Nanophotonics or Nano Optics

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Researchers from University of Hyderabad have shown how crystals can be sliced and even bent using atomic force microscopy. Manipulating them with precision and control comes in very useful in the field of nanophotonics.

In news: Nanophotonics: Hyderabad scientists manipulate tiny crystals
Placing it in syllabus: Science & Technology
Dimensions

- What is Nanophotonics?
- Its Applications
- Hurdles

Content:

What is Nanophotonics?

- Nanophotonics or nano-optics is a part of nanotechnology that investigates the behavior of light on nanometer scales as well as interactions of nanometer-sized objects with light.
- Nanophotonics is also considered a branch of electrical engineering, optics, and optical engineering—as well as being a branch of nanotechnology.
- nanophotonics, a qualitative, emerging field where the **aim is to go beyond electronics and build up circuits driven entirely by photons (light)**.
- If the technique can be successfully developed, it can achieve an unprecedented level of miniaturisation.
- All-optical-technology that is pliable, wearable devices operated entirely by light can be achieved.

Normal optical components, like lenses and microscopes cannot focus light to nanometer scale. But, it is possible to

squeeze light into a nanometer scale using other techniques like Surface plasmons, Metal optics, Near field optics, Metamaterials Principles

Its Applications

Nanophotonics has potential for wide ranging applications in fields ranging from biochemistry to electrical engineering.

- ***Miniaturization of Optoelectronics and microelectronics:***

- Miniaturization in optoelectronics, (for example the miniaturization of transistors in integrated circuits) has improved their speed and cost.
- However, optoelectronic circuits can only be miniaturized if the optical components are shrunk along with the electronic components. Nanophotonics helps to shrink the size of optical components.
- This is relevant for on-chip optical communication (i.e. passing information from one part of a microchip to another by sending light through optical waveguides, instead of changing the voltage on a wire)
- nanophotonics involves silicon chips that use light instead of, or in addition to, the types of traditional electrical signals common to semiconductor design.
- Companies like IBM have pioneered advancements in a chip that uses photodetectors and emitted light to send signals in an integrated circuit environment.

- ***Solar cells***

- Solar cells often work best when the light is absorbed very close to the surface, both because electrons near the surface have a better chance of being collected, and because the device can be made thinner, which reduces cost.
- Researchers have investigated a variety of nanophotonic techniques to intensify light in the optimal locations within a solar cell.

- This would allow efficient solar cells to be made cheaper than the conventional one.

- ***Spectroscopy***

- Using nanophotonics to create high peak intensities allows sensitive spectroscopy measurements of even single molecules located in the hot-spot, unlike traditional spectroscopy methods which take an average over millions or billions of molecules.

- ***Near-field scanning optical microscope (NSOM or SNOM)***

- nanophotonic technique that accomplishes the goal of taking images with resolution far smaller than the wavelength
- A “superlens” which would use metamaterials or other techniques to create images that are more accurate than the diffraction limit.

What Indian researchers have achieved?

Bending path of light:

- Light, when left to itself moves along straight paths, so it is crucial to develop materials and technology that can cause its path to bend along what is required in the circuits.
- This is like using fibre optics, but at the nanoscale level using organic crystals.
- The Hyderabad group has demonstrated how such crystals can be lifted, bent, moved, transferred and sliced using atomic force microscopy.
- The researchers have named this technique “**mechanophotonics**” as this method can be used to generate the basic elements needed to build up a photonic integrated circuit.

Method Used:

- Researchers added a crucial piece to the jigsaw puzzle of building an “organic photonic integrated circuit” or OPIC.
- Generally, millimetre- to centimetre-long crystals were bent using hand-held tweezers.
- This method lacks precision and control. Also, the crystals used were larger than what was required for miniaturisation.
- The atomic force microscopy (AFM) cantilever tip could be used to lift a crystal, as crystals tend to stick to the tip due to tip–crystal attractive forces.
- Thus they demonstrated the real waveguiding character of the crystal lifted with a cantilever tip.

What is Atomic Force Microscopy (AFM)?

- AFMs are a type of electron microscope used for the observation at an atomic level.
- It is commonly used in nanotechnology.
- The AFM works by employing an ultra-fine needle attached to a beam.
- The tip of the needle runs over the ridges and valleys in the material being imaged, “feeling” the surface.

Hurdles

- The field is in its infancy and the results are qualitative.
- Successful application of the current research depends on the fabrication of high-density photonic circuits using organic passive, active and energy-transfer mechanisms

Mould your thought: Write a short note on Nanophotonics.

Approach to the answer:

- Introduction
- What is nanophotonics?

- Discuss its applications
- Discuss its hurdles
- Conclusion