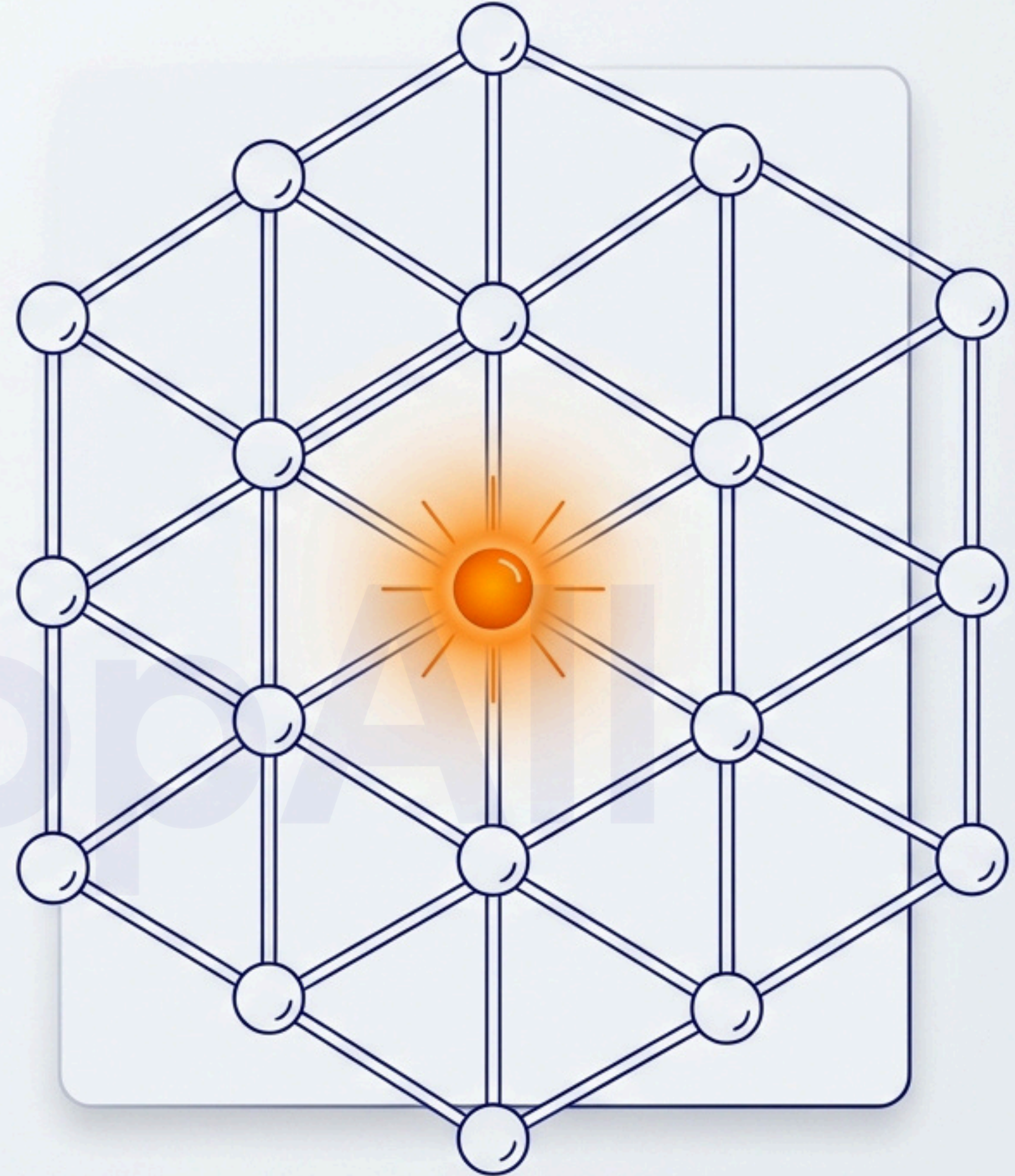




PHASE 01: EXTRINSIC DOPING

p-Type Semiconductor

Engineering positive charge carriers through trivalent doping.



The Trivalent Acceptor Impurity

Dopant Profile

Group:

13 Elements

Valency:

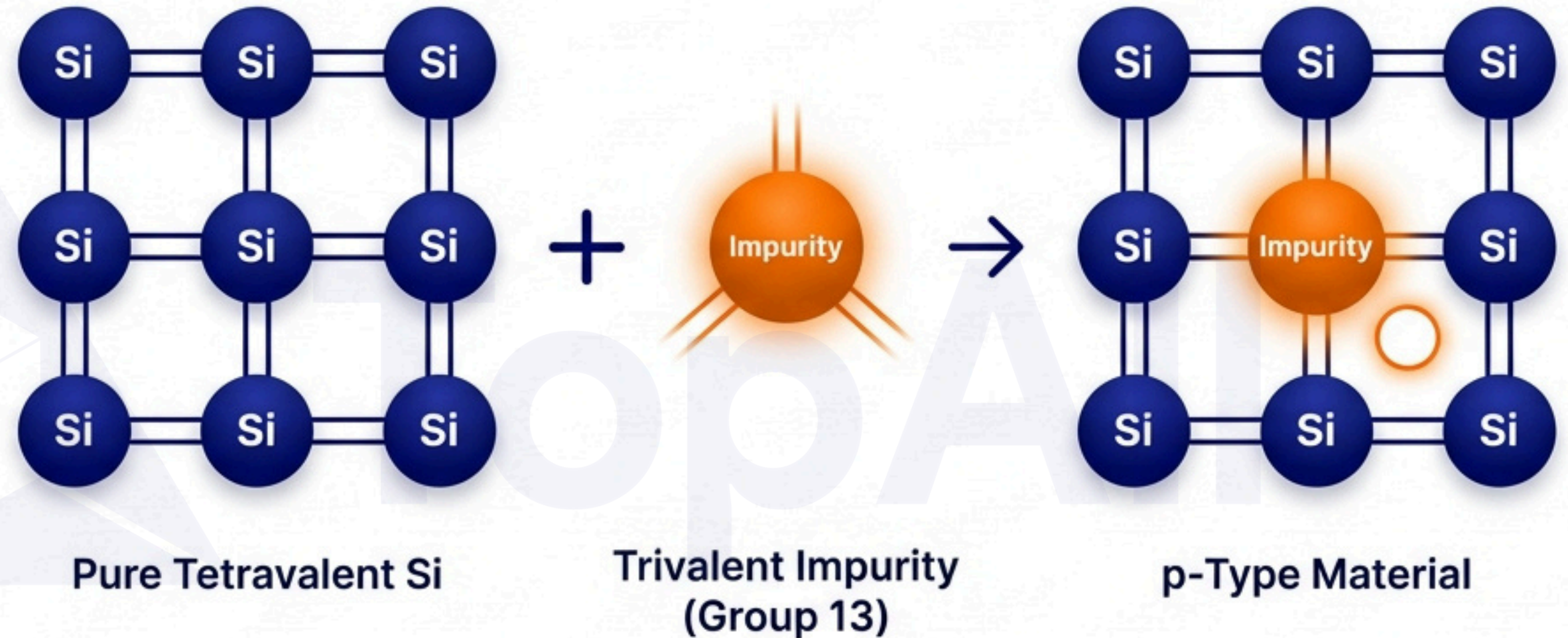
3 (one less than Si/Ge)

Common Dopants:

Boron (B)

Aluminum (Al)

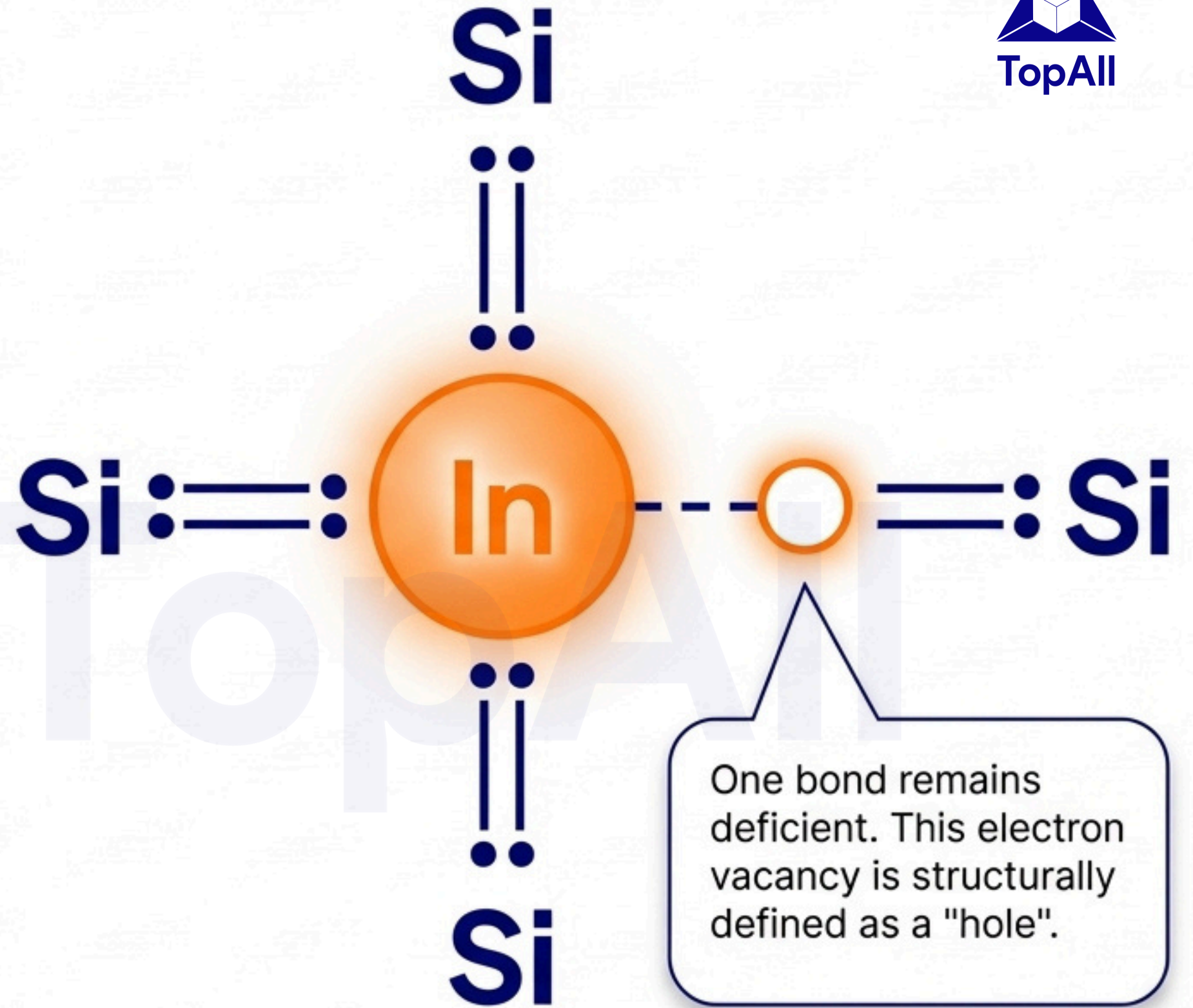
Indium (In)



The dopant atom perfectly substitutes a single Silicon atom without distorting the overall crystal lattice.

The Incomplete Bond

A trivalent dopant has only three valence electrons. It forms perfect covalent bonds with three neighboring Silicon atoms, but cannot satisfy the bonding requirement of the fourth.





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Let's Test Them Now.**

$$E=mc^2$$



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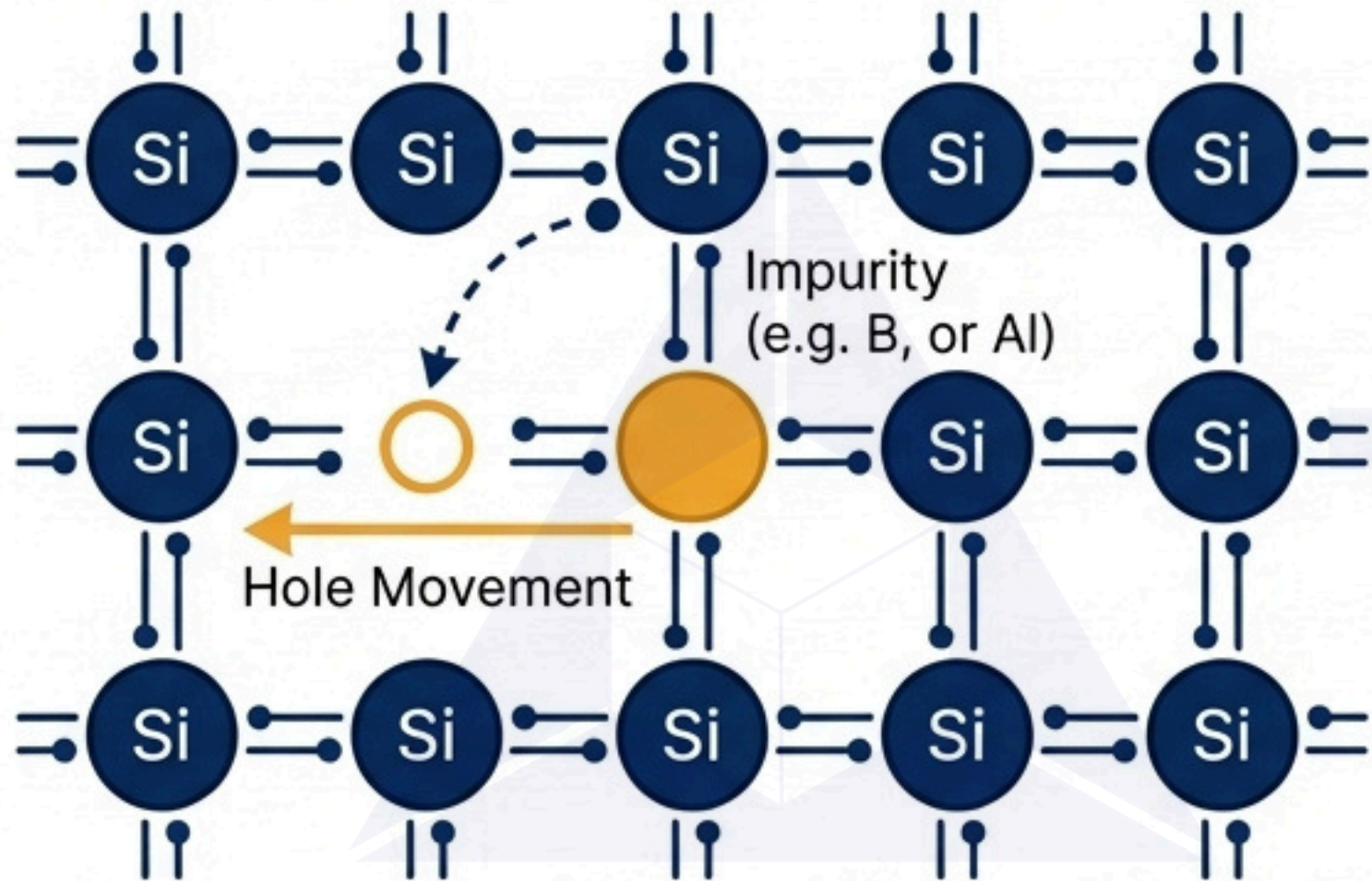
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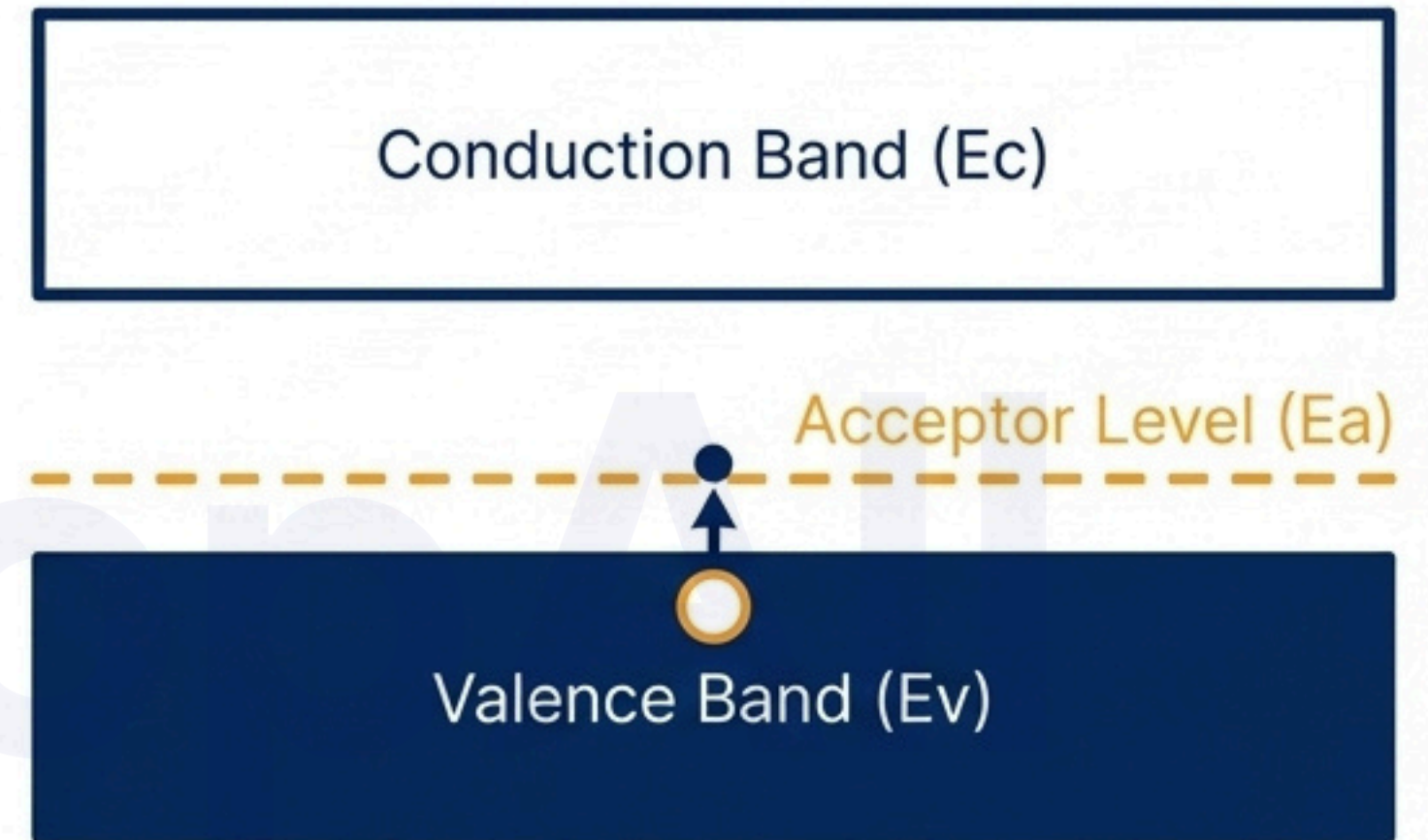
Hole Creation & The Acceptor Level

Physical Space



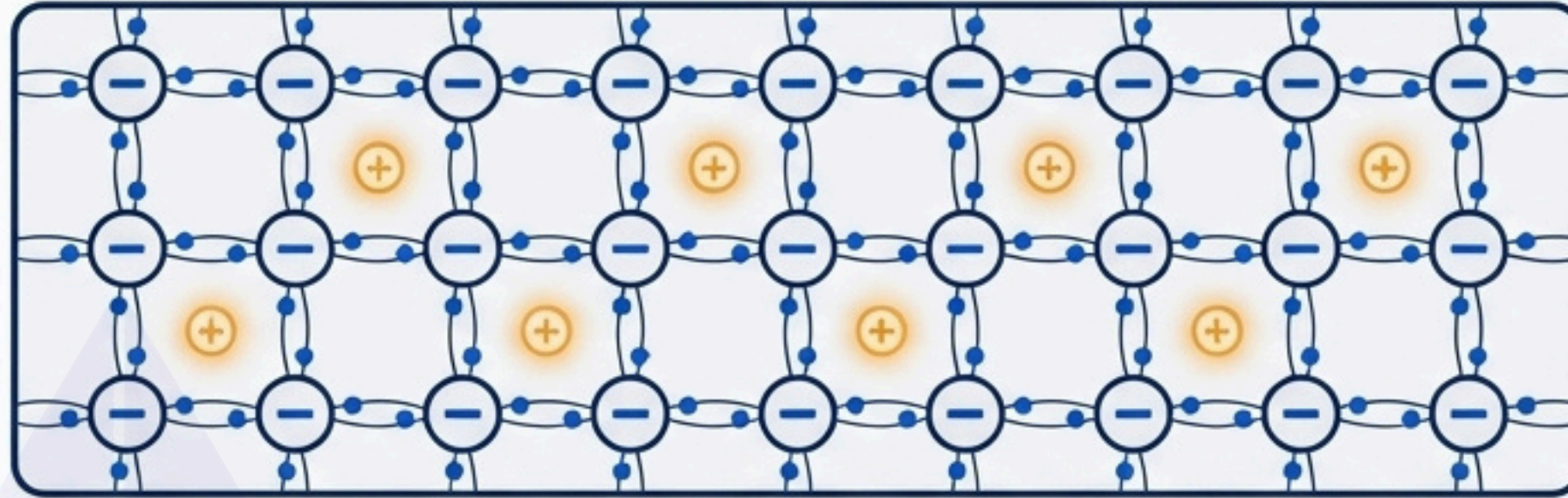
An adjacent electron jumps to fill the vacancy, effectively moving the "hole" to a new site. The hole behaves as an apparent free particle with an effective positive charge.

Energy Space



The dopant creates an Acceptor Level (E_a) just above the valence band. Minimal thermal energy allows valence electrons to jump to E_a , ionizing the acceptor negatively and leaving a free conducting hole in E_v .

Carrier Concentration & Neutrality



Majority Carriers

HOLES

$$n_h \gg n_e$$

Created predominantly by the 1:1 ratio of acceptor atoms to holes.

Minority Carriers

ELECTRONS

$$n_e \ll n_h$$

Generated strictly through intrinsic thermal excitation.



EXAM TRAP: The **crystal remains electrically neutral**. The abundance of positive holes is exactly balanced by the fixed, negatively charged ionized acceptor cores in the lattice.

Key Takeaways: p-Type Semiconductors



Dopant:

Group 13 elements (Valency 3).
E.g., Boron, Aluminum, Indium.



Mechanism:

Dopant's missing electron creates one structural vacancy (hole) per atom.



Energy Bands:

Acceptor Level (E_a) is positioned just ABOVE the Valence Band (E_v).

$$\frac{X_h}{X} \neq \frac{n_h}{n_e}$$

Concentration:

Holes are majority carriers ($n_h \gg n_e$), but the material maintains overall charge neutrality.



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