Tailoring of Physical Properties and Bio-Interactions on Semiconductors

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Introduction

- Nanostructures(~10^{-9}m) grown on Wide Band Gap(TiO_2, ZnO, etc.) semiconductors have shown potential applications in Memory Devices, Transparent Conducting Oxides, Spintronics, Solar Cells, etc.
- Depending upon shape and size of these structures, several physical properties such as Electrical, Optical, Magnetic, etc. have been studied for above mentioned applications using Atomic Force Microscopy, X-Ray Photoelectron Spectroscopy, Raman Spectroscopy.
- Coming together of Nanotechnology and Bio-Engineering, when these surfaces have been interacted with biological molecules such as DNA, have lead to major findings in Bio-Transplants and Bio-Sensors.

Atomic Force Microscopy(AFM)

- AFM microscope is used for visualizing very small Nanostructures and Atoms on the surface.
- It works almost like 'A Blind Man with a Stick'. It has a very sharp needle which moves onto the surface, building up the map of nanostructures on the surface as it goes along.
- It provides information about the sample surface which is very useful for explaining various physical properties as mentioned in Introduction.
- Gerd Binning and Heinrich Rohrer got the Nobel Prize in Physics in 1986 for the developement of AFM.

X-Ray Photoelectron Spectroscopy(XPS)

- It is based on the principle of the famous Einstein Photoelectric Effect(1905).
- It is a surface sensitive spectroscopic technique that provides qualitative and quantitative information about the elemental composition, chemical state(Oxidation state, bonding), etc. of the elements that exists within a material.
- XPS spectra are obtained by irradiating a material with a beam of X-Rays while simultaneously measuring the Kinetic Energy and Number of Electrons that escape from the top of the surface(between 0-10nm) of the material being analyzed.
- It is a non-destructive technique as the energy of the X-ray which is use to get XPS spectra is in energy range of 1200-1400eV. (1eV=1.6×10^{-19}Joules)
- Prof. Kei Siegbahn has been awarded Nobel Prize in Physics in 1981.

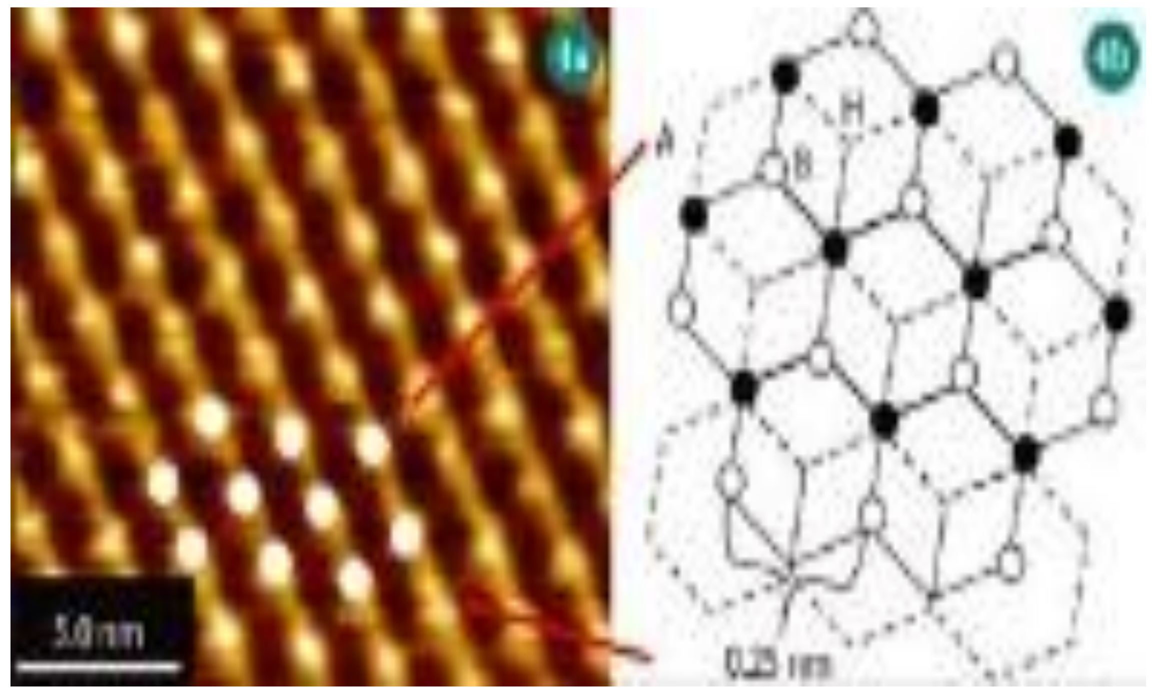
Raman Spectroscopy

- It relies on inelastic scattering of monochromatic light usually from LASER. The theory has been developed by Adolf Smeakel in 1923.
- It is commonly used to provide a fingerprint by which the symmetry and nature of chemical bonds of all molecules can be identified, as Raman Scattering is very sensitive to these properties.
- We can also get information about the Crystal Orientation and its structure by using Raman Spectroscopy.
- Sir C.V. Raman, who observed inelastic scattering of light experimentally(along with K. S. Krishnan and independently by Grigory Landsberg and Lenoid Mandelstam), has got Nobel prize for Physics in 1930.
- Systematic pioneering theory of Raman effect was developed by Czechoslovak Physicist George Placzek between 1930 and 1934.

Key Findings

- Nanostructures grown on TiO_2 surfaces shows a reduction in Band Gap and enhanced absorption of visible light which can be used for Solar Cells, Photovoltaic, etc.[1, 2].
- When nanostructured TiO_2 surfaces have been interacted with DNA, enhanced Hydrophlicity has been observed which makes TiO_2 an important material for Bio-Transplants[3].
- Metal conjugated with DNA can be used as a sensor for Mercury contamination which can lead to several disorders in human body[4].
- Room temperature Ferromagnetism has been observed which can be used for future Spintronics applications[5].

Carbon Atoms on Graphite using AFM



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