

# NANOWIRE



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# Outline

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**Introduction**

2

**Synthesis methods**

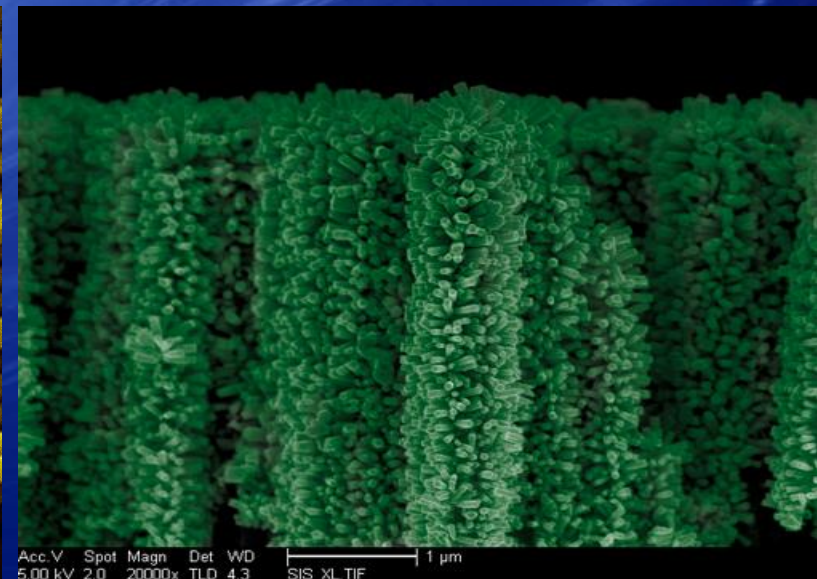
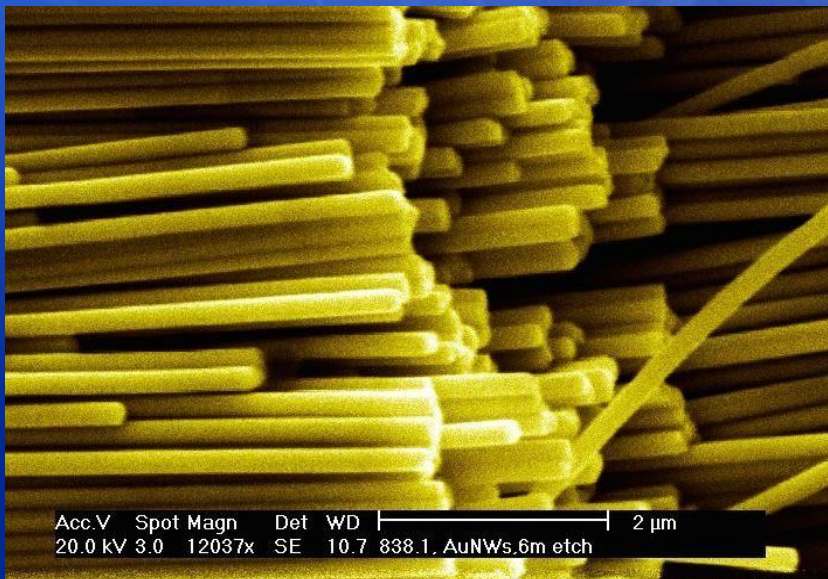
3

**Applications**



# Introduction

A nanowire is a nanostructure, with the diameter of the order of a nanometer ( $10^{-9}$  meters). Alternatively, nanowires can be defined as structures that have a thickness or diameter constrained to tens of nanometers or less and an unconstrained length. At these scales, quantum mechanical effects are important which coined the term "quantum wires".





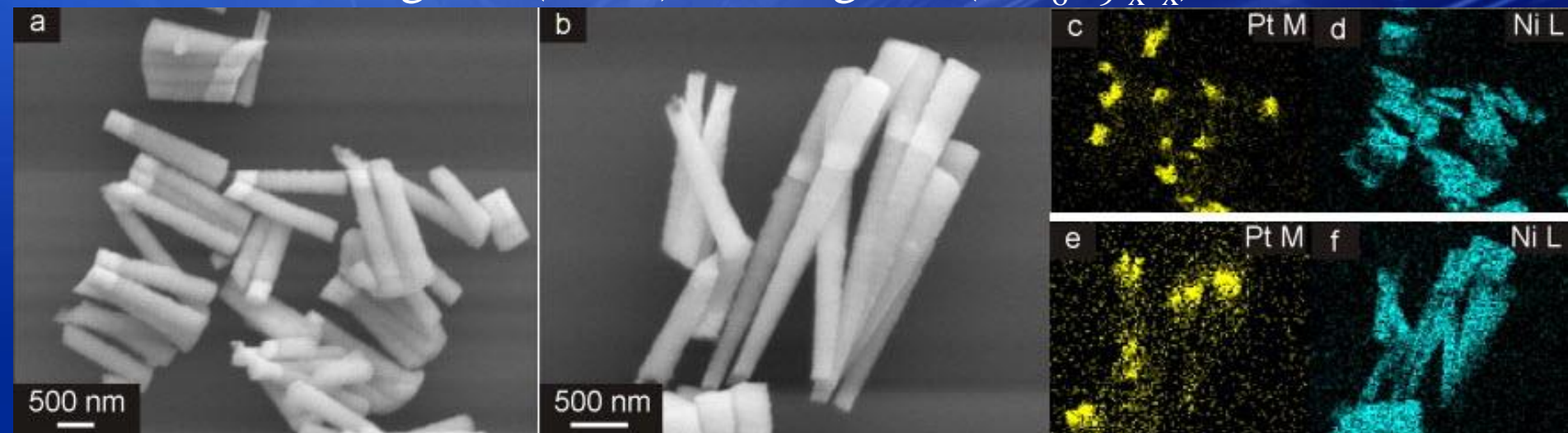
# Types of nanowires (of Base material)

- 1) Metallic Nanowires**
- 2) Organic Nanowires**
- 3) Semiconducting Nanowires**

# Types of nanowires (of variety)

- 1) Metallic (Ni, Pt, Au)
- 2) Semiconducting (Si, InP, GaN, etc.)
- 3) Insulating ( $\text{SiO}_2$ ,  $\text{TiO}_2$ )
- 4) Oxide (  $\text{ZnO}$  ,  $\text{SnO}_2$  ,  $\text{In}_2\text{O}_3$  , etc.)

Also Molecular nanowires are composed of repeating molecular units either organic (DNA) or inorganic ( $\text{Mo}_6\text{S}_9\text{I}_x$ ).



SEM images (a, b) and EDX spectral imaging (c–e) of Ni|Pt nanowires grown by templated electrodeposition



# Synthesis methods

## two basic approaches to synthesizing nanowires

### **top-down approach**

reduces a large piece of material to small pieces, by various means such as lithography or electrophoresis.

### **bottom-up approach**

synthesizes the nanowire by combining constituent atoms. Most synthesis techniques use a bottom-up approach.



# Nanowire Synthesis to laboratory techniques



Ion track technology enables growing homogeneous and segmented nanowires down to 8 nm diameter.



# Suspension

A suspended nanowire is a wire produced in a high-vacuum chamber held at the longitudinal extremities.

Suspended nanowires can be produced by:

- 1) The chemical etching of a larger wire
- 2) The bombardment of a larger wire, typically with highly energetic ions
- 3) Indenting the tip of a STM in the surface of a metal near its melting point, and then retracting it.





# Electrochemical deposition

- ❖ This method can be understood as a special electrolysis resulting in the deposition of solid material on an electrode.
- ❖ Only applicable to electrically conductive materials:  
**metals, alloys, semiconductors, and electrical conductive polymers.**

Two template for Electrochemical deposition :

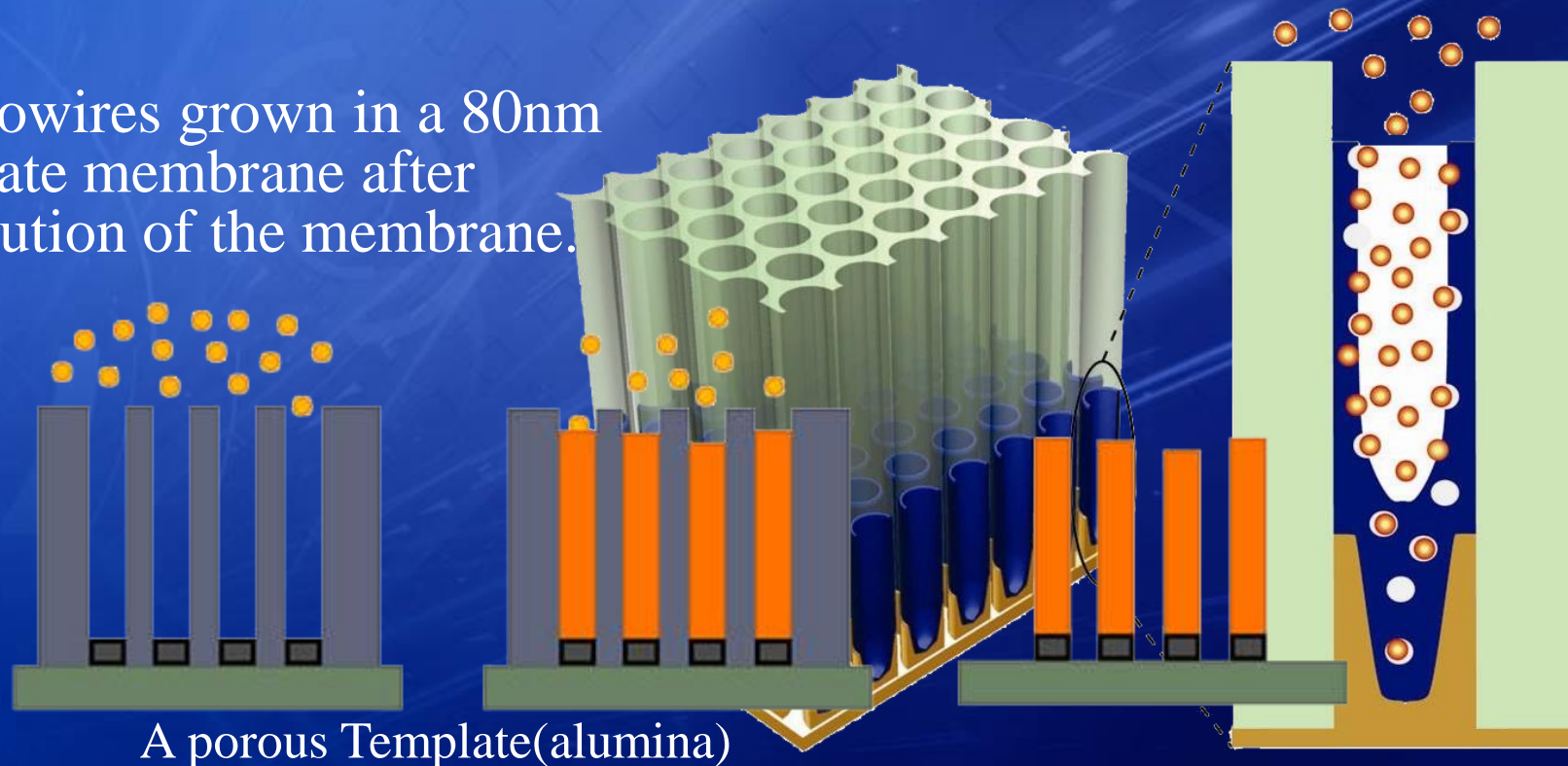
- ✓ **Negative template**
- ✓ **Positive template**

# Electrochemical deposition

## ✓ Negative template

☐ The diameter of the nanowires is determined by the geometrical constraint of the pores.

☐ nanowires grown in a 80nm template membrane after dissolution of the membrane.

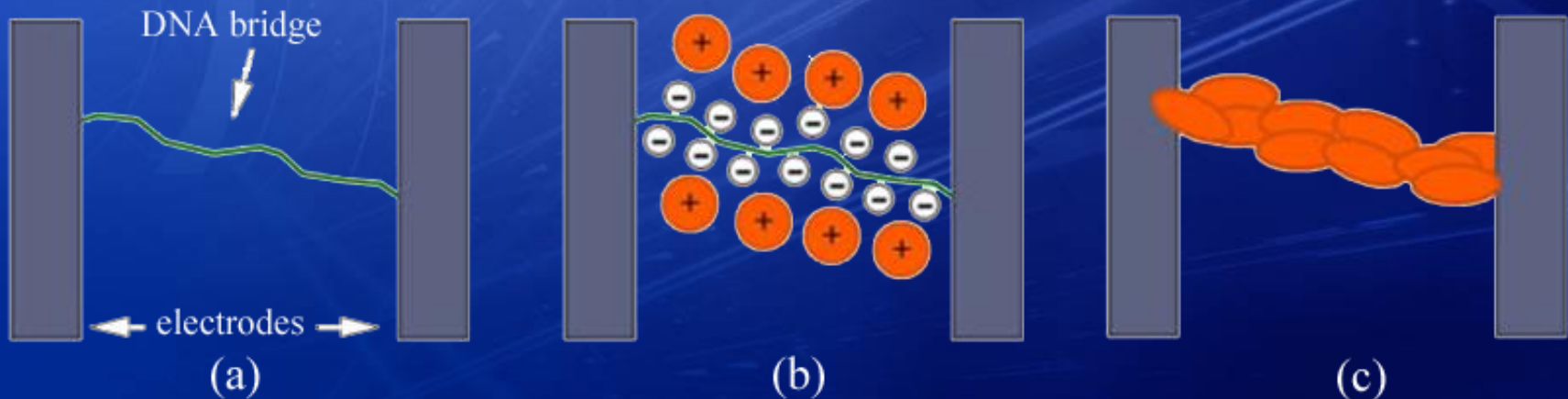


# Electrochemical deposition

## ✓ Positive Template

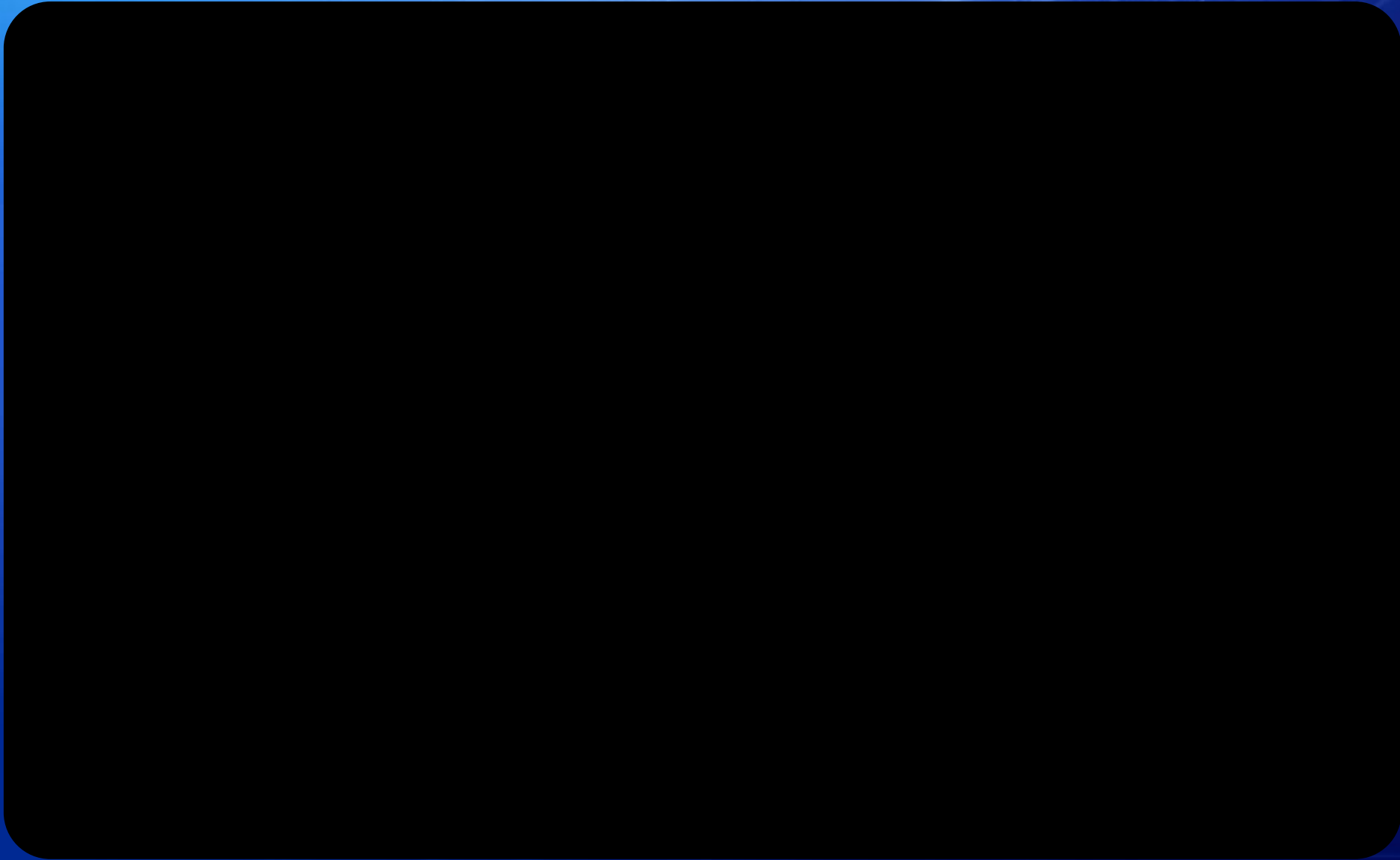
Method (DNA based template) General procedure:

- Fix a DNA strand between two electrical contacts
- Exposed to a solution containing some ions
- Ions bind to DNA and are then form some nanoparticles decorating along the DNA chain.



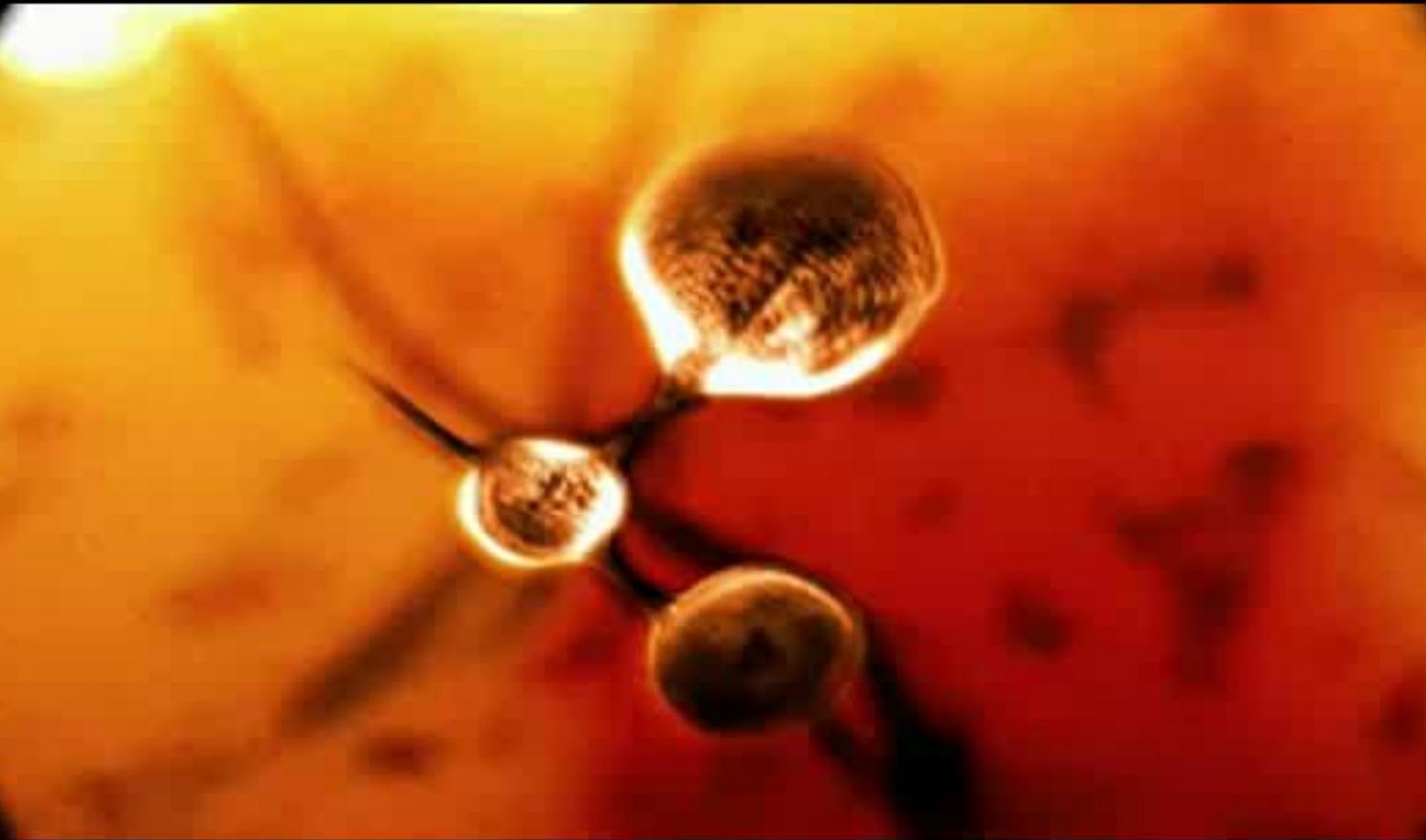


# Solution-phase





# VLS Growth





# Applications

- ✓ NANOWIRs in **TFT**
- ✓ NANOWIRs in **Touch Screen**
- ✓ NANOWIRs in **Medicine**
- ✓ NANOWIRs in **Chemical Sensor**
- ✓ NANOWIRs in **PH Measuring**
- ✓ NANOWIRs in **Nano Generator**
- ✓ NANOWIRs in **Flexible Solar Cell**

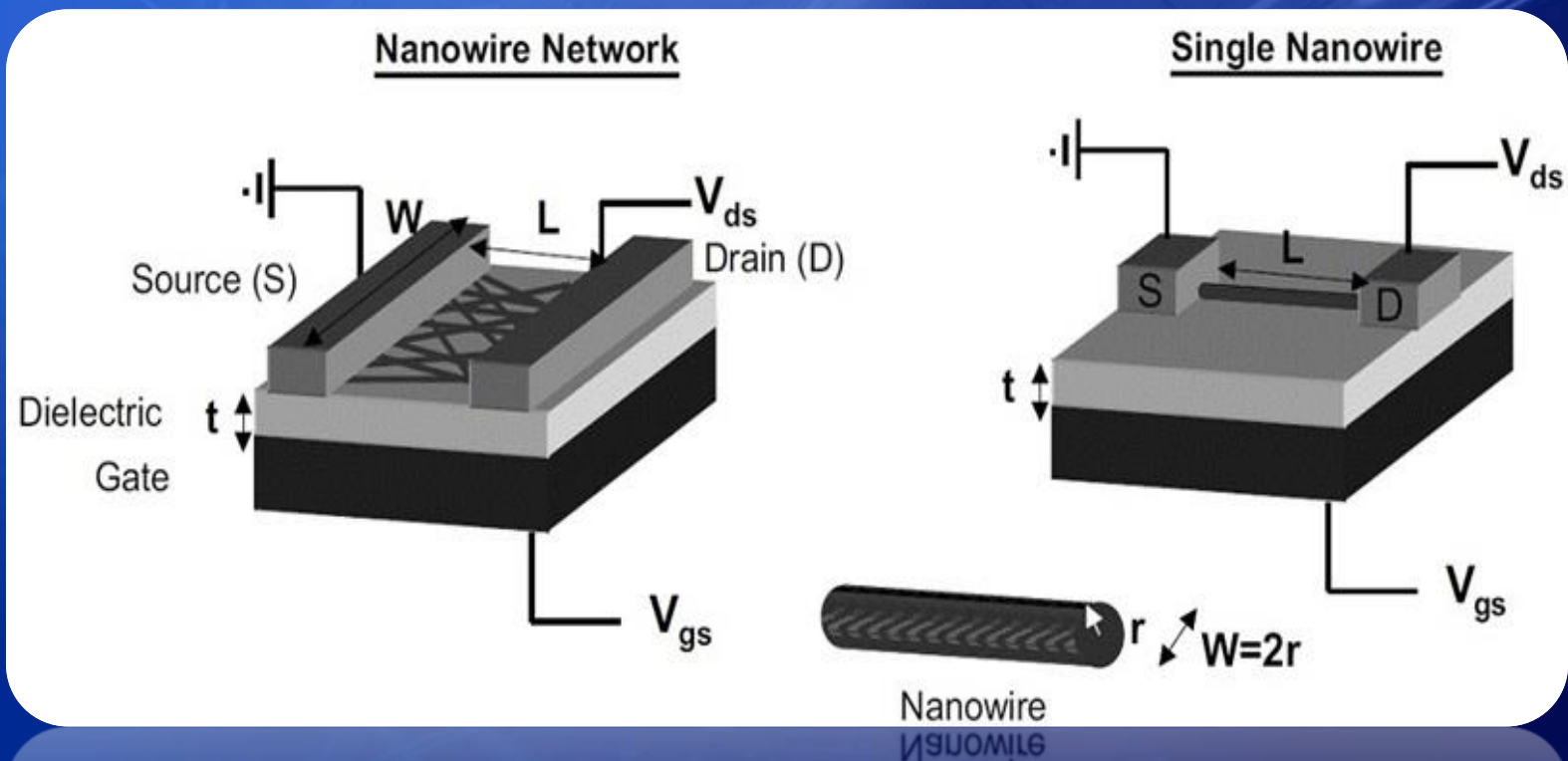


# TFT (Thin Film Transistor)

- ❖ One class nanowires suited for transparent electronics are metal oxides nanowires, including ZnO, SnO<sub>2</sub>, and In<sub>2</sub>O<sub>3</sub>
- ❖ Advantages of these nanowires versus thin film Si TFTs such as:
  - 1) Optical
  - 2) Transparency
  - 3) High mobility
  - 4) Mechanical flexibility
  - 5) Their electronic properties can be tuned by controlled doping during nanowire growth

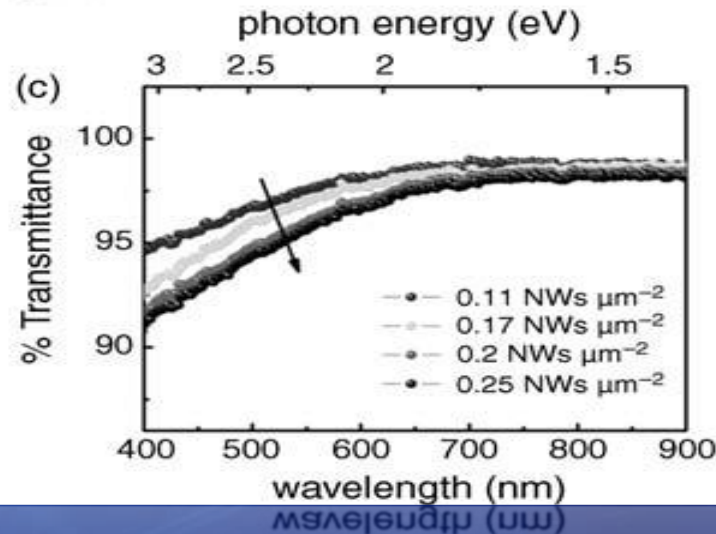
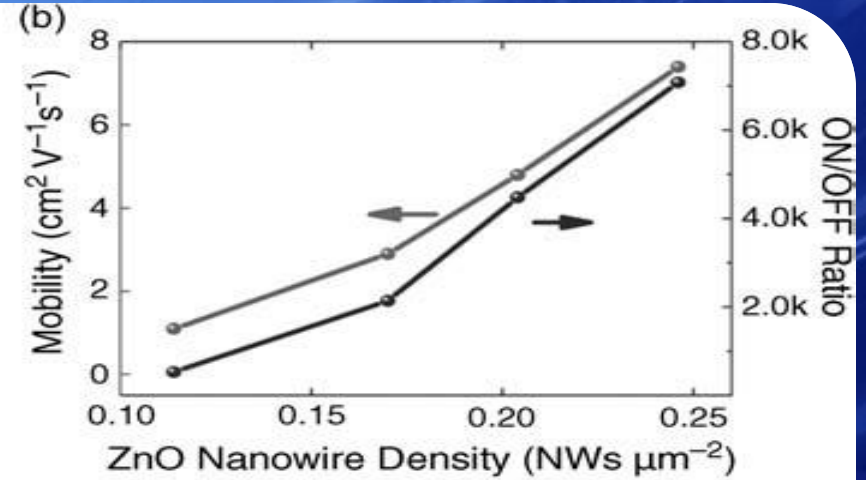
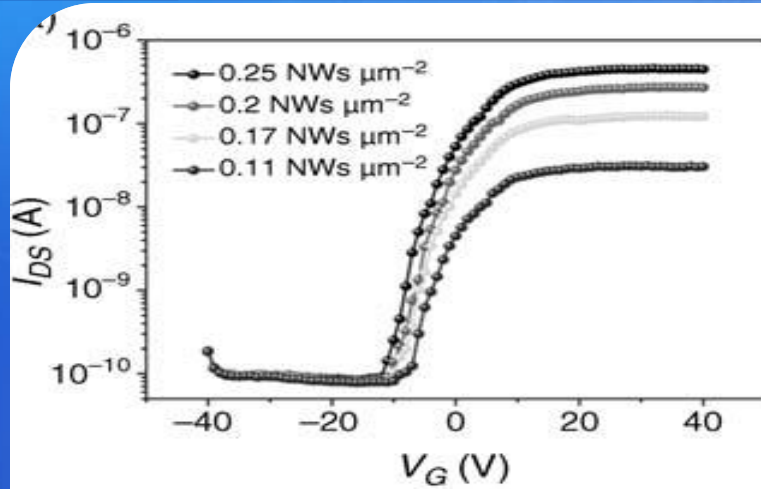
# TFT (Thin Film Transistor)

But, four different gate configurations can be fabricated:  
**back** (or bottom), **top**, **side** and **surrounding** gates.  
The **back gate** configuration is the most common.



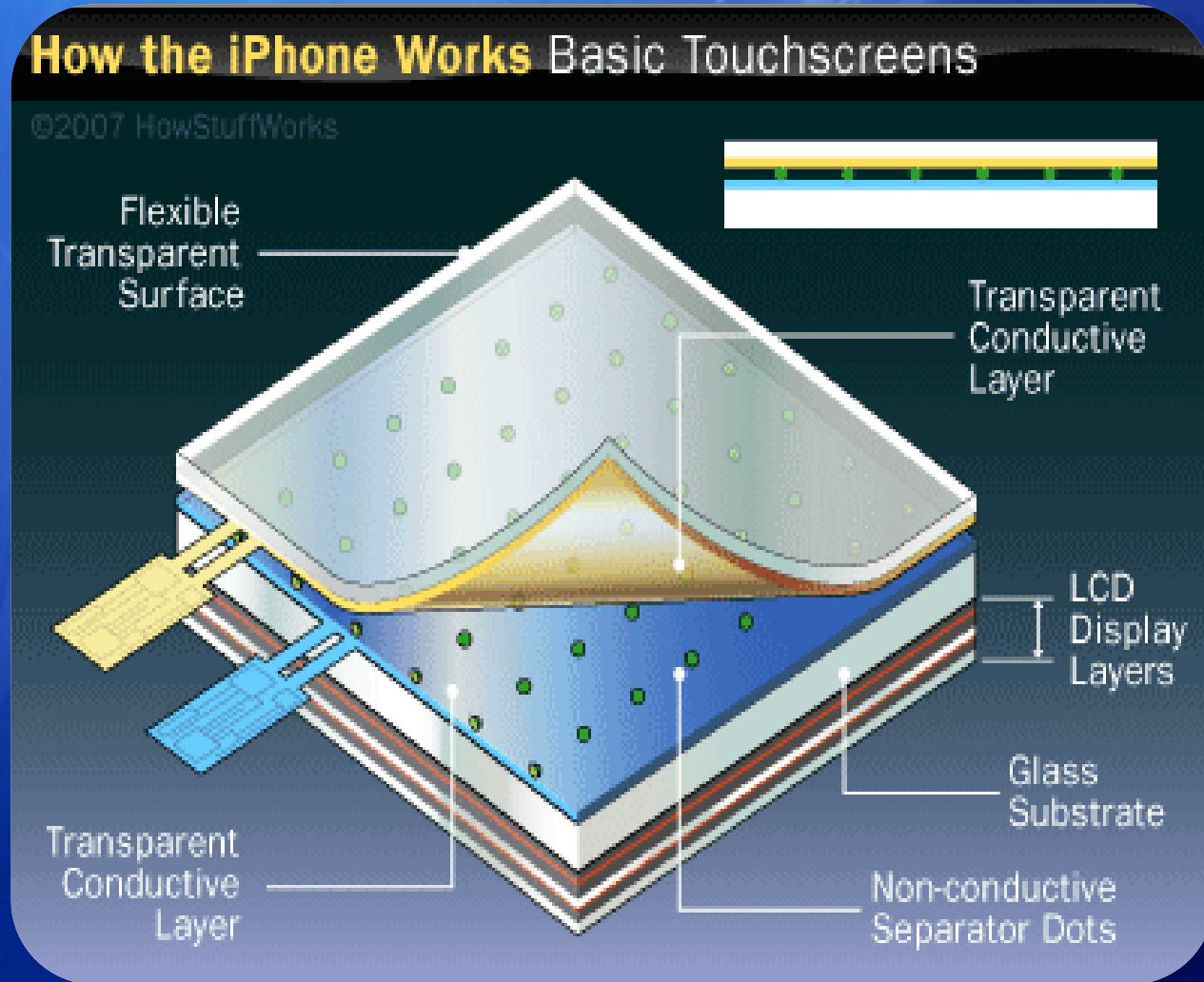


# TFT (Thin Film Transistor)



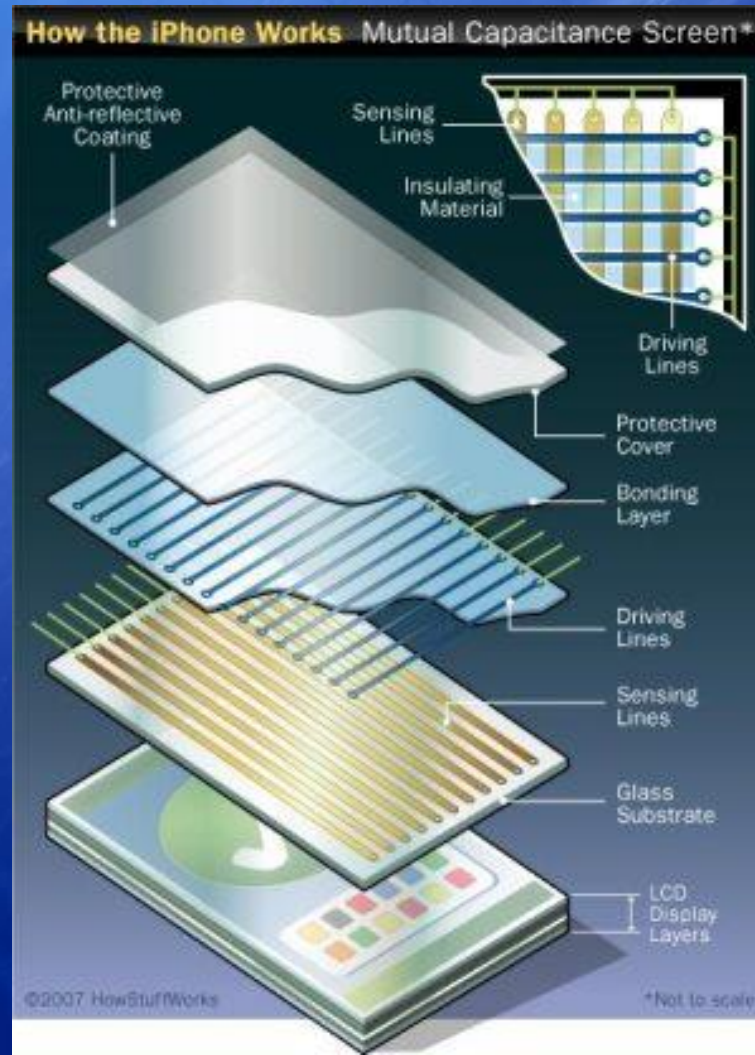
# Touch Screens

**How it's Made traditional touch screen (capacitive touch screen ) :**



# Touch Screens

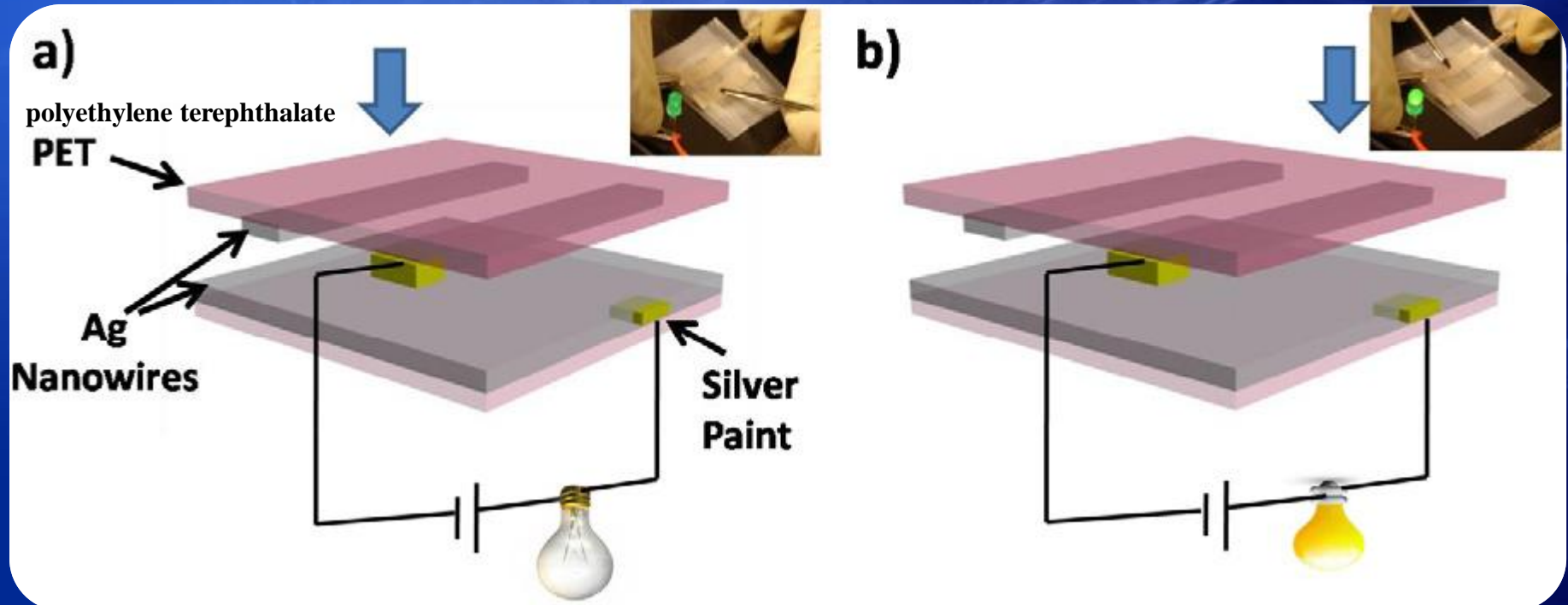
**How it's Made traditional touch screen (capacitive touch screen ) :**



# Touch Screens

## How it's Made touch screen using nanowire :

figure Prototype demonstration of a touch screen using silver nanowire transparent conductive electrodes TCE. Schematic of a touch screen fabricated (a) without and (b) with complete connection. Insets show the actual working devices.



# Touch Screens

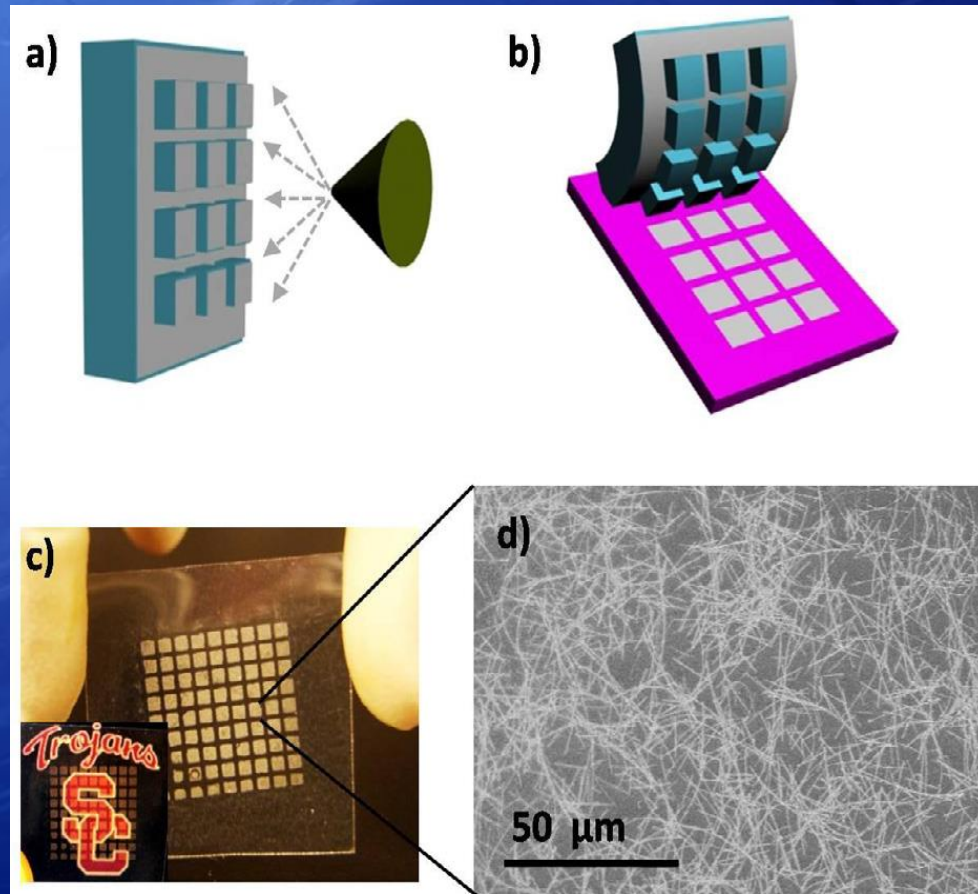
## Patterned transfer of silver nanowire film.

**(a)** Ag nanowire solution was sprayed uniformly on the patterned PDMS stamp.

**(b)** Schematic diagram of the contact transfer of Ag nanowire from the patterned PDMS stamp to the substrate.

**(c)** Photograph of a patterned nanowire film transferred on the PET substrate. The size of each pixel is  $1 \text{ mm} \times 1 \text{ mm}$  with a spacing of  $0.5 \text{ mm}$ . Inset shows that the patterned nanowire film is highly transparent, as the background image can be clearly seen.

**(d)** SEM image showing the nanowire network from one pixel





# Near Future for Touch Screens !





# Medicine



# Chemical Sensor

## Chemical sensors built on metal oxide nanowires

- ❖ chemical sensors built on  $\text{SnO}_2$ ,  $\text{ZnO}$ , and  $\text{In}_2\text{O}_3$  nanowires have been widely reported due to their easy synthesis, good sensitivity to chemicals, and good stability compared to other metal oxide nanomaterials.
- ❖ Metal oxide nanowire-based chemical sensors are usually fabricated in two configurations, resistors and FET devices with single or multiple nanowire.





# Chemical Sensor

Material	Device	Diameter (nm)	Analytes	Detect limit	Response time (s)	Working temperature
$\text{In}_2\text{O}_3$	FET	10	$\text{NO}_2$ CO	$\text{NO}_2$ 5ppb	5–10	RT
$\text{SnO}_2$	Resistor	20	CO	5ppm	100	20 - 200 °C
ZnO	Resistor	30	Ethanol	50ppm	60	RT - 300°C

- The working principle of metal oxide nanowire-based chemical sensors relies on changes of electrical conductivity due to the interaction of nanowires with the surrounding environment.
- The charge transfer process induced by the redox reactions between nanowire surface.



# Chemical Sensor

For example, when a reducing gas (eg. CO) is introduced to a chemical sensor, the following reaction happens:



Here, CO reacts with adsorbed oxygen ions on the nanowire surface and thus results in an overall increase of the electrical conductance of metal oxide nanowires.

My God is My HERO :

☞ WITHOUT HIM THIS WORLD WOULD BE EMPTY

**Thank You !**

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