DISCOVERY OF GRAPHENE

NP 2010

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Coming Up

1. Introduction of Winners.
2. What is Graphite and Graphene??
3. History of Discovery Practices.
4. Methods of Successful Discovery.
5. Importance of this Discovery.
6. Recent Research Trend on Graphene.
7. Conclusion.

1. Introduction to winners

Andre Geim

Konstantin Novoselov

University of Manchester , England

Awarded Noble Prize in Physics in 2010

2. GRAPHITE AND GRAPHENE

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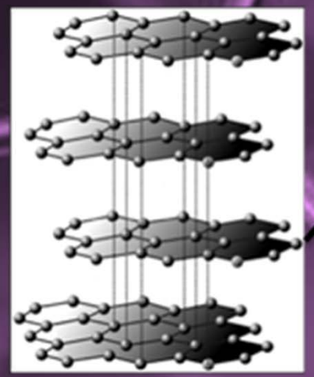
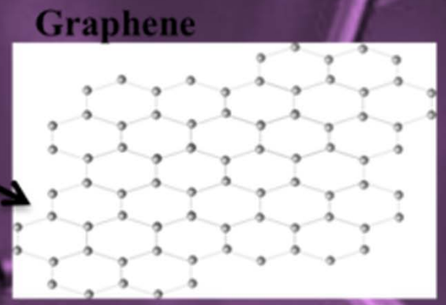




Graphite

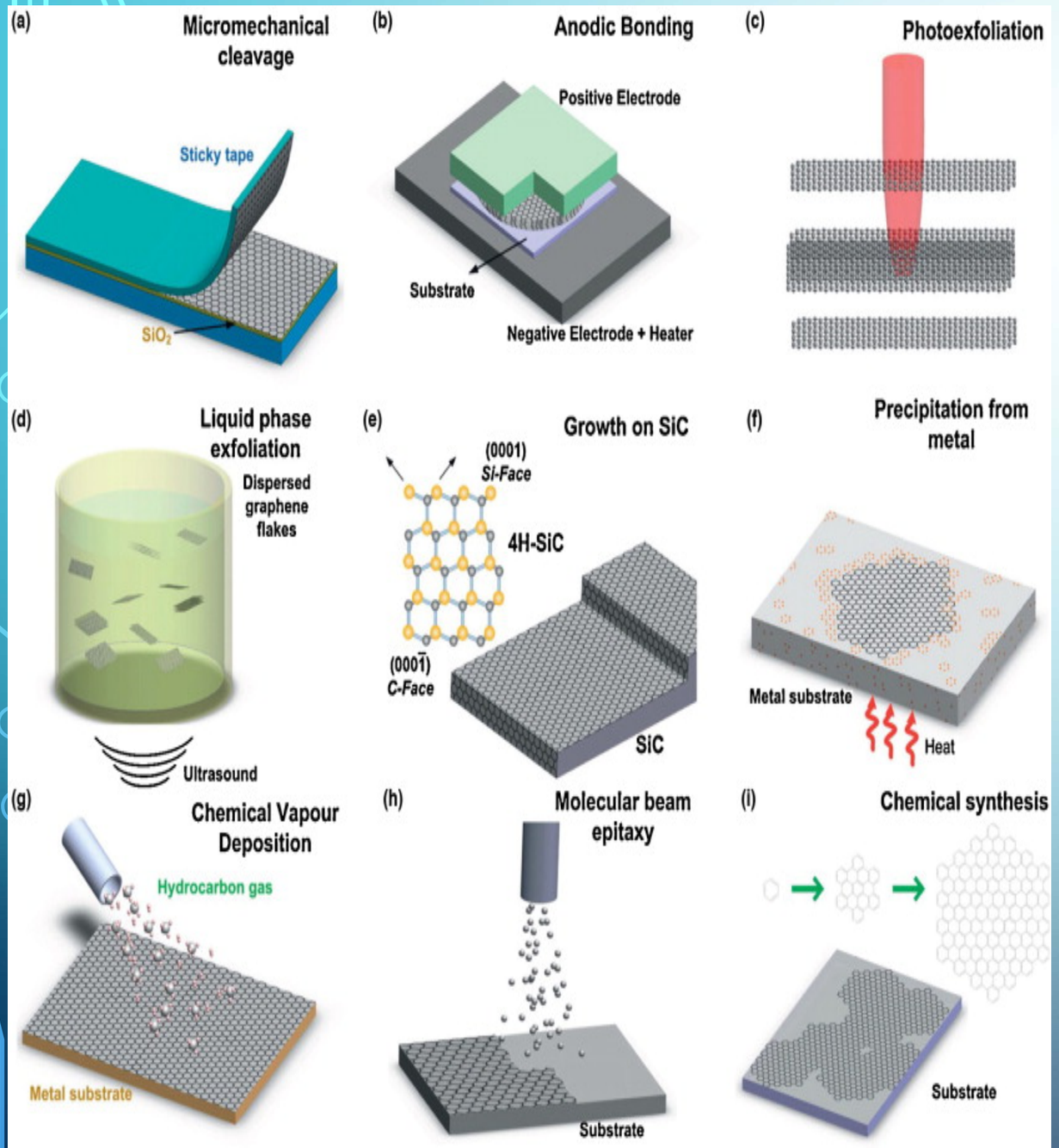
1. 3D allotropes of Carbon.
2. Stack of graphene layer one over another attached by Vander Waal force.

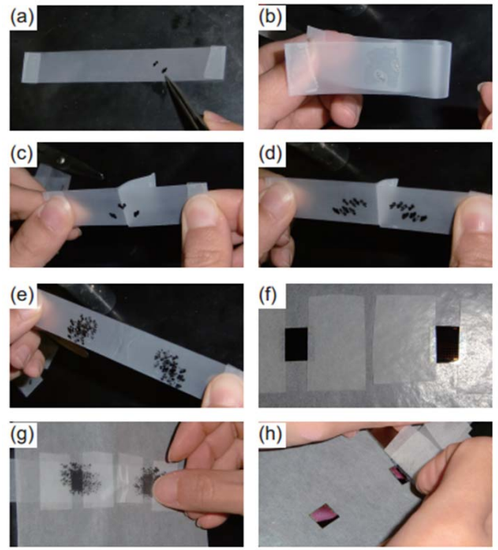
Graphene

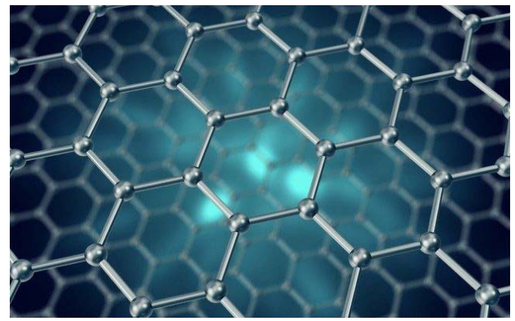
1. 2D thinnest layer of Graphite .
2. One atom thick layer of carbon atoms in hexagonal honeycomb lattice.

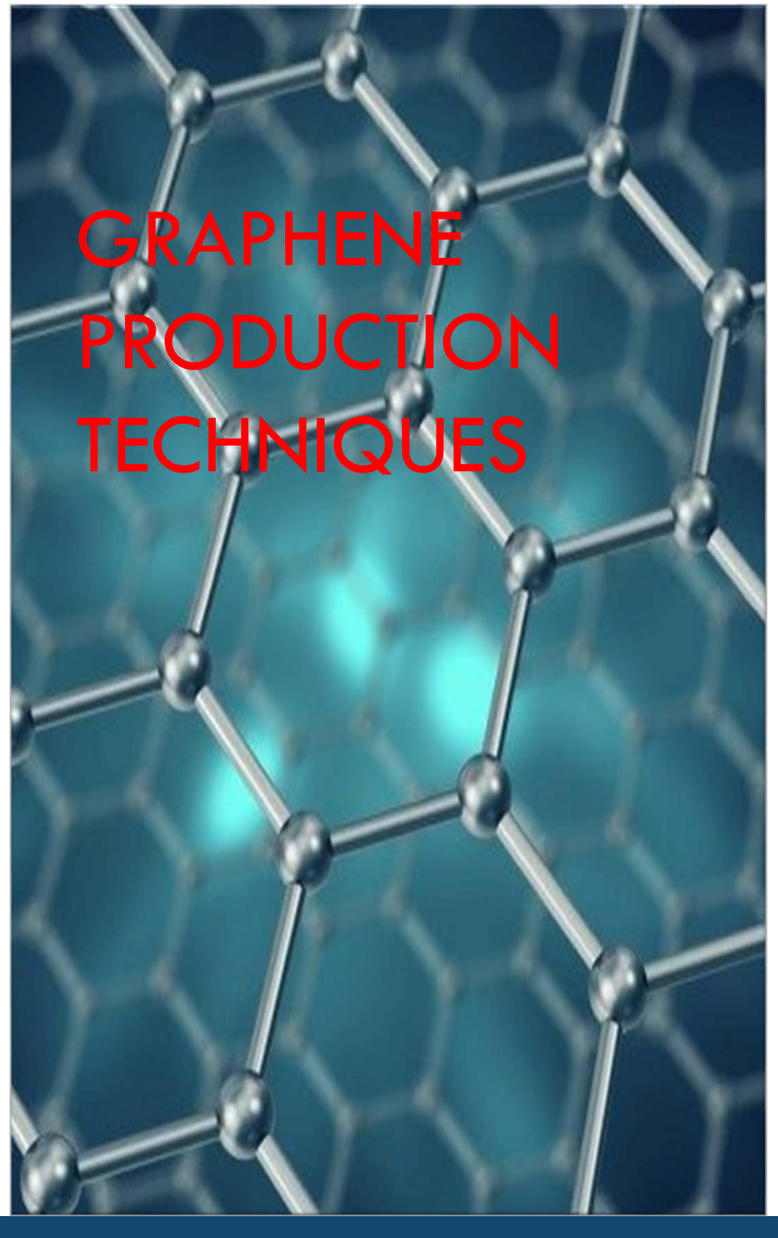
HISTORY

1. The theory of graphene was first explored by P. R. Wallace in 1947 as a starting point for understanding the electronic properties of 3D graphite.
2. The term *graphene* was introduced in 1986 by chemists Hanns-Peter Boehm, Ralph Setton and Eberhard Stumpp.
3. in 2004 Geim and Novoselov extracted single-atom-thick crystallites from bulk graphite.[25] They pulled graphene layers from graphite and transferred them onto thin silicon dioxide (SiO_2) on a silicon wafer in a process called either micromechanical cleavage or the Scotch tape technique.

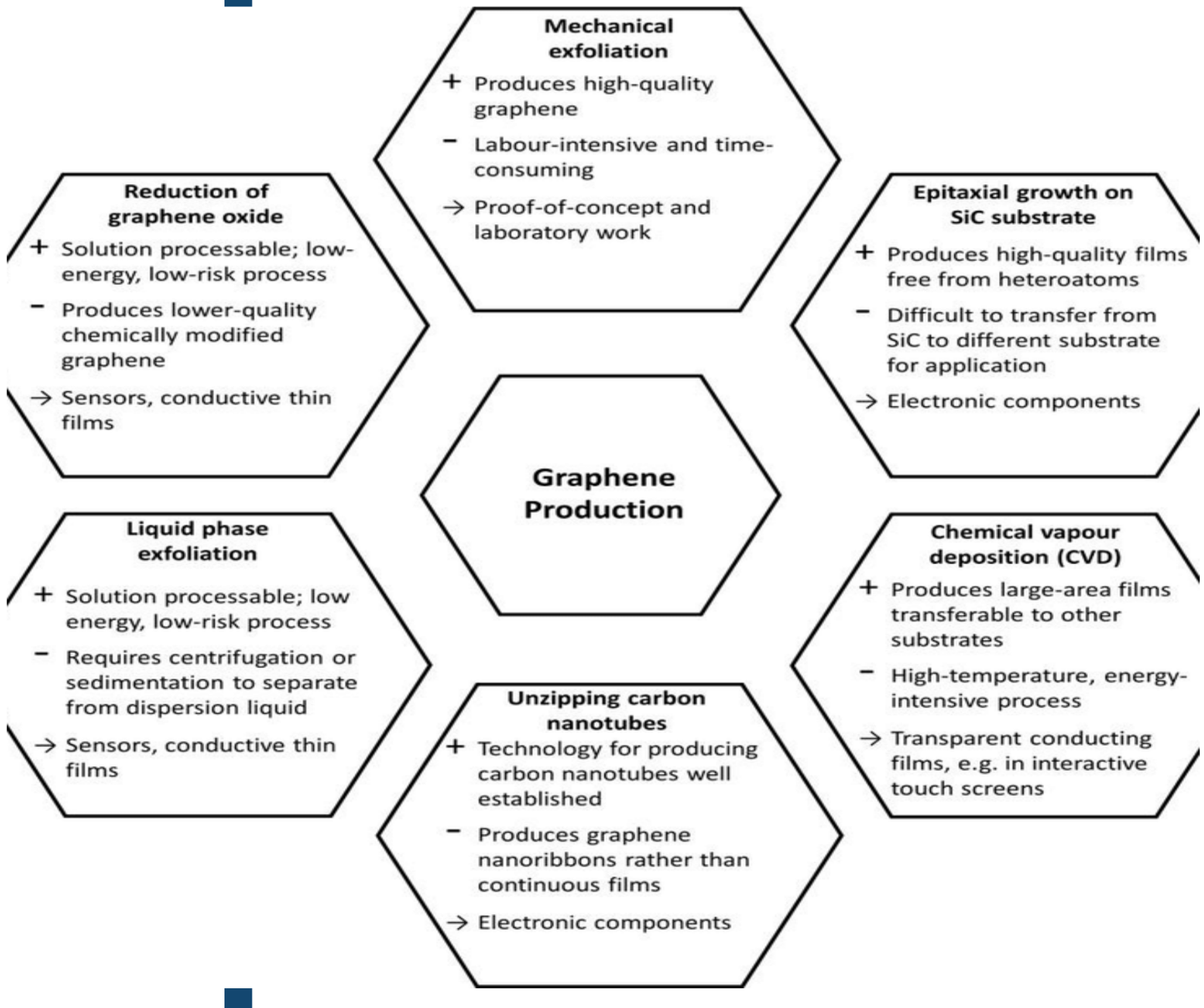

(a)
Micromechanical cleavage
Sticky tape
SiO_2
(b)
Anodic Bonding
Positive Electrode
Substrate
Negative Electrode + Heater
(c)
Photoexfoliation
(d)
Liquid phase exfoliation
Dispersed graphene flakes
Ultrasound
(e)
Growth on SiC
(0001)
Si-Face
4H-SiC
(000$\bar{1}$)
C-Face
SiC
(f)
Precipitation from metal
Metal substrate
Heat
(g)
Chemical Vapour Deposition
Hydrocarbon gas
Metal substrate
(h)
Molecular beam epitaxy
Substrate
(i)
Chemical synthesis
Substrate


(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)



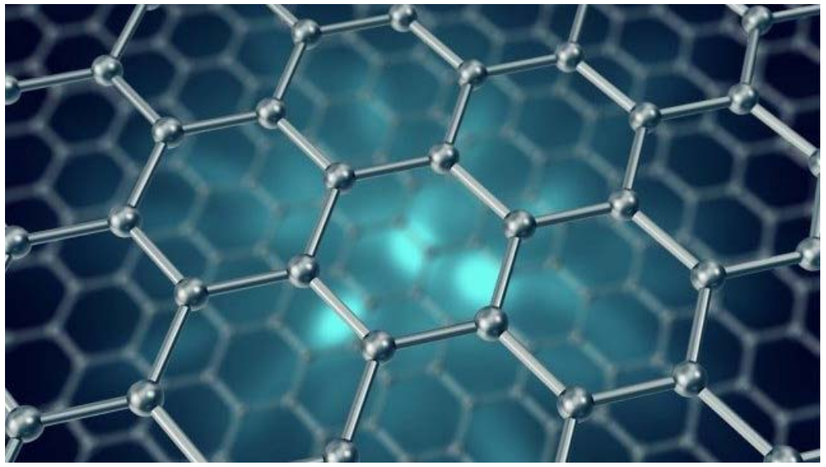


GRAPHENE PRODUCTION TECHNIQUES

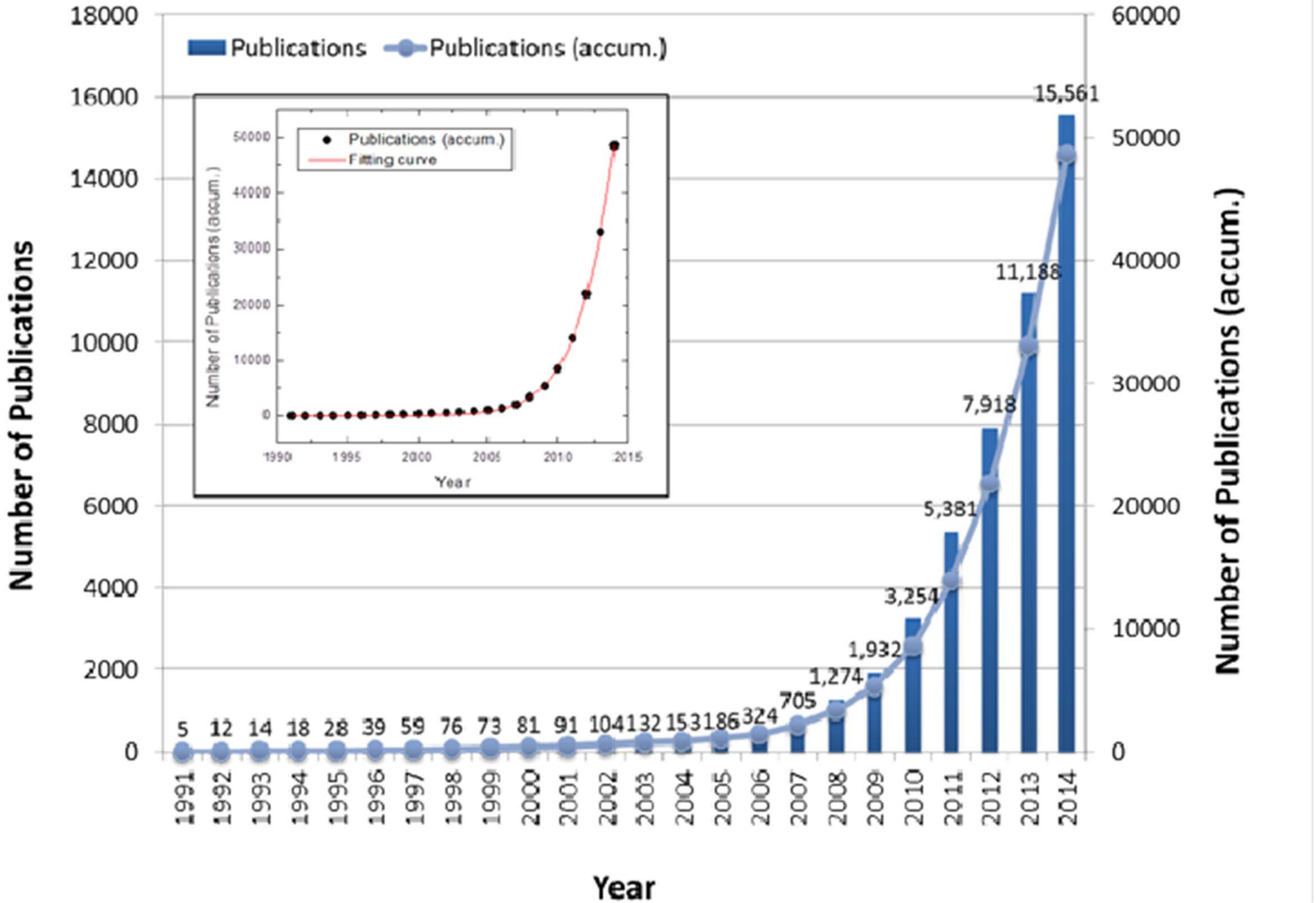


INTERESTING PROPERTIES OF GRAPHENE.

1. Strongest Material. 100 to 300 times stronger than the steel
2. Highly Transparent. It is 97.7% transparent.
3. Highly Conductive. It conducts heat two times better than iamond.
4. Electron mobility is 100 times faster than silicon.
5. Highly impervious .Smallest atom Helium also cannot pass through it.



Physical Properties	Graphene	Carbon nanotube	Si	Cu
Melting point (K)	3800	3800	1687	1357
Thermal conductivity (10^3 W/mK)	3-5	1.75-5.8	0.15	0.385
Current density (A/cm^2)	> 10^8	> 10^9	-	10^7
Electron mobility (cm^2/(V.s))	> 10,000	> 10,000	1400	-
Mean free path (nm)	1 × 10^3	> 10^3	20-30	40


Publications
Publications (accum.)
Number of Publications
Number of Publications (accum.)
Year
Publications (accum.)
Fitting curve
Number of Publications (accum.)
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5
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18
28
39
59
76
73
81
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132
153
186
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705
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1,932
3,254
5,381
7,918
11,188
15,561
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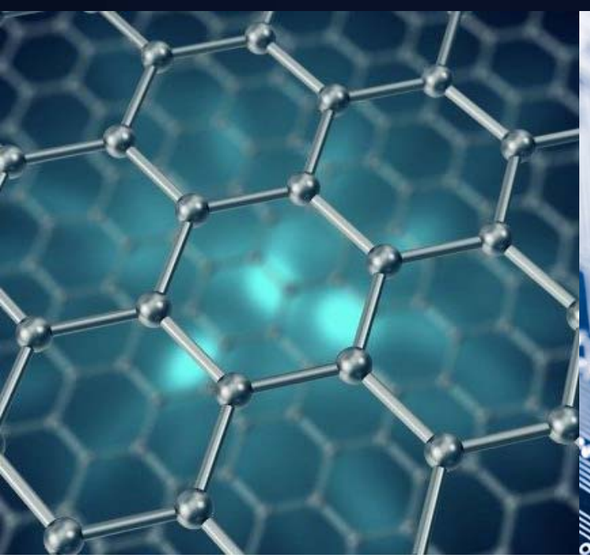
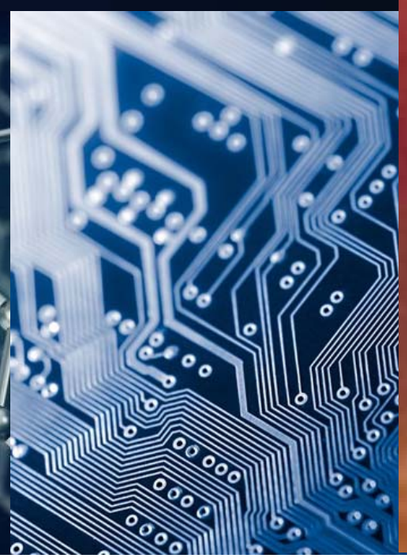
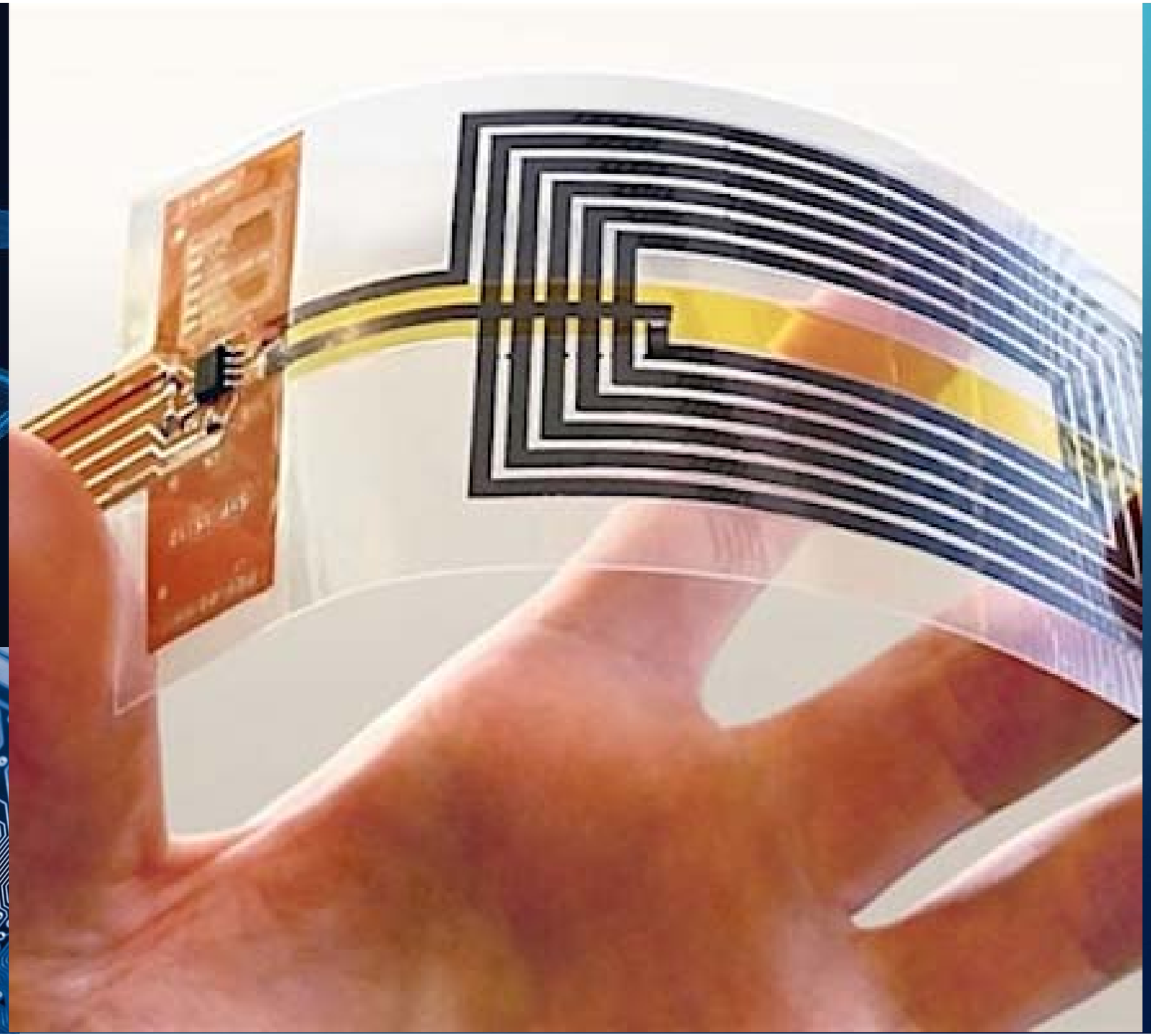
APPLICATION OF GRAPHENE

1. BIOLOGICAL ENGINEERING
2. OPTICAL ELECTRONICS
3. ULTRAFILTRATION
4. COMPOSITE MATERIALS
5. PHOTO VOLTAIC CELLS
6. ENERGY STORAGE

USES







Graphene

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Graphene Complex materials

Transparent Electrodes

Flexible/Transparent Electrodes, Touch Panels

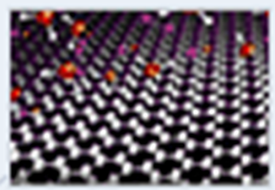
Pritable Inlk

Conductive Ink EMI shielding coatings Gravia printing electrodes

Semicon -ductor

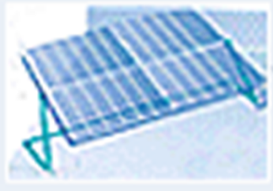
Ultrafast transistors RFIC Photo /Bio sensors

Gas Barriers



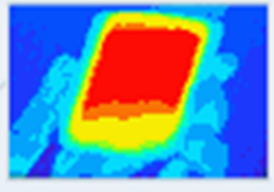
Gas/Water barrier Oxidation protectants

Energy Electrodes



Solar cells Secondary batteries Fuel cells

Heat Dissipation



Led, BLU etc.

Light

References.

1. nobelprize.org/prizes/physics/2010/geim/lecture
2. Geim, A. K.; Novoselov, K. S. (26 February 2007). "The rise of graphene". Nature Materials.
3. www.graphenea.com
4. graphene-supermarket.com
5. en.wikipedia.org/wiki/Graphene