

Topological Materials

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Topological Materials Latest News

The United Nations has declared 2025 as the International Year of Quantum Science and Technology, marking 100 years since quantum theory began to revolutionise science.

What are Topological Materials?

- **Topological materials** are substances that **exhibit different physical properties on their surface and in their interior**.
- These materials may behave like a **metal on the outside** (conducting electricity) but like an **insulator on the inside** (not conducting electricity).
- The term “**topological**” refers to the **unique geometric and quantum properties** of the material, which remain unchanged even if the shape of the material is distorted.
- **Discovered in the latter half of the 20th century**, these materials represent a new class of quantum matter.

- **Nobel Prize in Physics (2016)** was awarded to scientists (David Thouless, Duncan Haldane, and Michael Kosterlitz) for their theoretical discoveries in this field.

How Do They Work?

- These materials exhibit a **metallic surface (conducting electrons freely)** while maintaining an **insulating core (electrons remain localized)**.
- This strange duality arises from **quantum mechanical effects**, especially the **topology of electronic band structures**.
- The behaviour is deeply rooted in the principles of **quantum mechanics**, where **electron spin and momentum** interplay due to a phenomenon called **spin-orbit coupling**.
- The **interaction of light and matter**, the **collective behavior of electrons**, and **phase transitions** are governed by quantum principles.
- The **UN declared 2025 as the International Year of Quantum Science and Technology**, marking **100 years since the foundation of quantum mechanics**.

Mirror Analogy

- A **mirror** appears to be a single object, but it has **two materials**:
 - A **glass front** (an insulator that lets light through)
 - A **thin metallic back** (a conductor that reflects light)
- This setup makes it possible to **see your reflection clearly**, as the **metal reflects light** that passed through the glass.

Why Do Metals and Insulators Differ?

- In **metals**, **electrons are free** to move — like a **soup of charge**, allowing **conduction of electricity and heat**.
- In **insulators**, electrons are **bound tightly** to their atoms and **do not move freely**, hence they **do not conduct electricity**.
- When **light (an electromagnetic wave)** hits these materials:
 - In **metals**, **electrons move collectively** and reflect light.
 - In **insulators**, **electrons move individually**, allowing light to **pass through**.

Topological Materials FAQs

Q1. What are Topological Materials?

Ans. These are quantum materials that conduct electricity on their surface or edges while remaining insulators internally.

Q2. Why are Topological Materials significant?

Ans. They are key to next-gen electronics, quantum computing, and low-power devices due to their unique electronic properties.

Q3. What is an example of a topological material?

Ans. Topological insulators like bismuth selenide (Bi_2Se_3) are well-known examples.

Source: TH

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