the absorbing face of the object.

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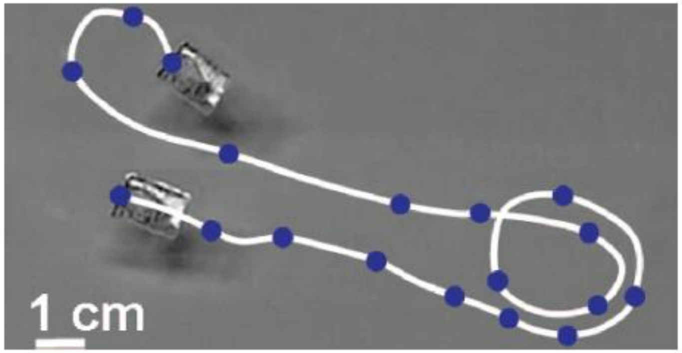
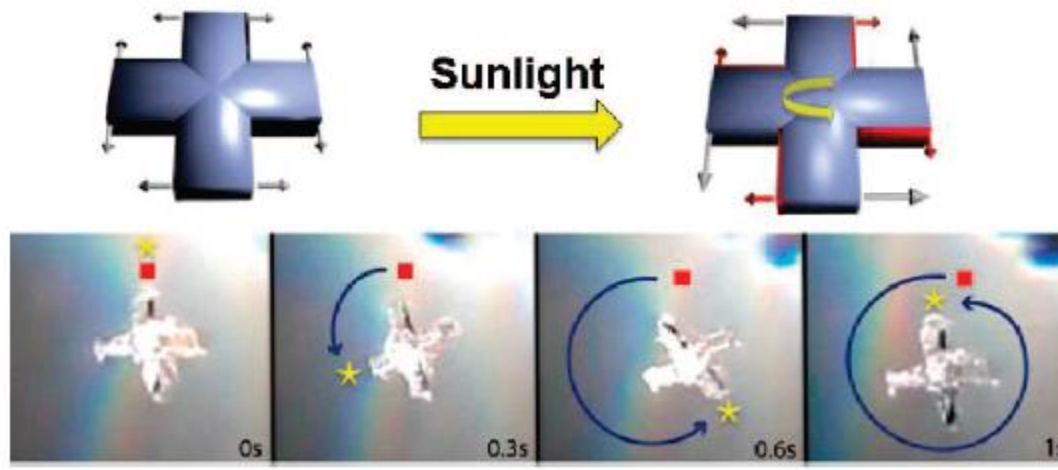


Figure 4. Light controlled linear motion of a VANT-PDMS composite floating on water. The top of the object has been colored black to aide the eye. The white line shows the path of the composite, with the dots representing two second time points. The composite is directed to the right, turned around in a circle, and sent back to the left. The final location of the boat has been superimposed upon the original image.

Figure 5. VANT-PDMS rotor timeline. Schematic (top) showing forces (gray arrows and with heating, red arrows) on PDMS rotor with absorbing material embedded on the clockwise face of each fin while dark and illuminated. Time line (bottom) of a VANT-PDMS rotor floating on deionized water with embedded VANTs on clockwise face of each fin and irradiated with focused sunlight. The square remains stationary as the star follows one fin.



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Outlines

I. Personal background

II. Nanomaterials vs. Green energy

III. Selected examples of applications

IV. **Research outlook**

V. Conclusion

二、另類綠能科技的研發

(1) 新型的(超級)電容器 ➔ 有效的電能儲存裝置

(2) 非電磁感應式的發電機制 ➔ 有效汲取各種再生能源

(3) 箔式(非典型)的平價光電池 ➔ 普及太陽能的接收利用

(4) 表面張力仲介的光能汲取裝置 ➔ 開發新型的太陽能利用

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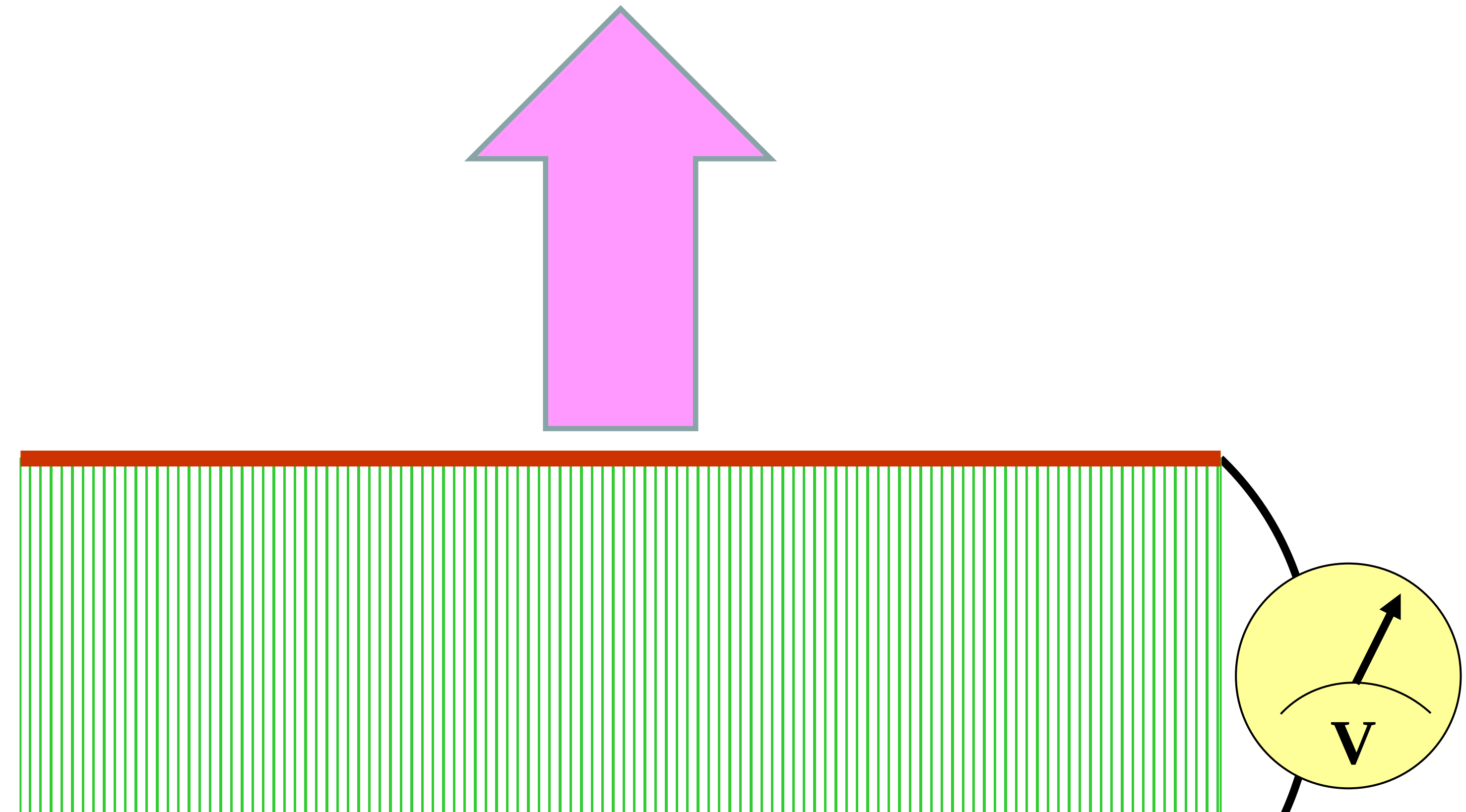
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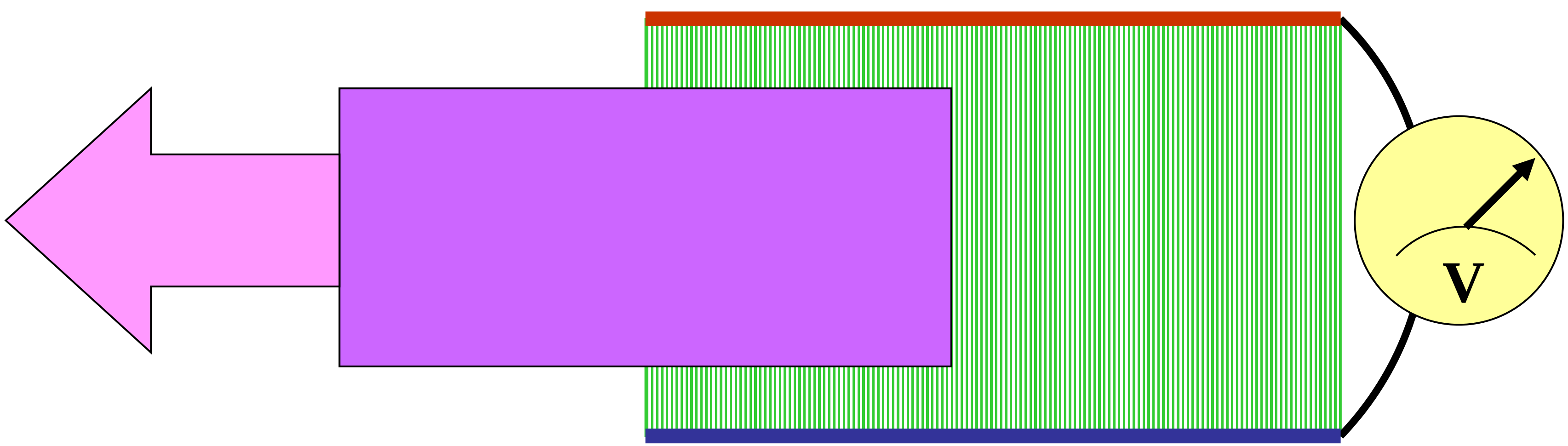
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ARTICLE

Received 11 May 2011 | Accepted 25 Jul 2011 | Published 23 Aug 2011

DOI: 10.1038/ncomms1454

Reverse electrowetting as a new approach to high-power energy harvesting

Tom Krupenkin[1,2,*] & J. Ashley Taylor[1,2,*]

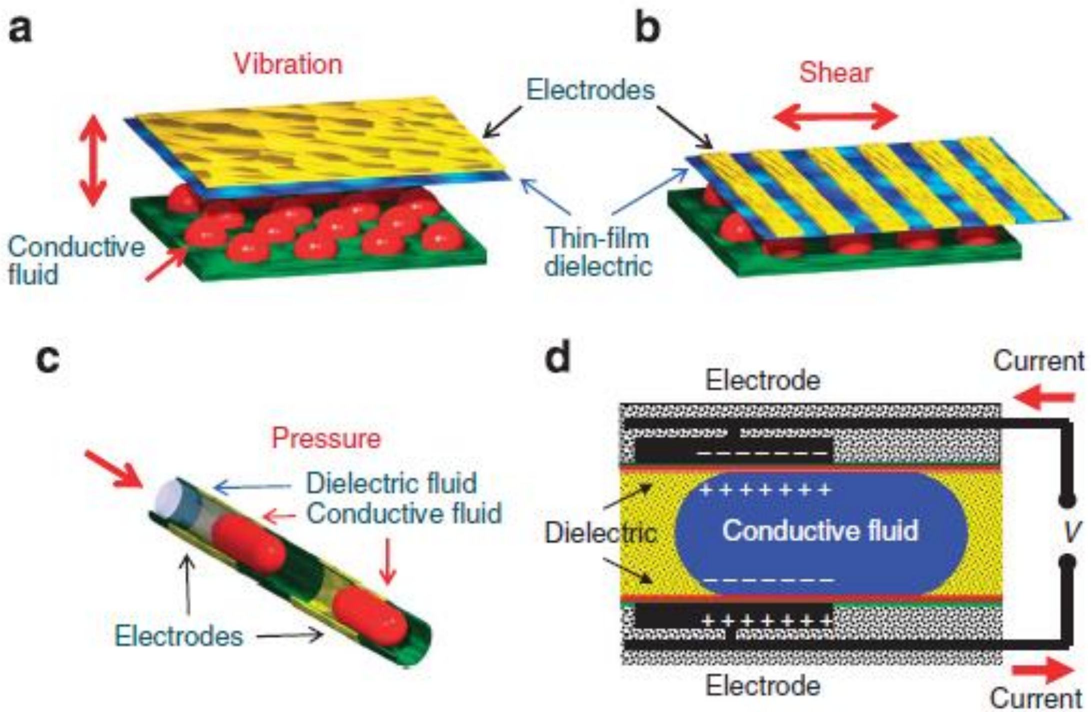

Figure 1 | Schematics of three major droplet actuation mechanisms. These include (**a**) droplets between oscillating plates, (**b**) droplets between sliding plates, and (**c**) droplets in a microchannel. (**d**) Shows in greater detail schematics of reverse-electrowetting-based energy generation process in a microchannel geometry.

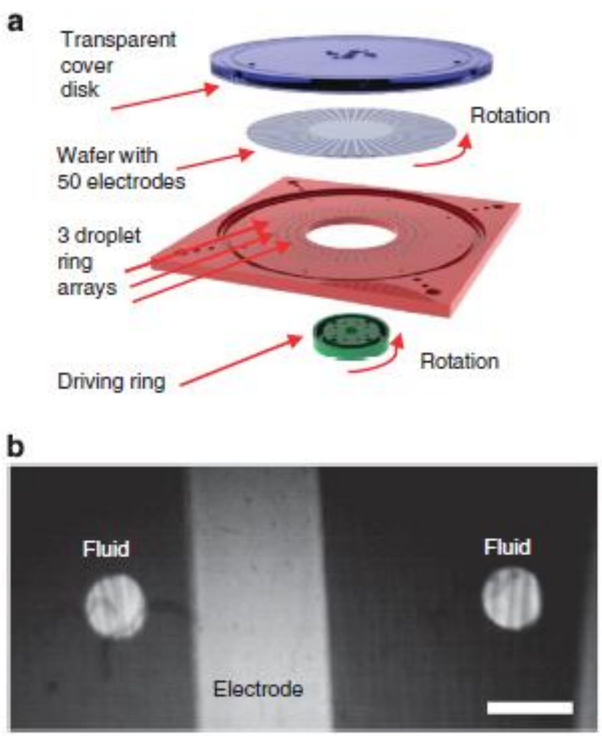

Figure 6 | Experimental set-up for droplets between sliding plates. (**a**) Schematics of the device and (**b**) a frame from a high-speed video showing a top view of the droplets overlapping one of the electrodes. Scale bar represents 1 mm.

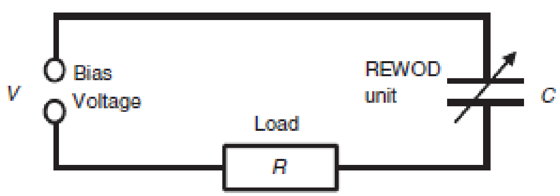

Figure 8 | Schematics of the electric circuit. The circuit used to investigate energy generation includes a source of a bias voltage V, a resistive load R, and a variable capacitor C (the REWOD unit, which represents a harvester set-up, that is, a set of droplets in contact with the electrode grid). The voltage drop on the resistive load was captured by the data acquisition board and converted into electrical current allowing direct calculation of the generated power as a function of time. Resistive loads with the values of R in the range from 10^4 to $10^6\,\Omega$ were investigated. A battery (with internal resistance of about $1\,\Omega$) was used to provide a bias voltage.

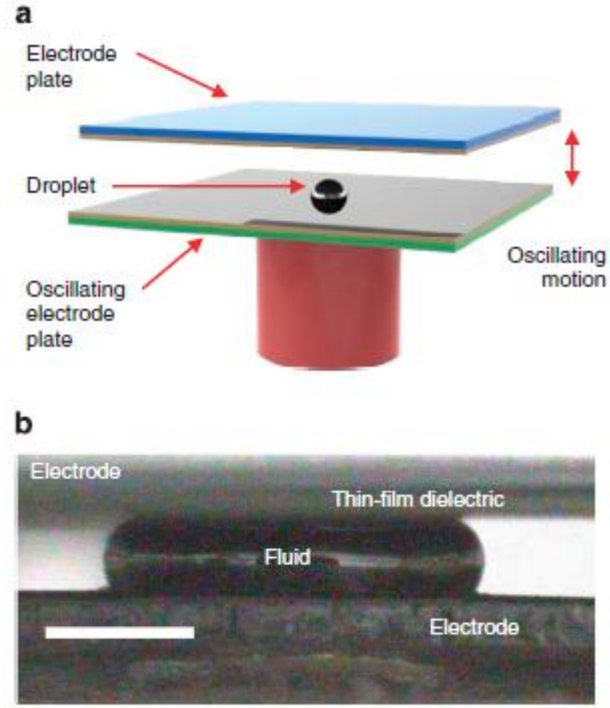

Figure 7 | Experimental set-up for a single droplet between oscillating plates. (**a**) Schematics of the device and (**b**) a frame from a high-speed video showing a side view of a droplet squeezed between two electrodes. Scale bar represents 0.5 mm.

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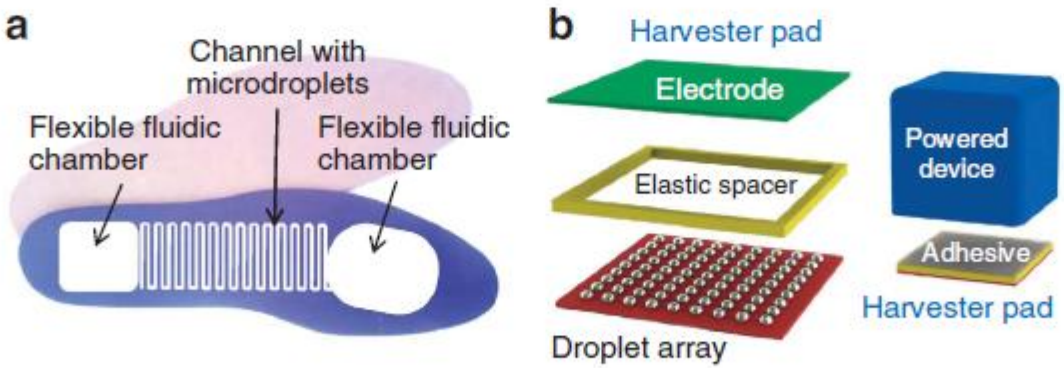

Figure 4 | Schematics of two REWOD applications. (**a**) Footwear-
nd (**b**) a REWOD-based

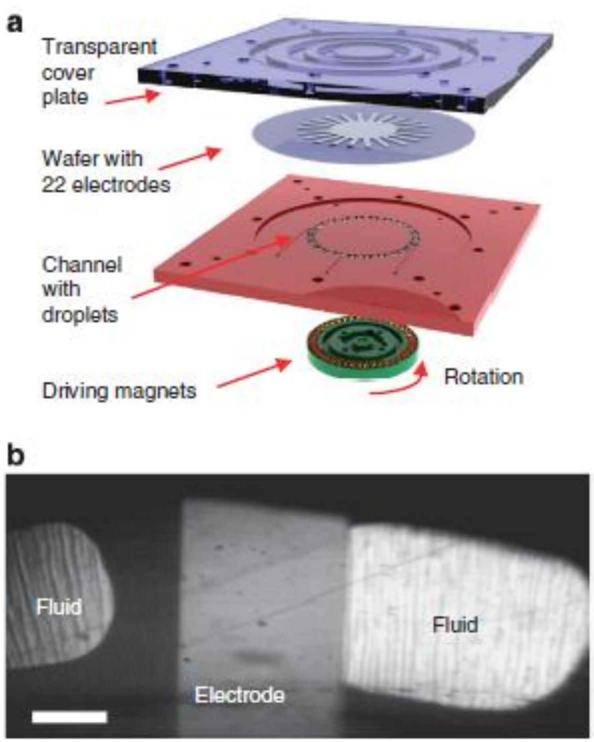

Figure 5 | Experimental set-up for droplets in a microchannel. (**a**) Schematics of the device and (**b**) a frame from a high-speed video showing a top view of the droplets overlapping one of the electrodes. Scale bar represents 1 mm.

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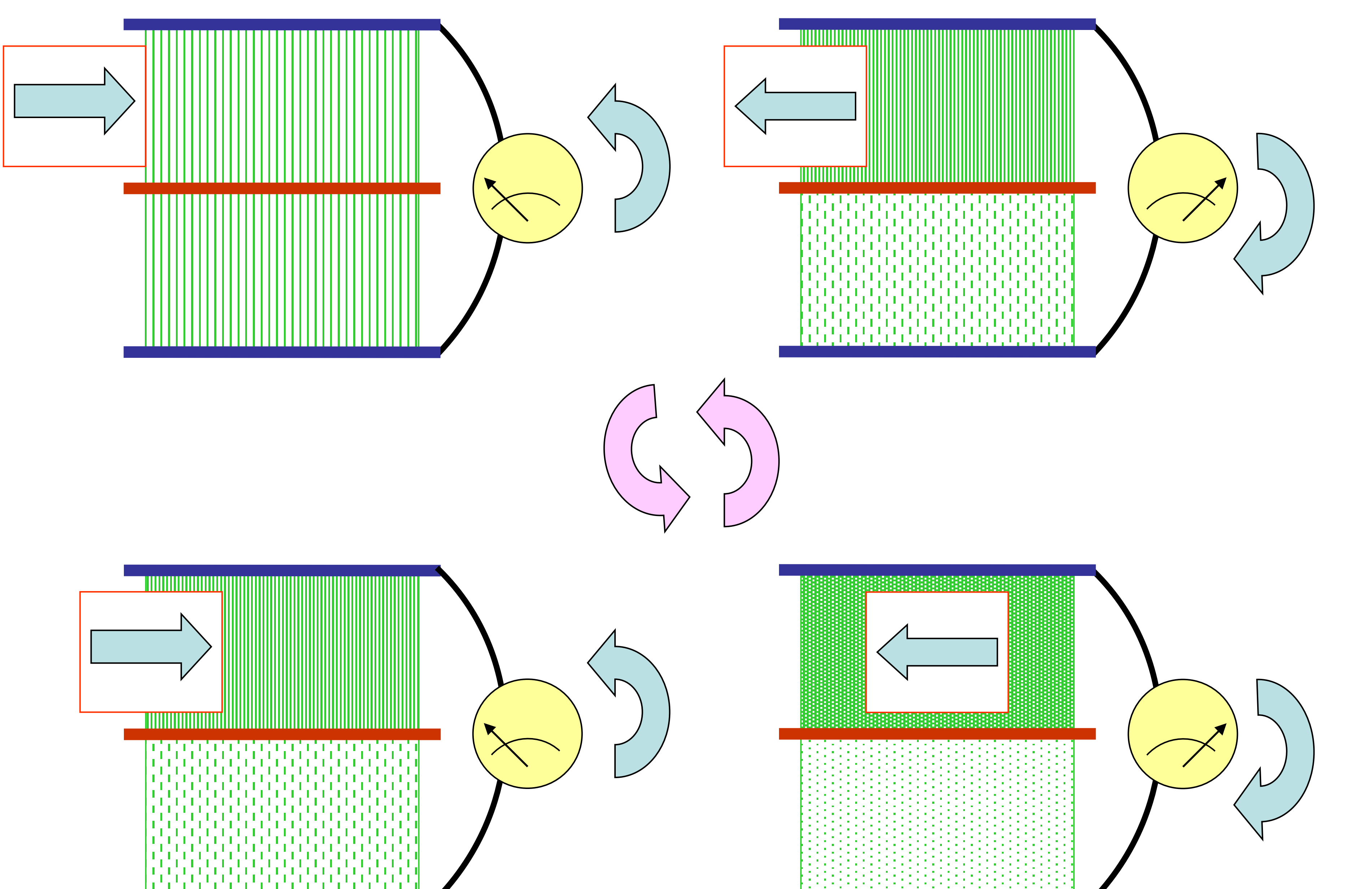


"breakdown" field strength (dry air) : $E_{bd} \approx 3 \times 10^6$ V/m

$V = E\,d$

permittivity :

$A = 1\ \text{m}^2$

$d = 1\ \mu\text{m}$

$\varepsilon_0 = 8.85 \times 10^{-12}$ (F/m)

$C \equiv Q / V = \varepsilon_0\ A / d$

$C \approx 8.85\ \mu\text{F}$

$Q = C\,V$

$U_E = Q^2 / 2C$ ========== $(1/2)\ Q\ V = (1/2)\ C\ V^2$

$\varepsilon = 1\ V$

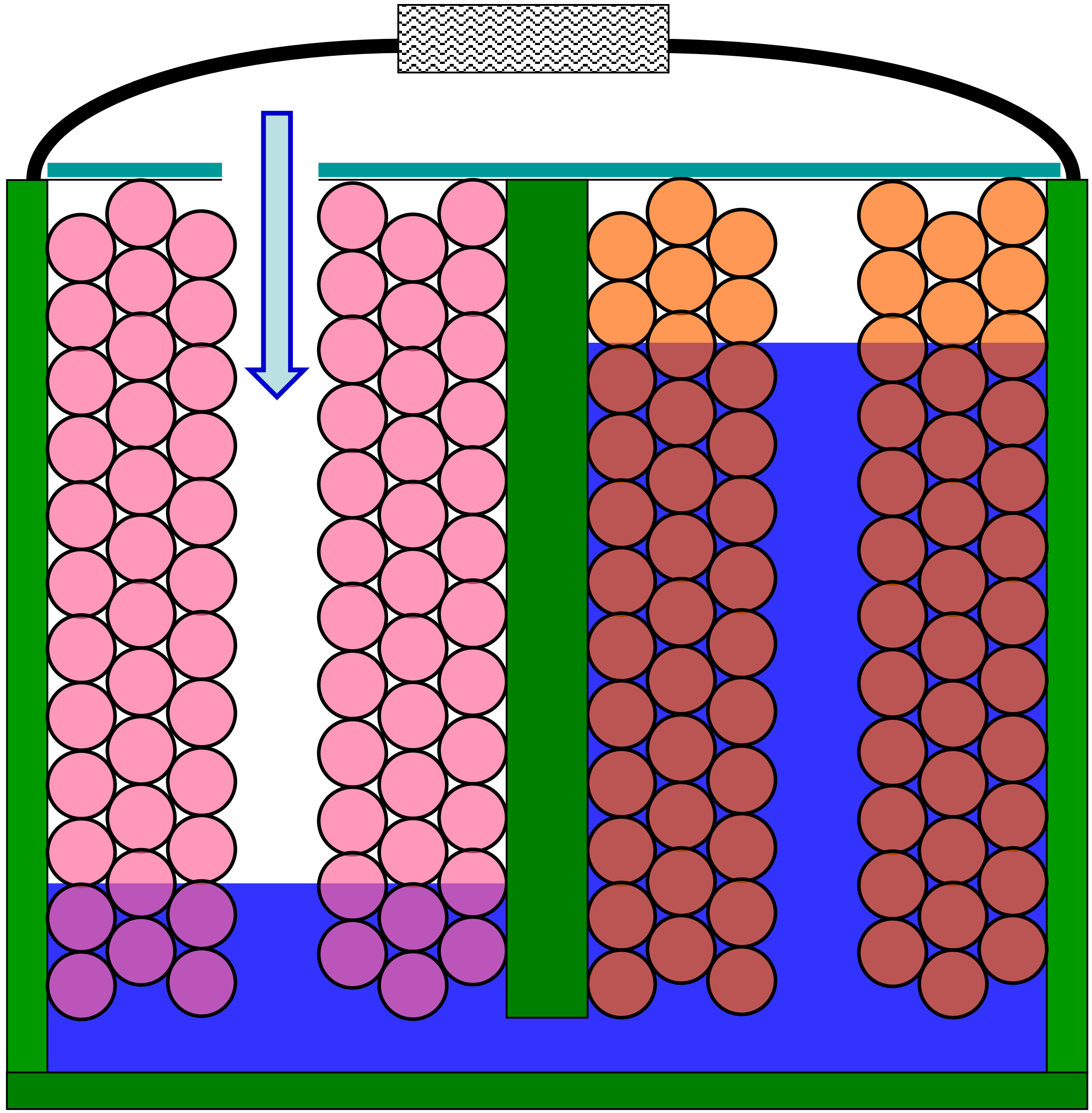
$C \approx 9\ \mu\text{F}$

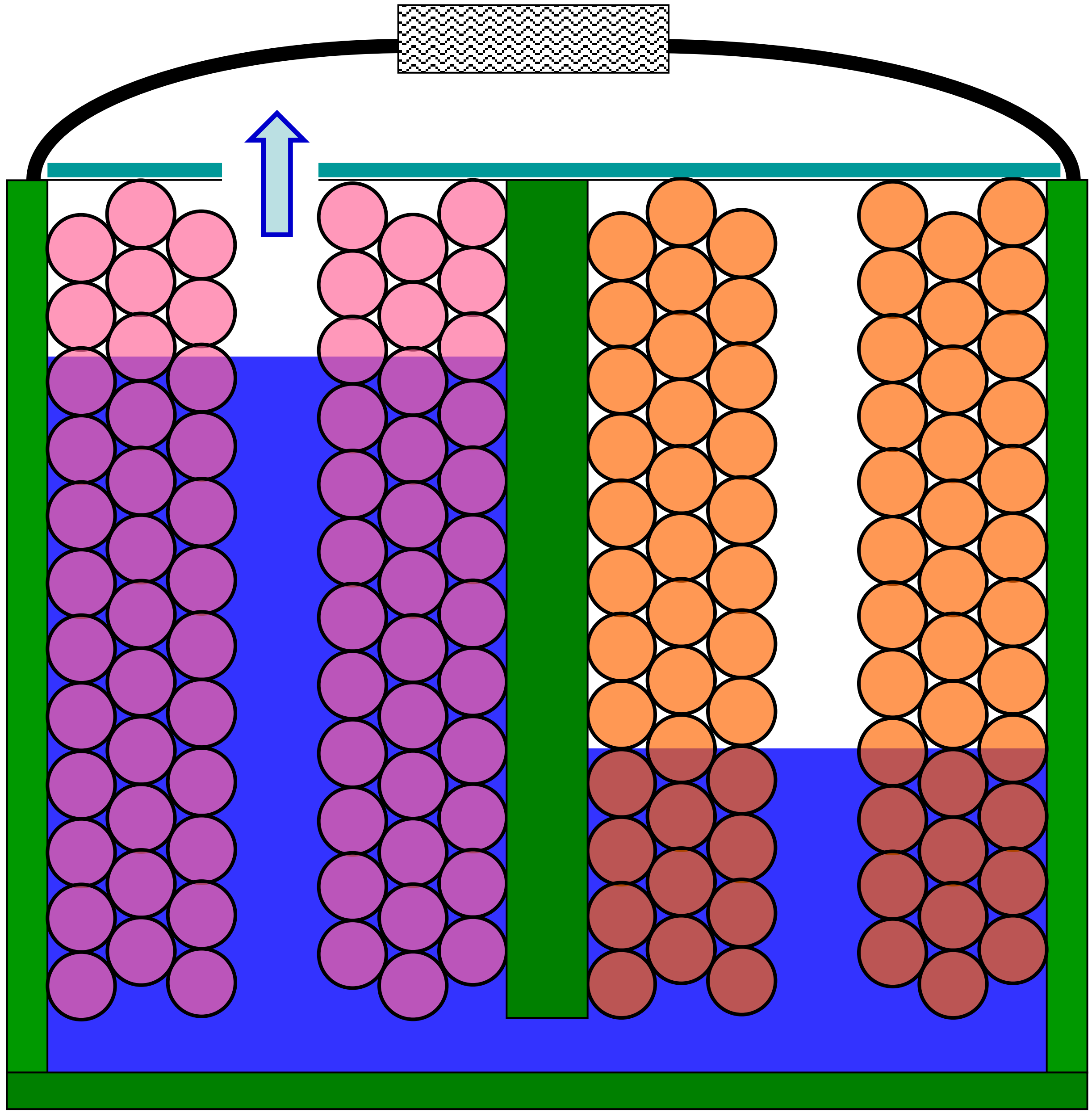
$U_E = (1/2)\ C\ V^2$

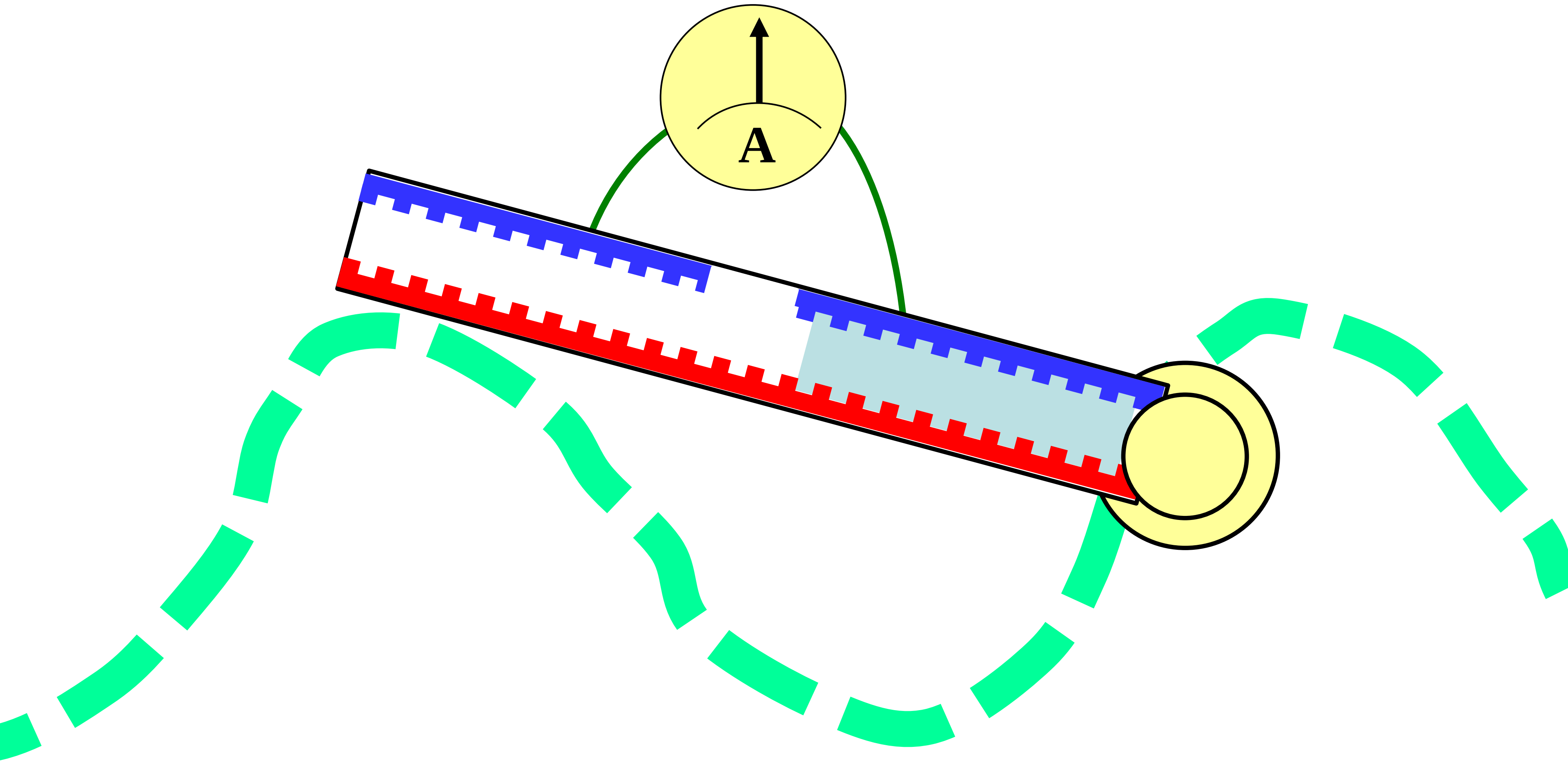
$U_E \approx 4.5\ \mu\text{J}$

$T \approx 1$ sec

$P = dW/dt \approx 9\ \mu\text{W}$



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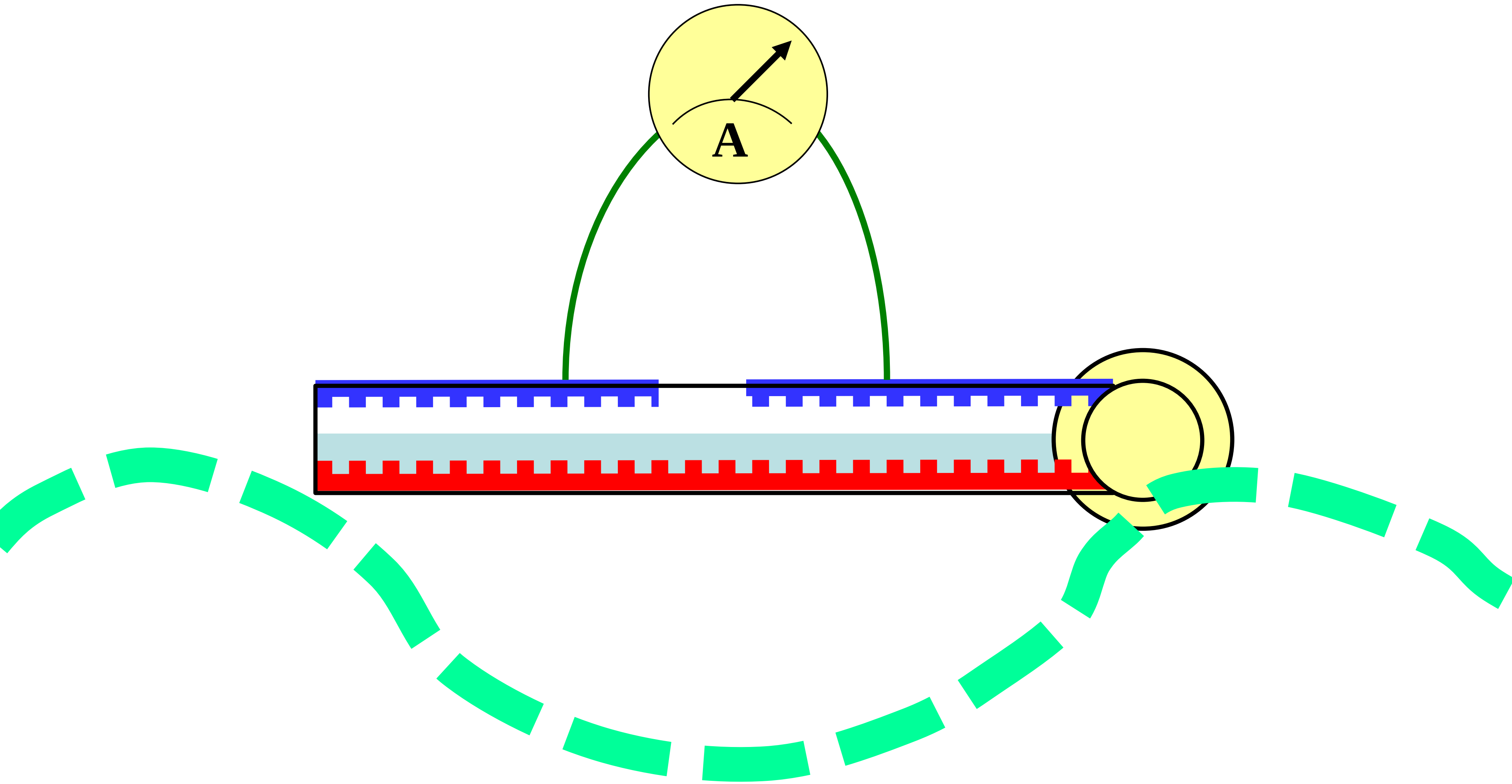
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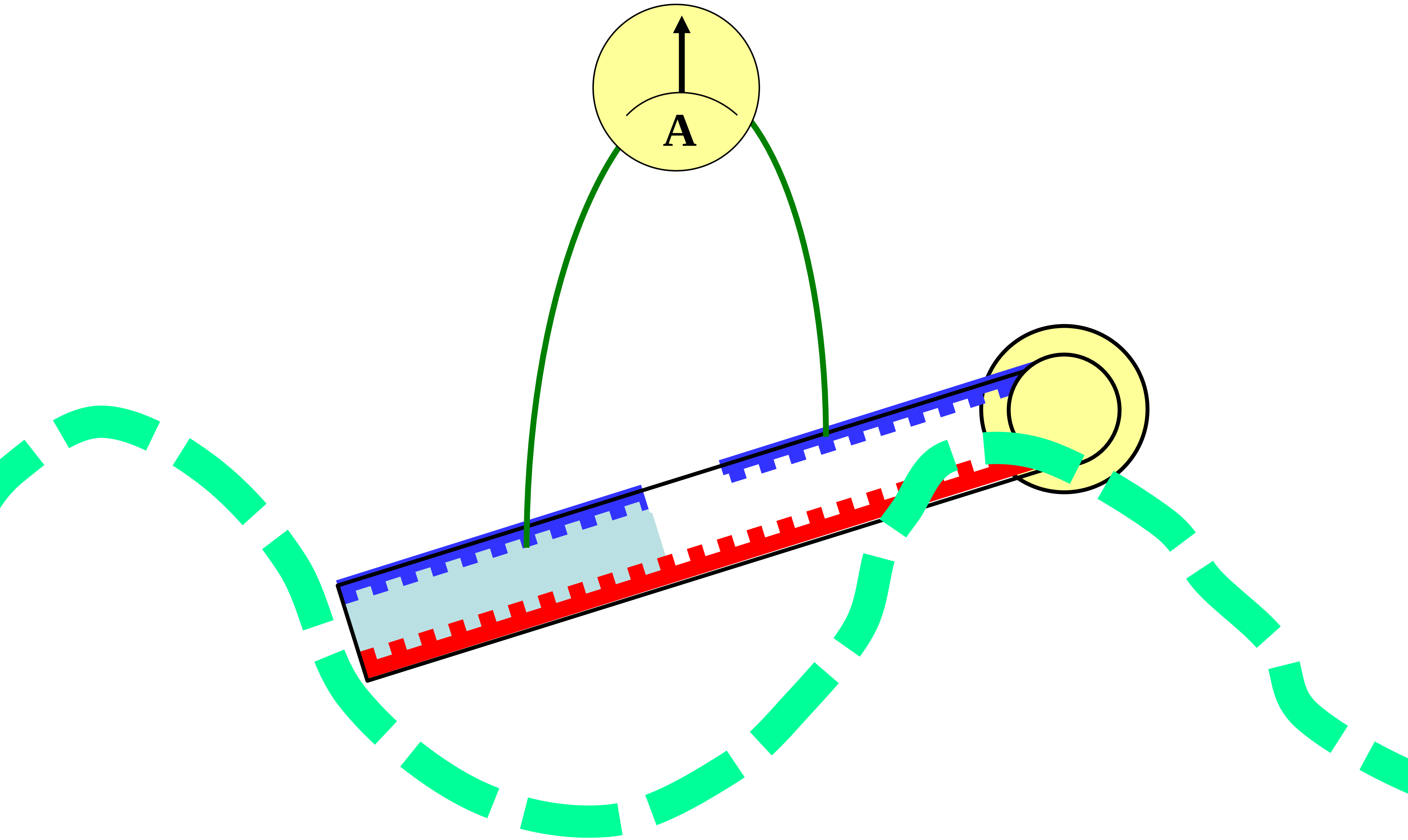
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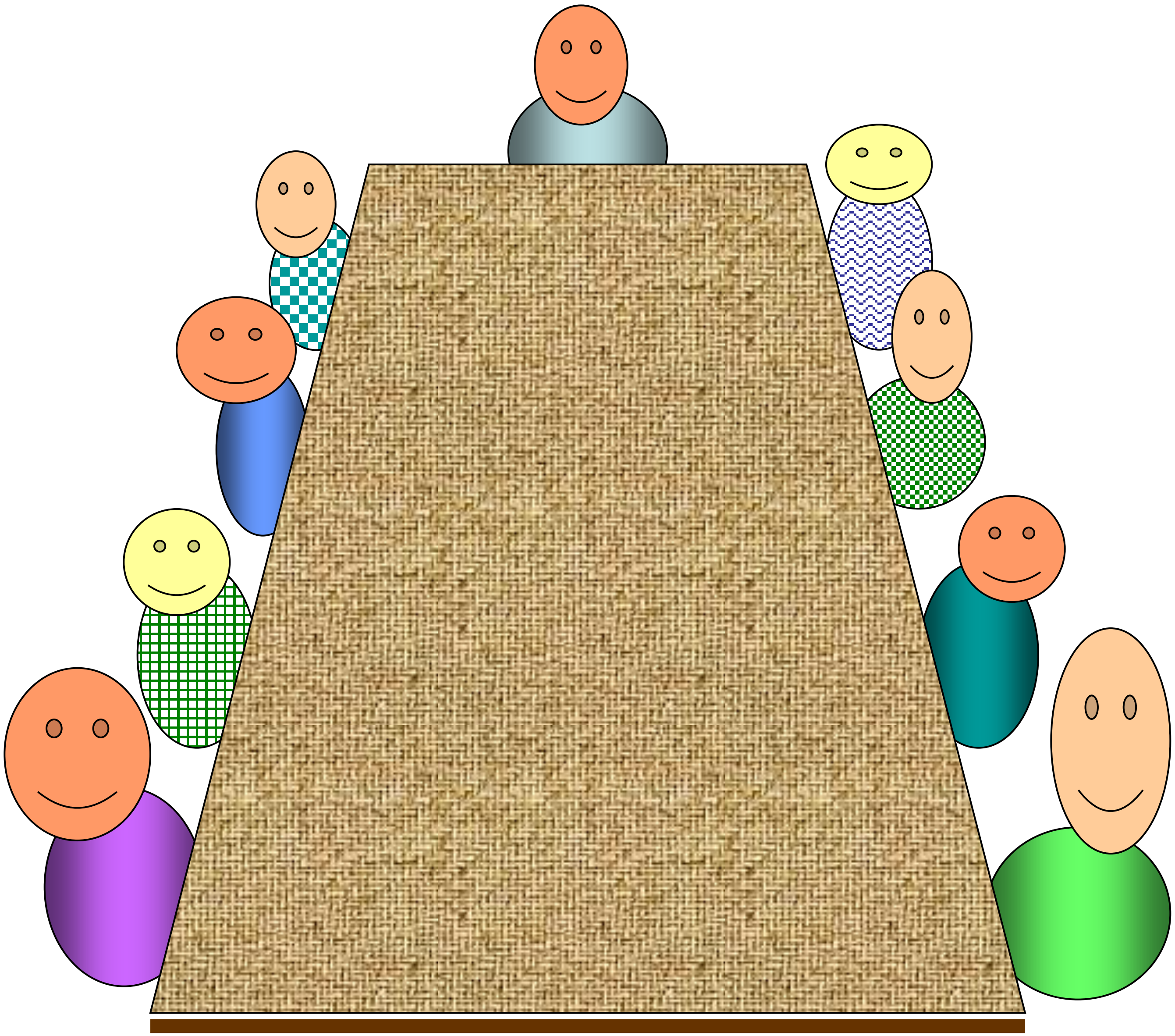
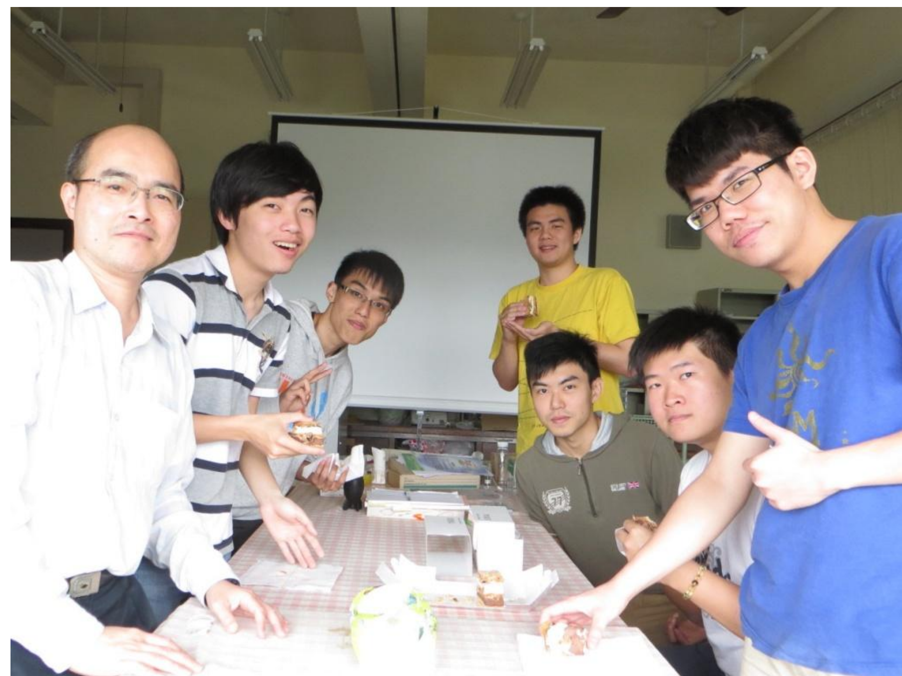
表面物理實驗室

表面上看起來，

好像物理實驗室




Manipulation of graphite microparticles
by the method of dielectrophoresis
MOTIVATION:
METHOD:
SETUP:
CONCLUSION:
REFERENCE:
Department of Physics, National Central University
The New Energy for Boats
The Super Capacitor Production



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