

Significance of Quantum Dots

Why in news?

Nobel Prize for Chemistry 2023 has been awarded to Alexei I. Ekimov, Louis E. Brus, and Moungi G. Bawendi for the discovery and synthesis of quantum dots.

What is a Quantum dot?

- **Quantum dots**- Quantum dots are man-made nanoscale crystals that exhibit unique optical and electronic properties, including the ability to transport electrons and emit light of various colors when exposed to UV light.
- The quantum dot change based on the nature of their properties.
- **Quantum theory**- The motion and behaviour of very small particles are radically different, and strange, when compared with any familiar object in normal human experience.
- Such strange behaviour at the sub-atomic level is described by the hugely successful Quantum Theory.
- **Nanoparticles**- They are much larger compared with atoms.
- It was theorised in the 1930s that when the size of particles was reduced to nanoscale, it could give rise to quantum effects.
- **Effect of light on a quantum dot** - When light is shined on a quantum dot, it absorbs and then re-emits it at a different frequency.
 - **Smaller dots**- Emits bluer light
 - **Larger dots**- Emits redder light
- This happens because light shone on the dot energises some electrons to jump from one energy level to a higher one, before jumping back and releasing the energy at a different frequency.



What did the Nobel laureats do?

- **Alexei Ekimov** - He added different amounts of copper chloride to a glass before heating it to different temperatures for different durations, tracking the dopants' structure and properties.
- They found that the glass's colour changed depending on the size of the copper chloride nanocrystals
- **Louis Brus**- He and his colleagues prepared similar crystals in a liquid solution, rather than in a glass.
- These crystals also interacted with light differently depending on small variations in their size.
- **Moungi Bawendi** - He devised a simple way to make quantum dots with just the right

properties using hot-injection method.



What are the applications of quantum dot?

- **Display**- An array of quantum dots can be a TV screen by receiving electric signals and emitting light of different colours.
- **Semiconductor**- If one of the energy levels an electron jumps between in a quantum-dot atom is the conduction band, the dot can operate like a semiconductor.
- **Photovoltaics**- The solar cells made with quantum dots are expected to have a thermodynamic efficiency as high as 66%.
- **Light Emitting Diodes (LEDs)**- Visible quantum dots-based LED is considered as a next generation display technology after OLED-displays (Organic LEDs) as it exhibits high colour purity, high luminance and lower power consumption.
- **Photodetectors**- They can be used in photodetectors for detecting both infrared and visible light.
 - **IR Photodetectors**- It finds application in night vision cameras, atmospheric spectroscopy for gas detection, biomedical imaging, quality control and product inspection.
 - **Visible light photodetectors**- They are used in image sensors for transforming the incoming light into electronic signals.
 - Quantum dots can also be used in surveillance, machine vision, industrial inspection, spectroscopy, and fluorescent biomedical imaging.
- **Medical diagnostics**- It can highlight a tumour that needs to be removed, for targeted drug delivery and other therapeutic measures.
- It is also used in DNA hybridization, receptor mediated endocytosis, monitoring of parasite metabolism, real time visualization of tissue and cellular structures, and diagnostics application.
- **Biological tissues**-They are also used to map biological tissues by biochemists.
- **Markers**- It can be used as security markers on currency and documents as an anti-counterfeit measure.
- It can be used as fluorescent markers to tag and track objects.

References

1. [The Hindu- Significance of quantum dots in nanotechnology](#)
2. [Indian Express- Quantum dots Nobel Prize for Chemistry 2023](#)