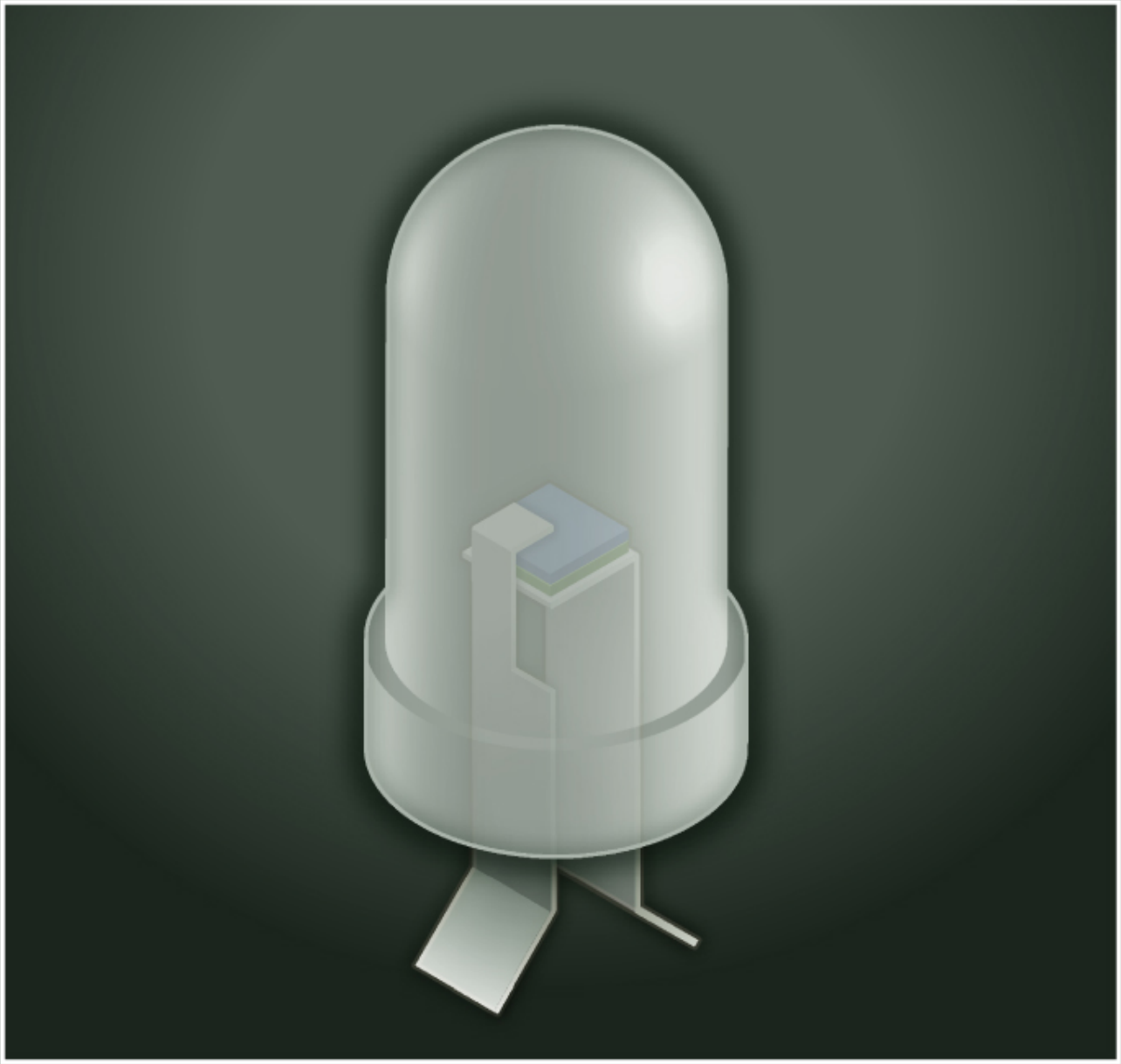
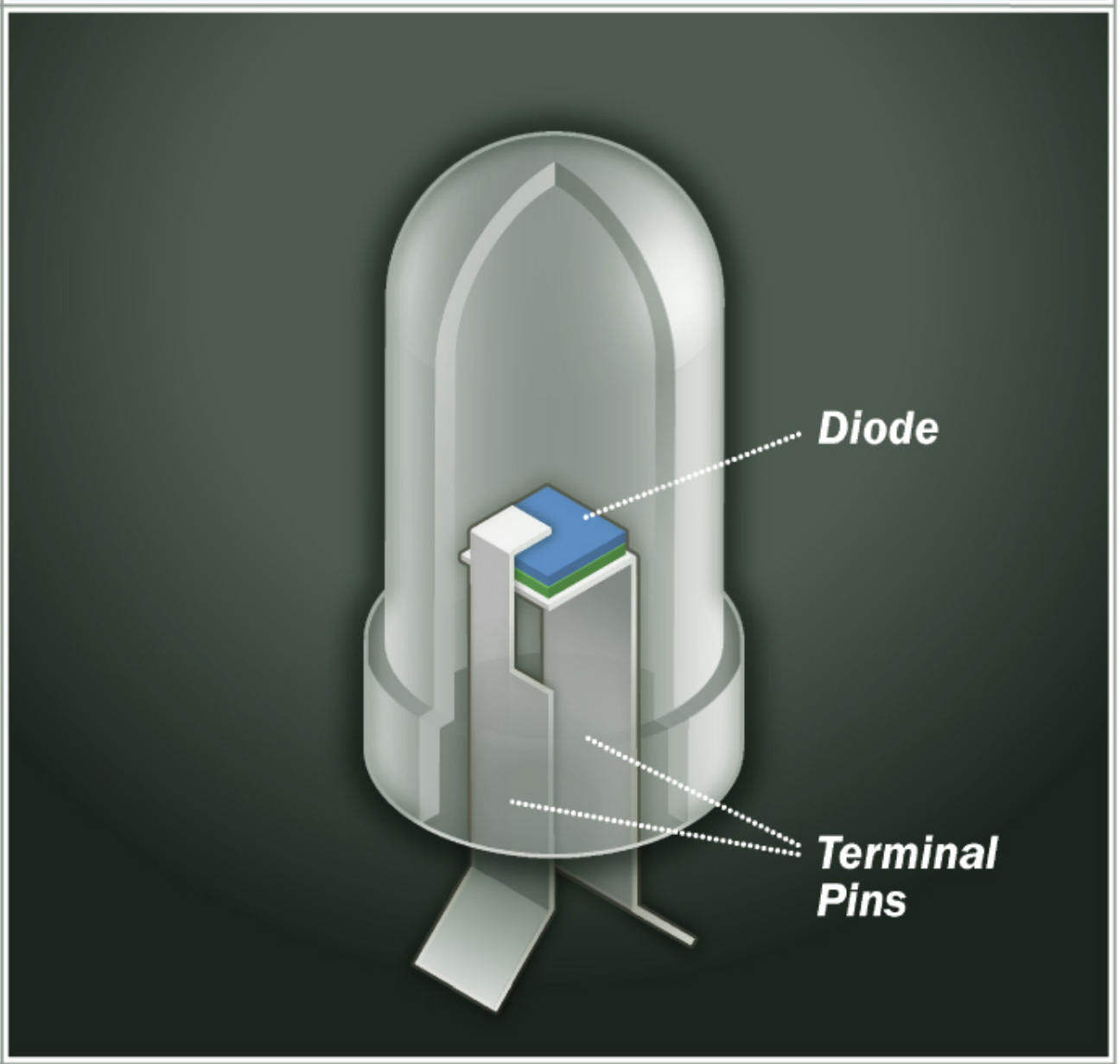
Light Emitting Diodes (LEDs)



Light Emitting Diodes (LEDs)



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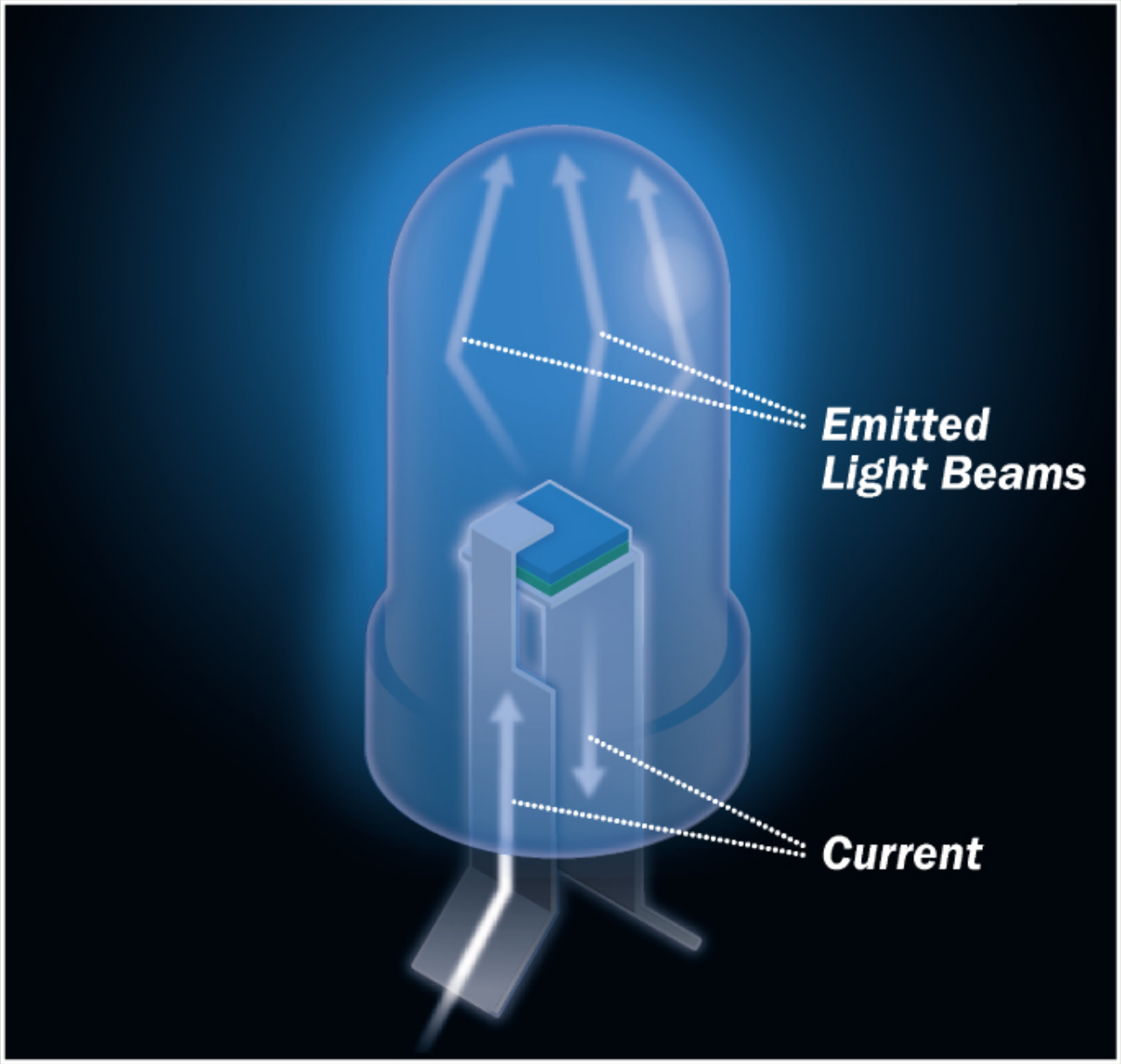
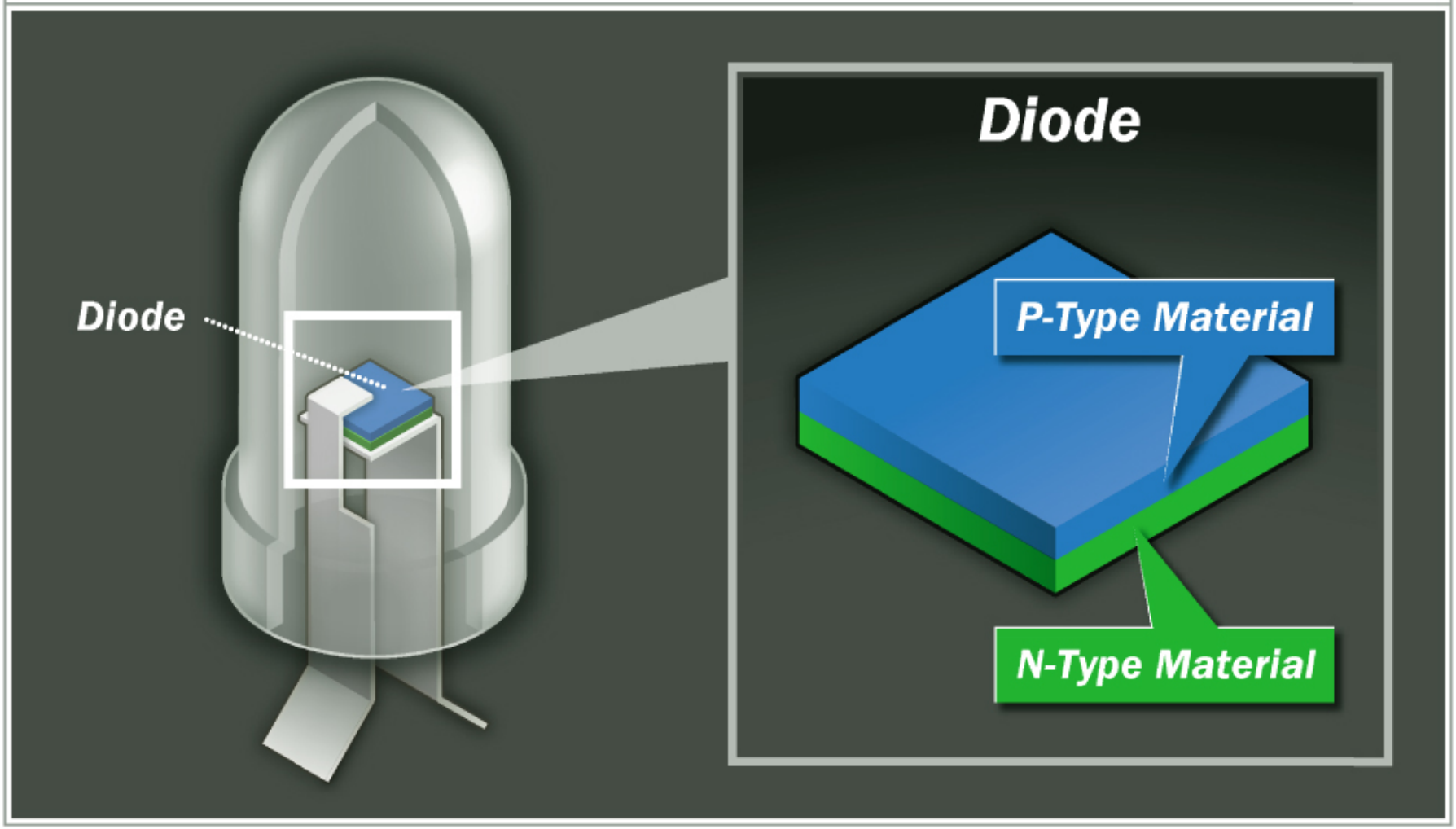


A ***Diode*** Is the Simplest Kind of Semiconductor Device



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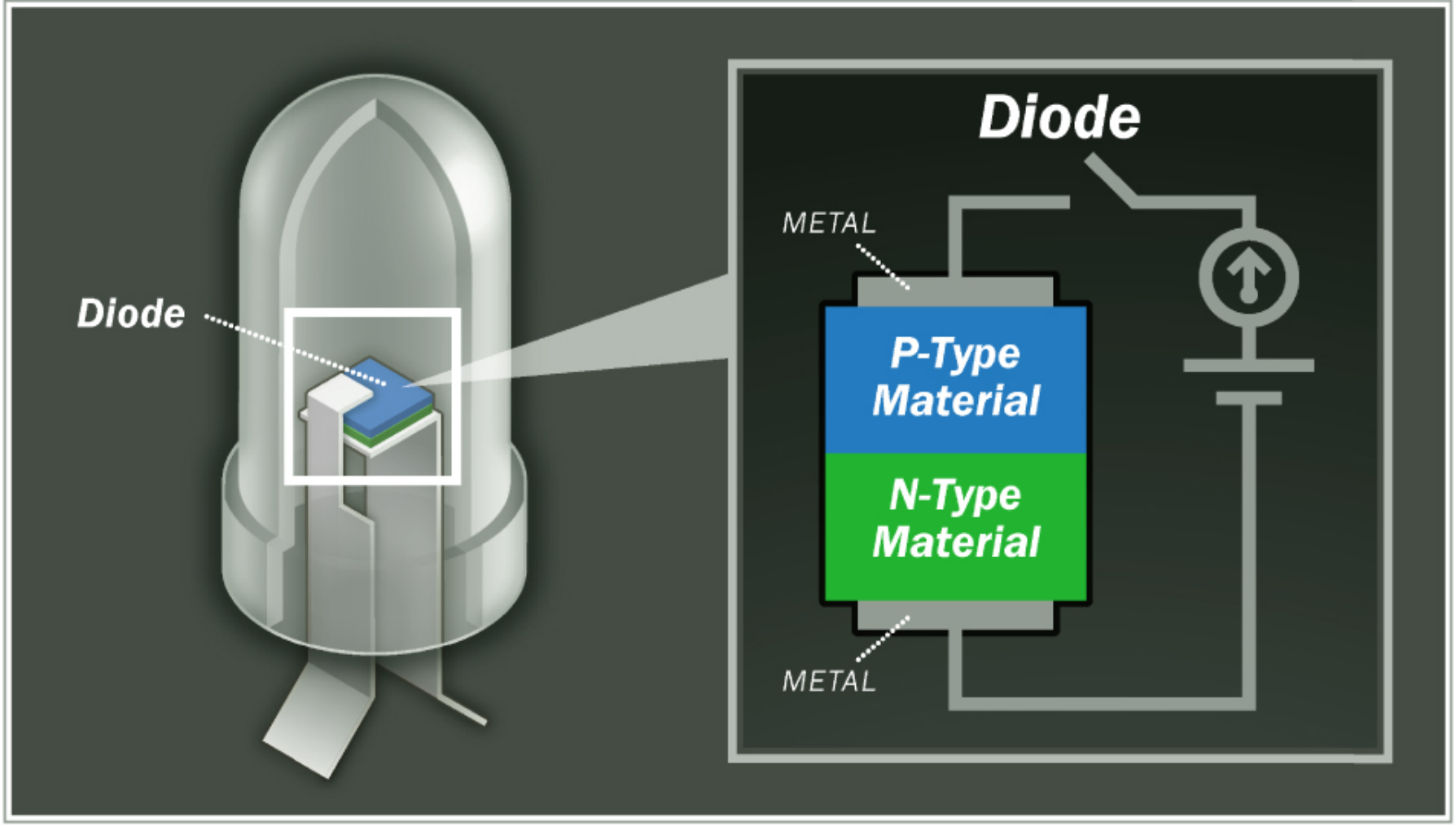
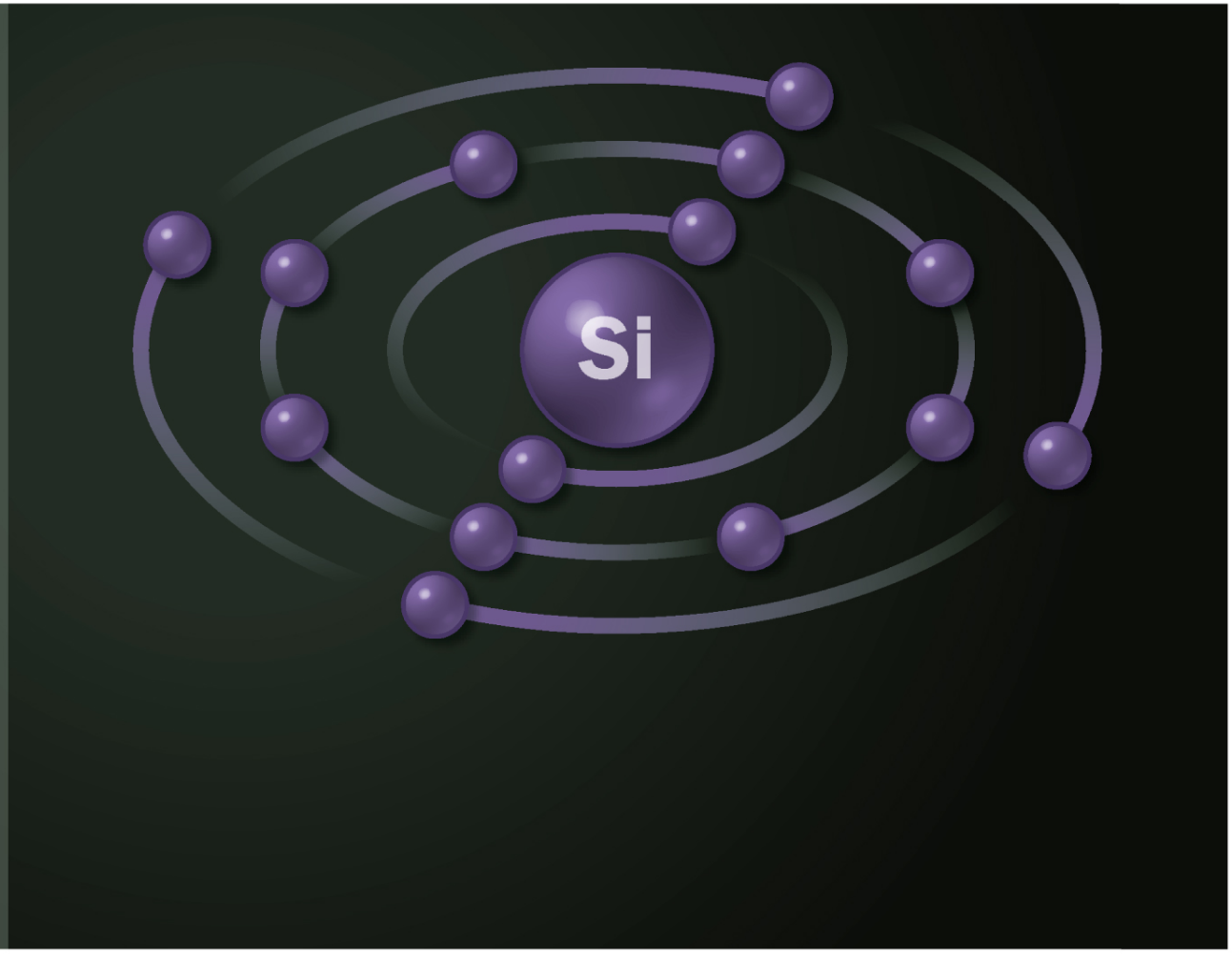


Silicon Is Commonly Used to Make Semiconductors

GROUP IV

14
Si
Silicon



Silicon Is Commonly Used to Make Semiconductors

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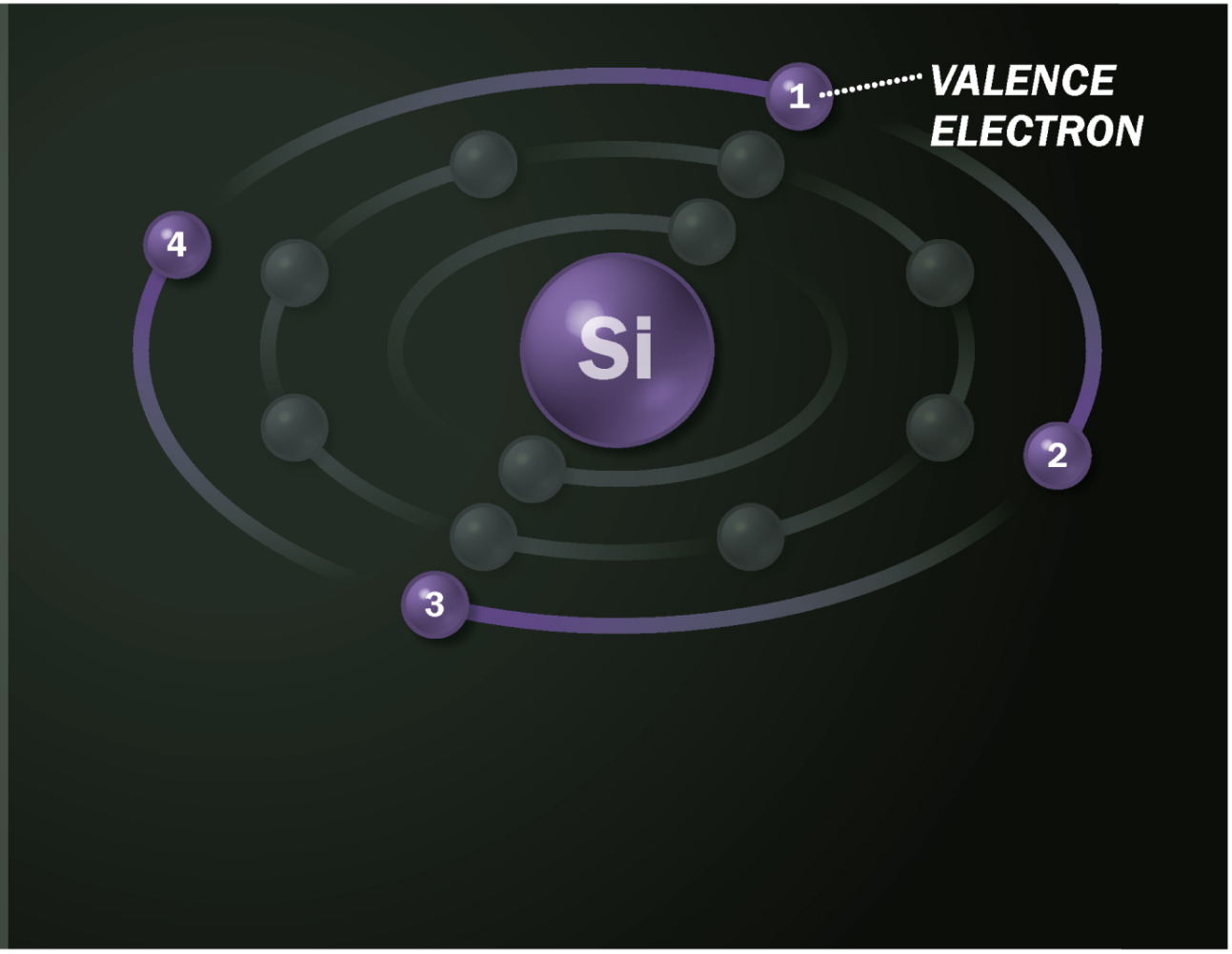
4 valence electrons participate in covalent bonds.

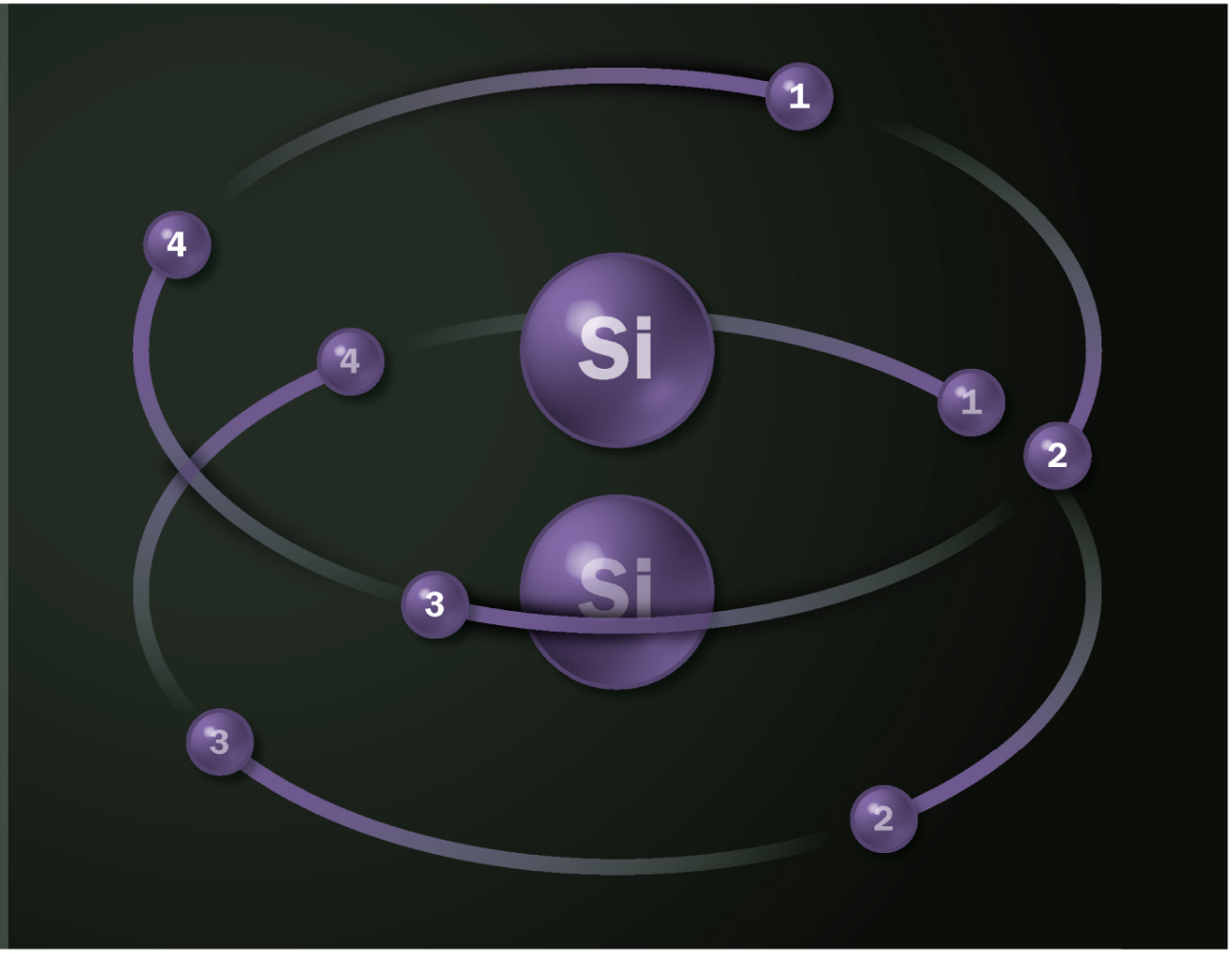


Silicon Is Commonly Used to Make Semiconductors

GROUP IV

14
Si
Silicon

Two silicon atoms form perfect covalent bonds because each has four electrons in its outer orbital.



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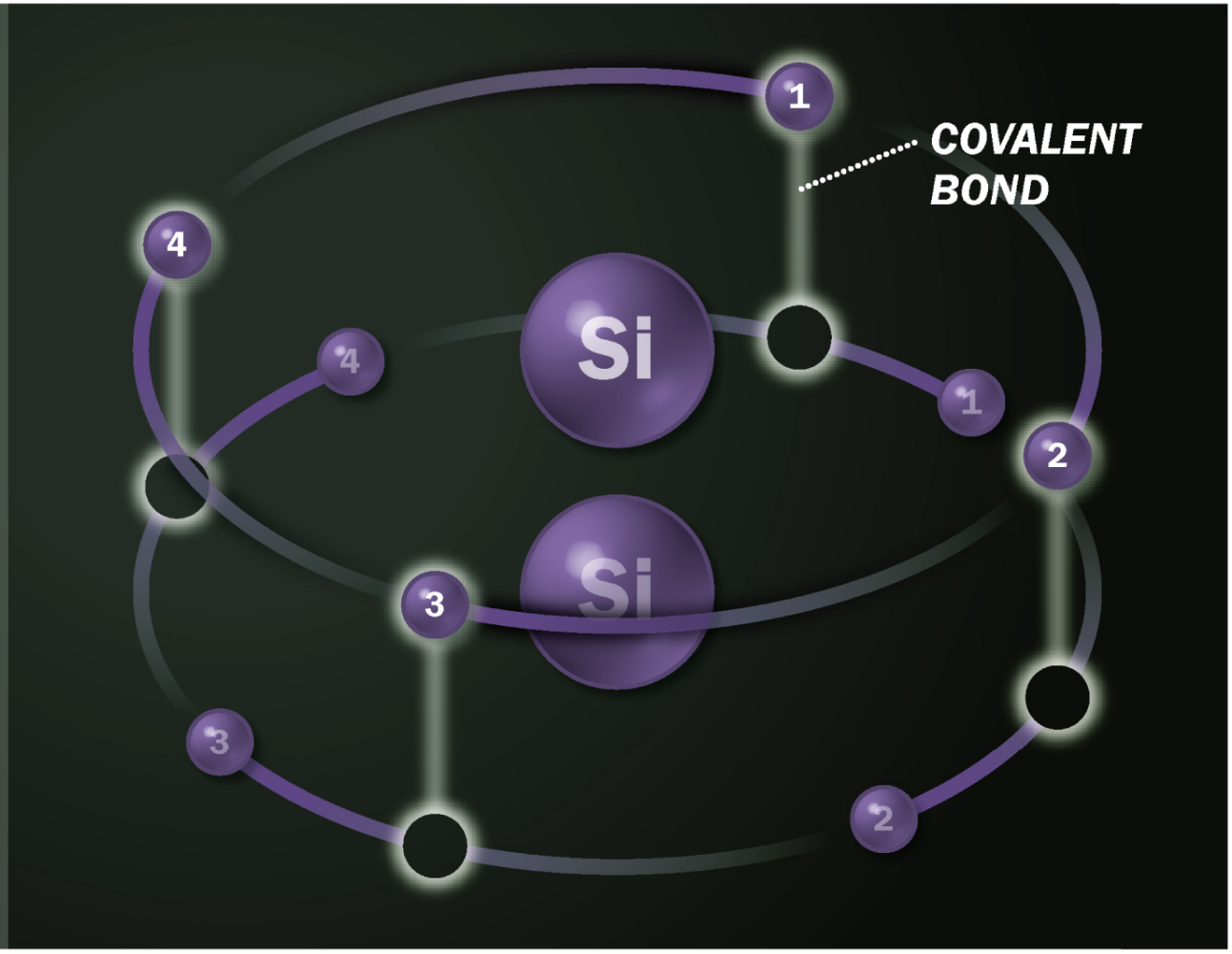

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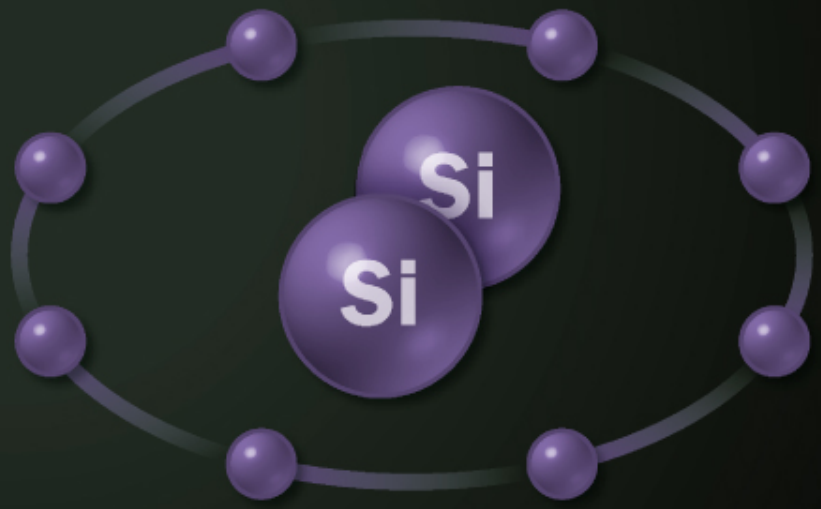
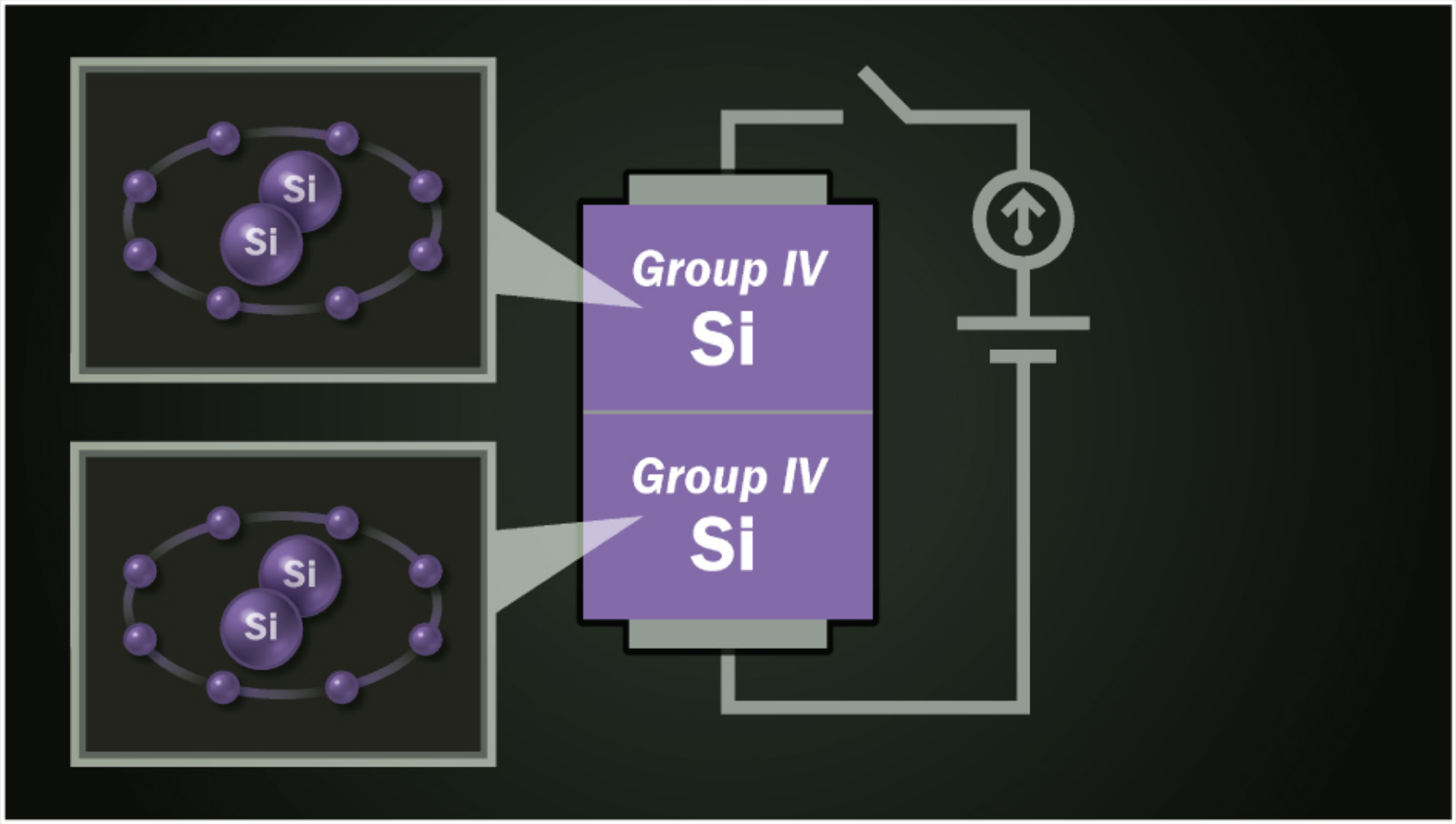
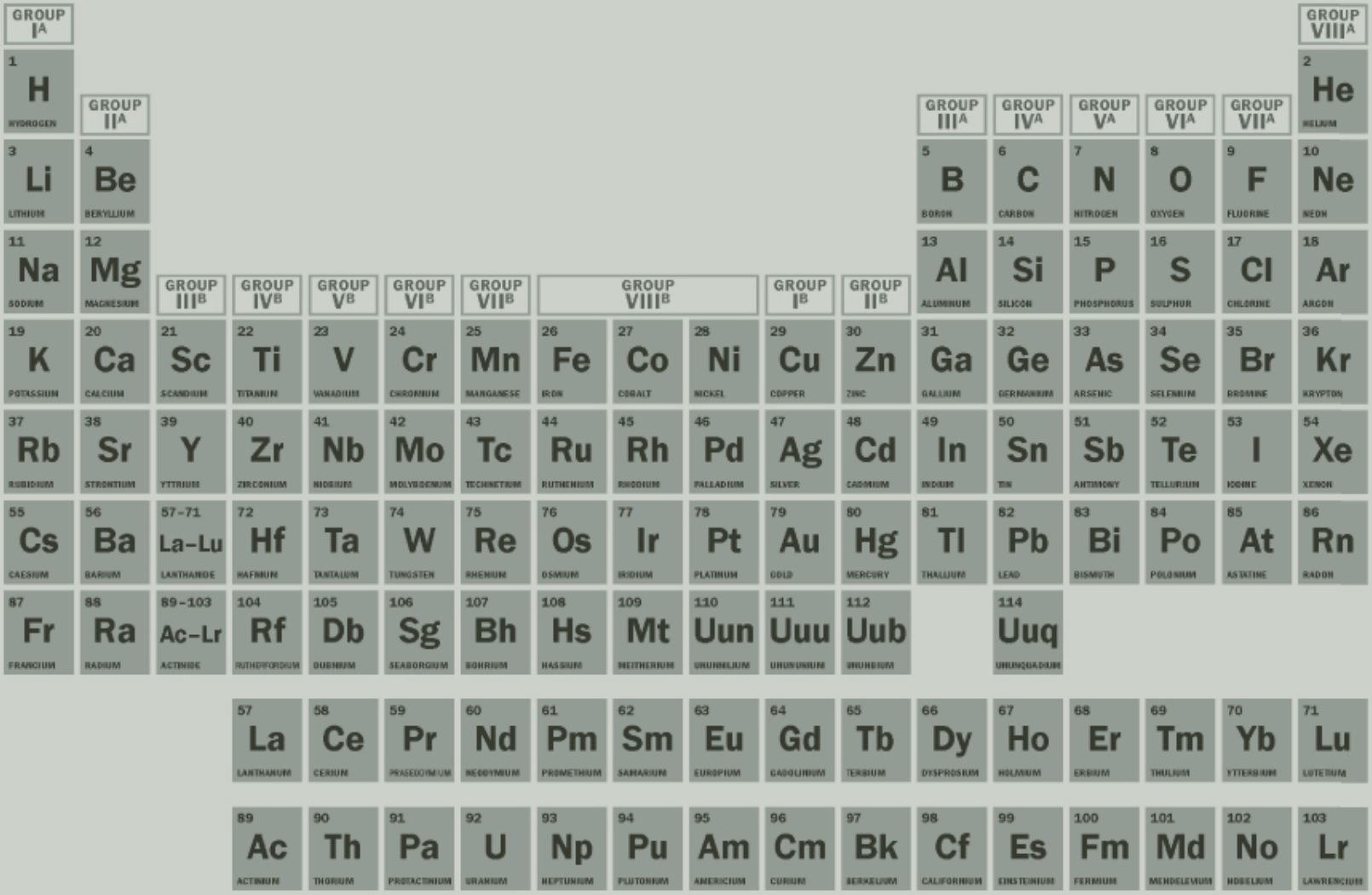


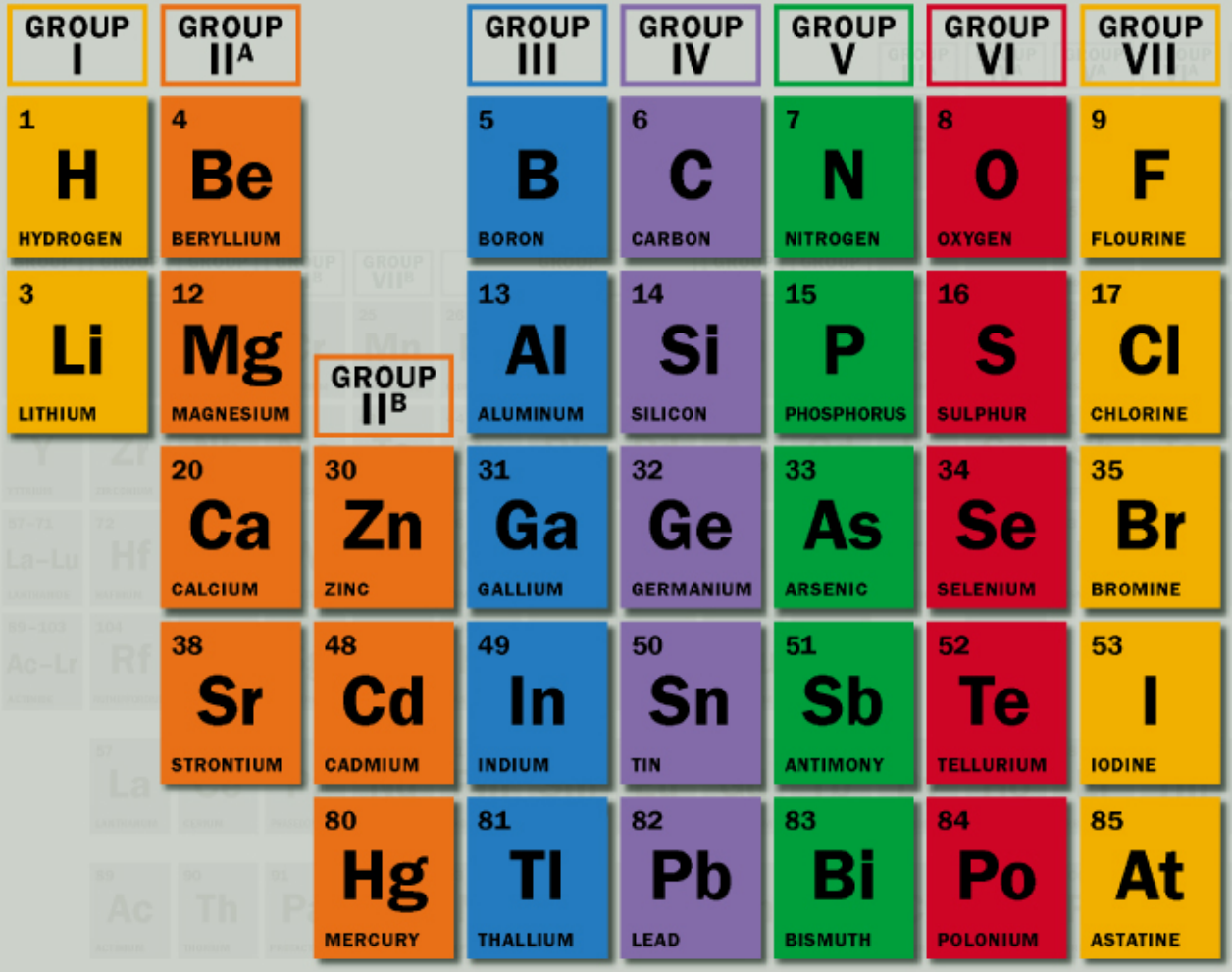
Ordinary Semiconductor "Diode"
(Before Doping)



Periodic Table of Elements



Periodic Table of Elements

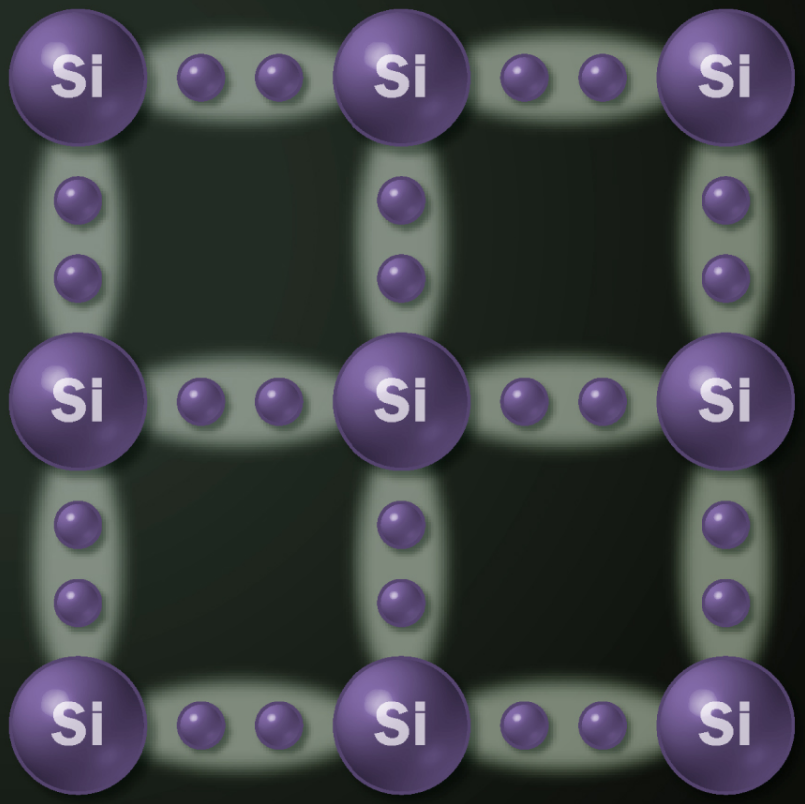


Doping Is Used to Change the Electrical Properties of a Semiconductor

N-TYPE DOPING

14
Si
Silicon

Group IV Semiconductor
Example: Silicon



SILICON CRYSTAL LATTICE

Doping Is Used to Change the Electrical Properties of a Semiconductor

N-TYPE DOPING

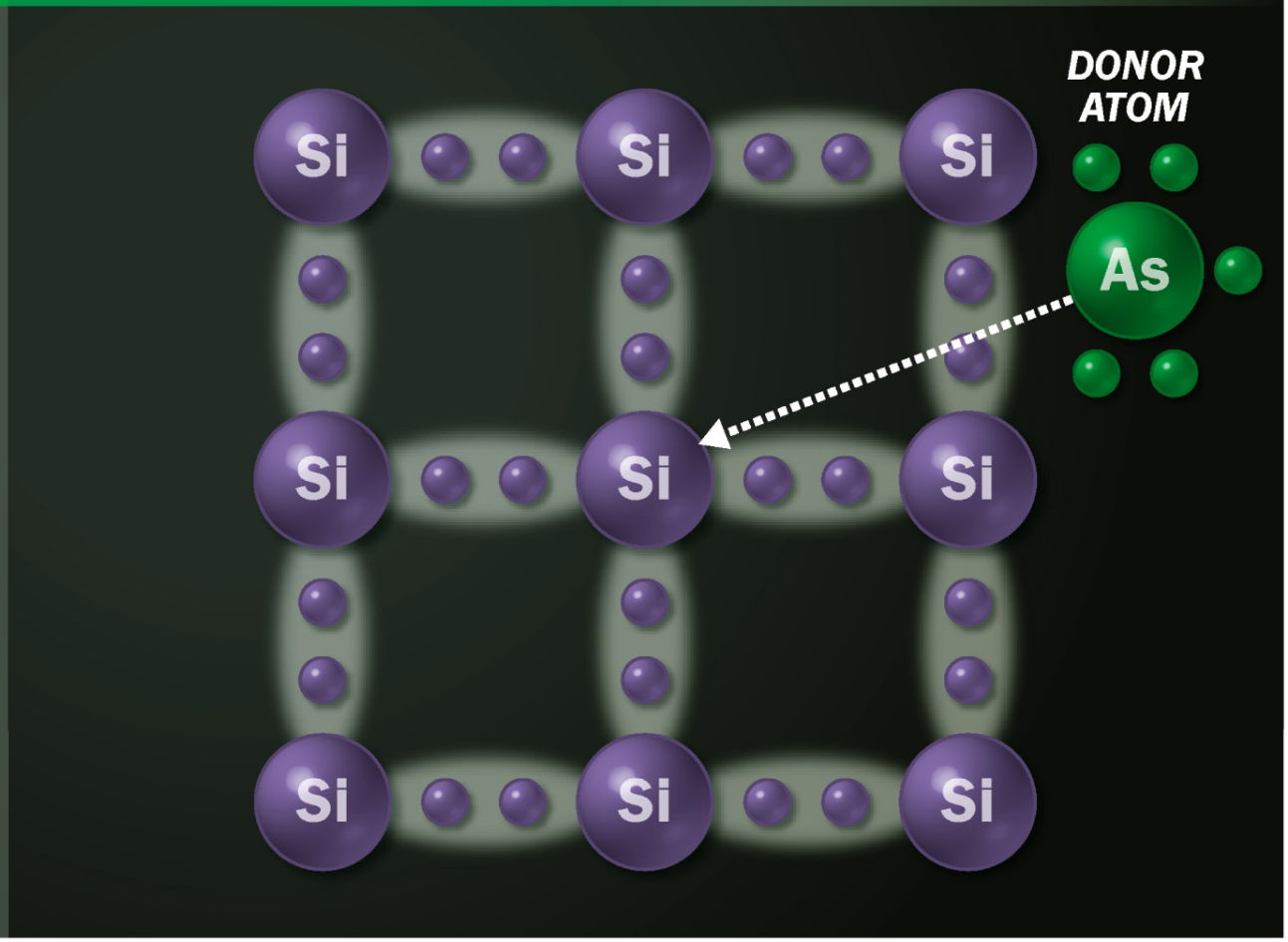
14
Si
Silicon

Group IV Semiconductor
Example: Silicon

ADD:

33
As
Arsenic

Group V Dopant Element
Example: Arsenic



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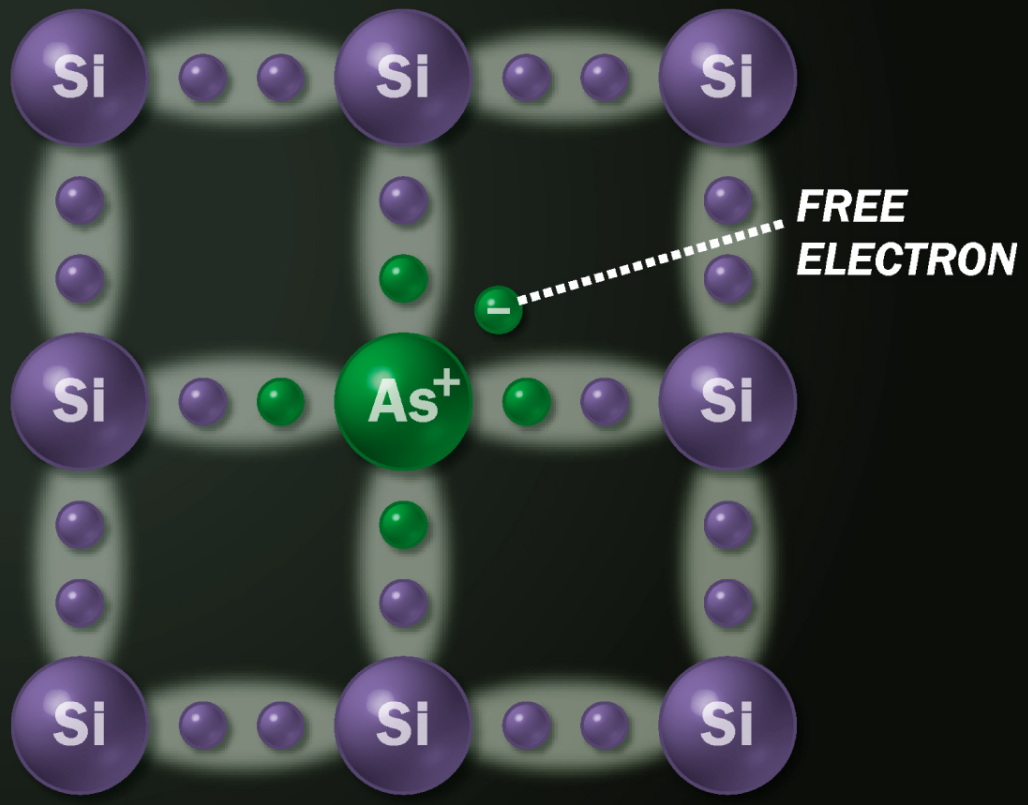
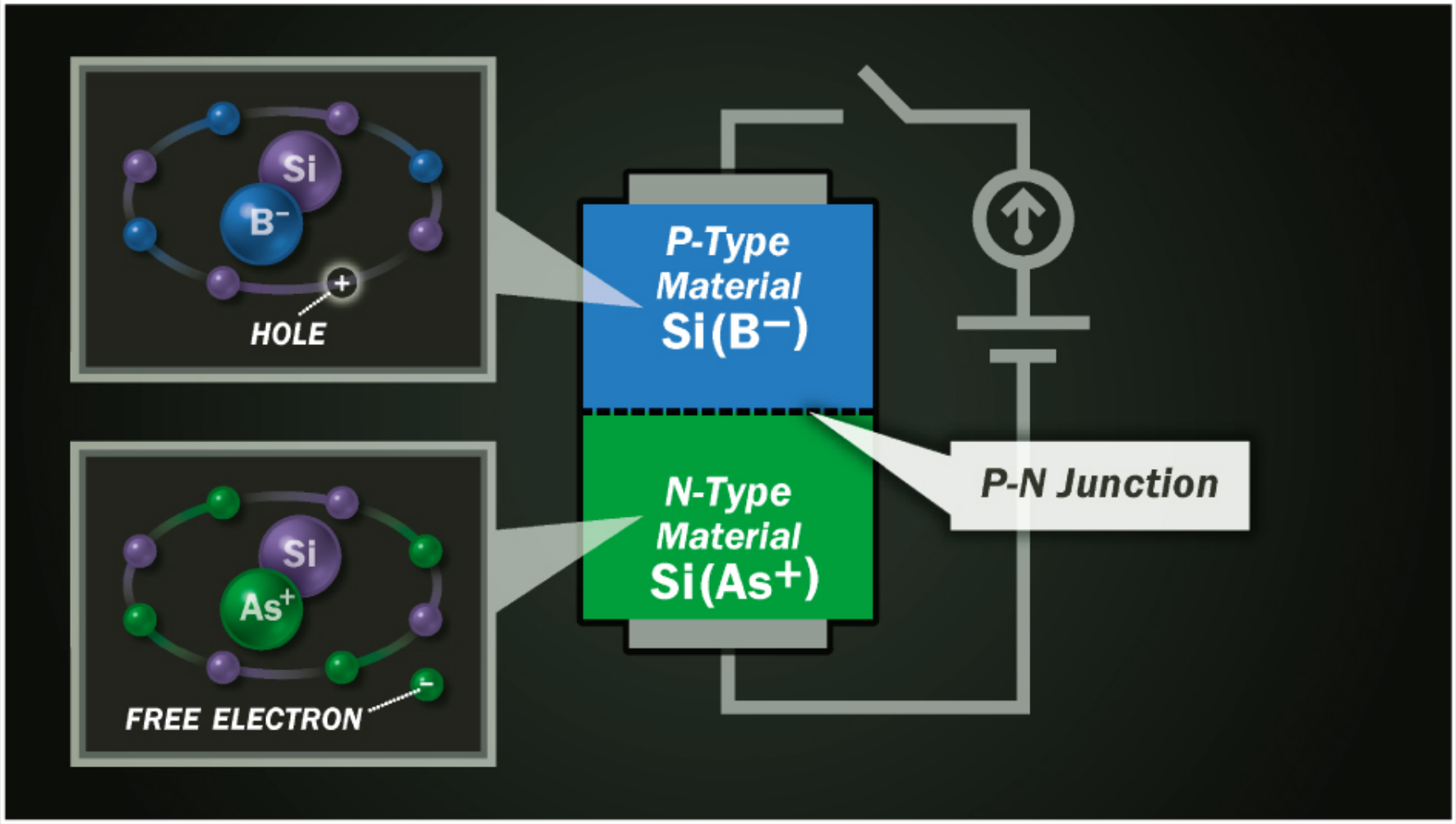


Example of an Ordinary Semiconductor Diode
(Doping)



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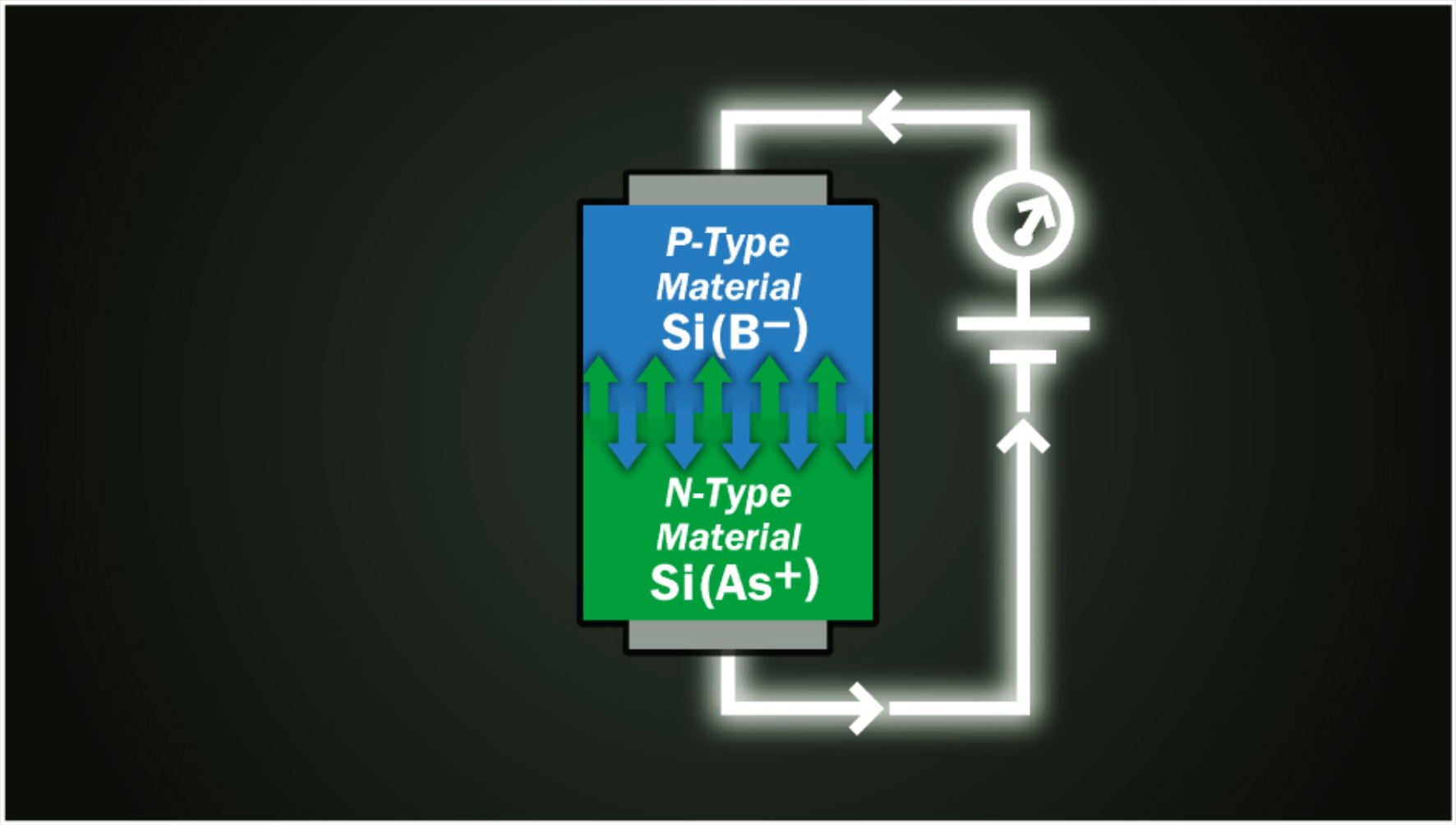
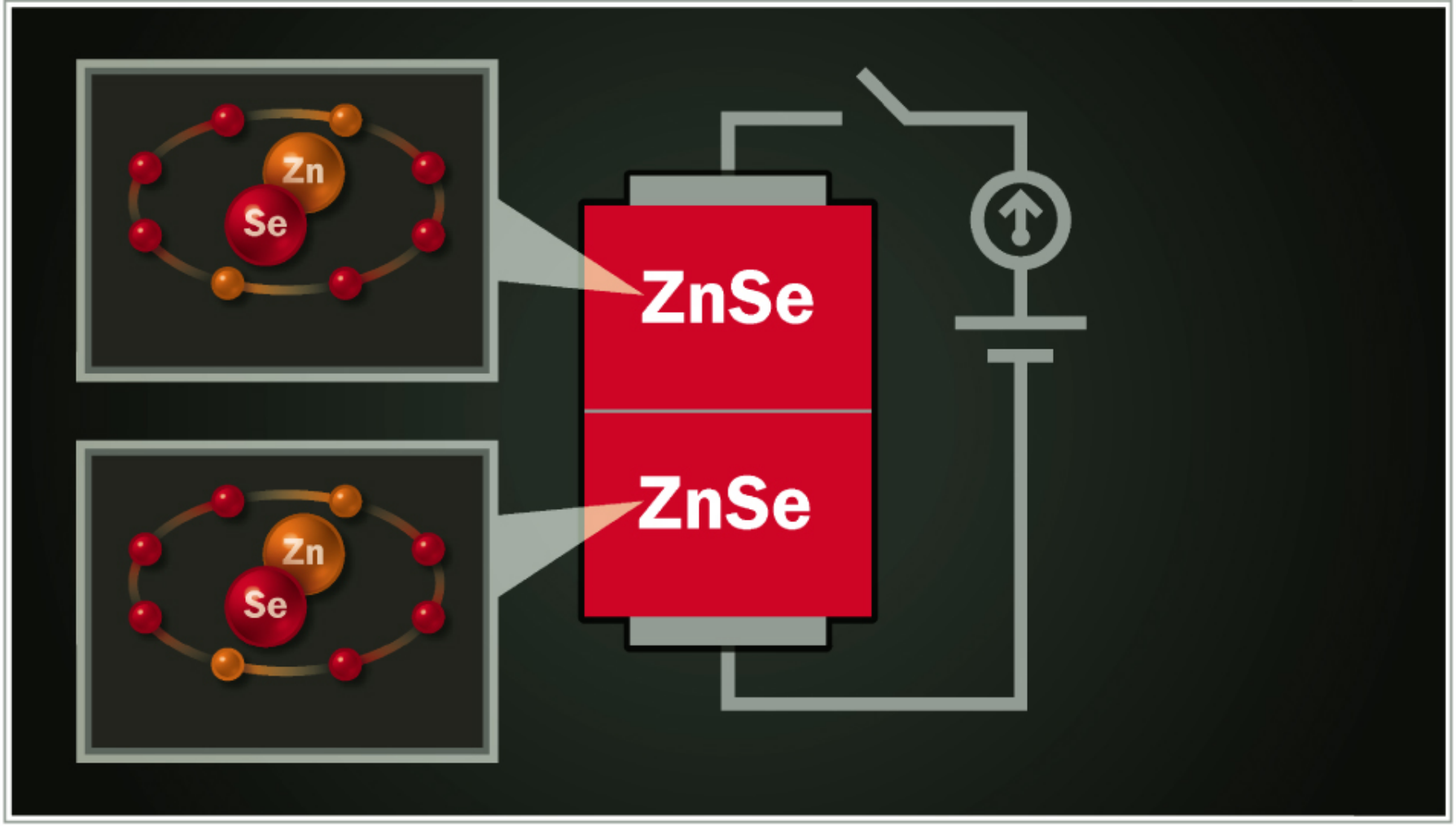
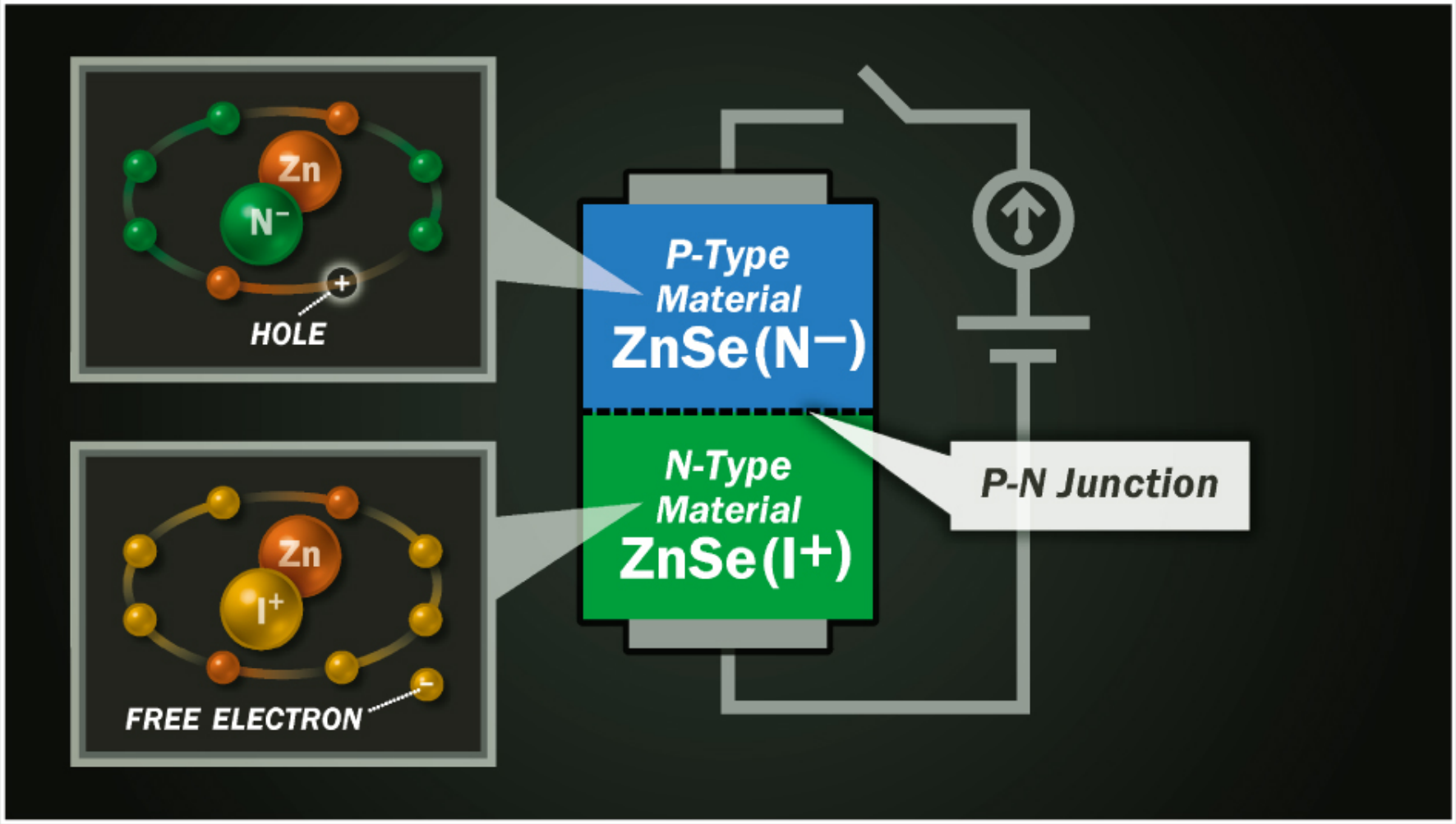


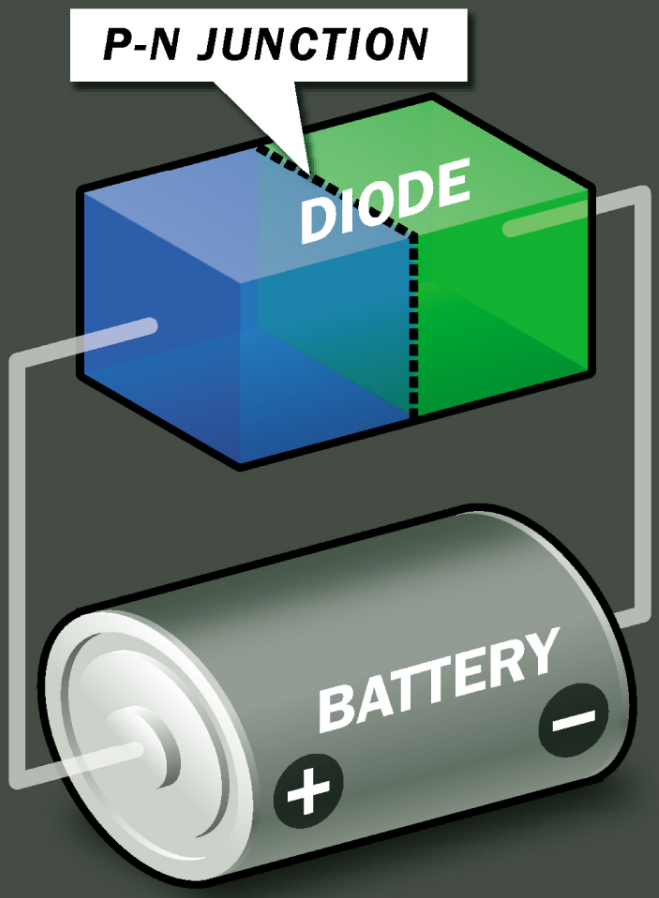
Wide Band-Gap Semiconductor Diode
(Before Doping)



Wide Band-Gap Semiconductor Diode
(Doping)



The P-N Junction and Light Emission



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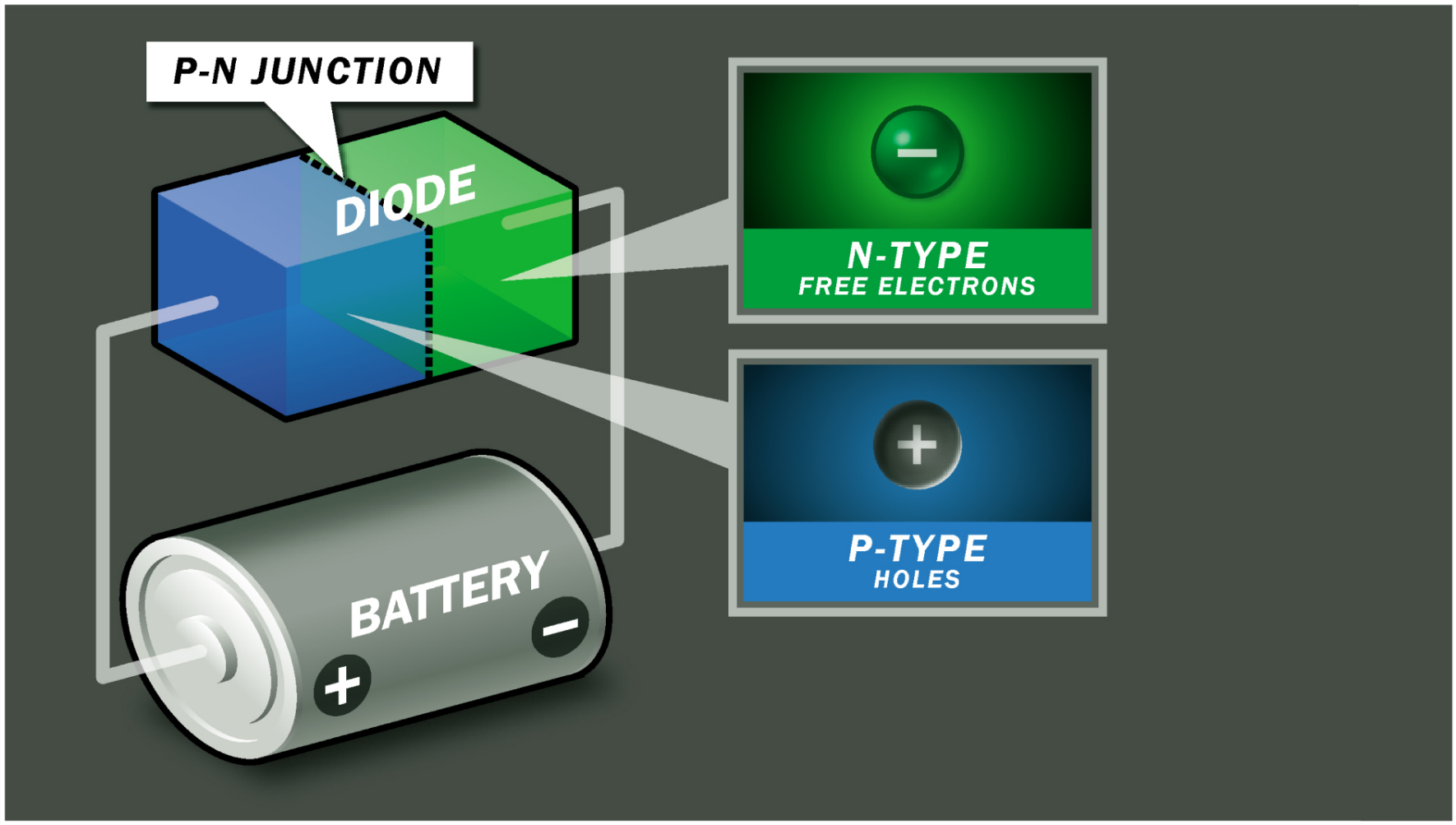

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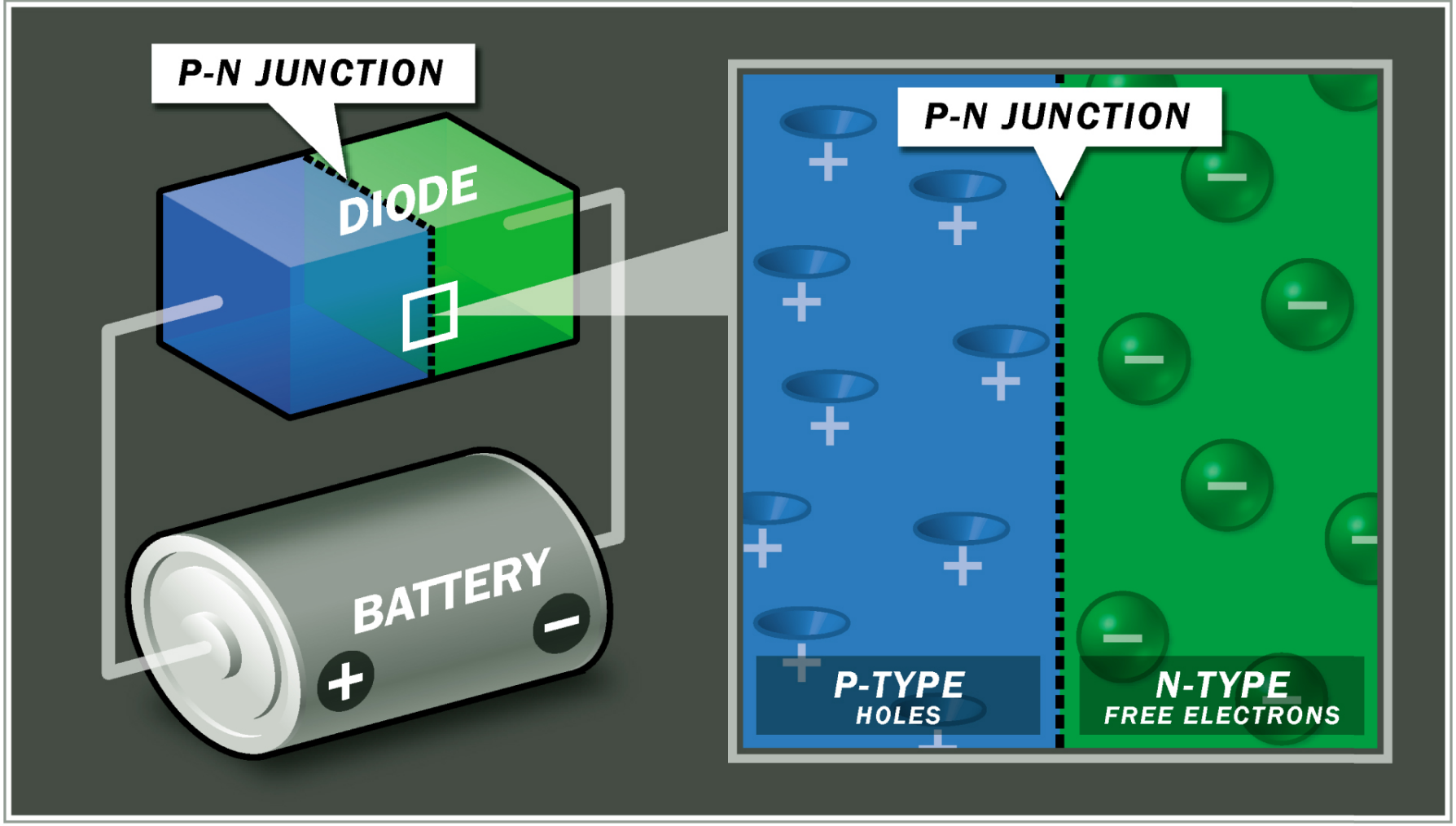
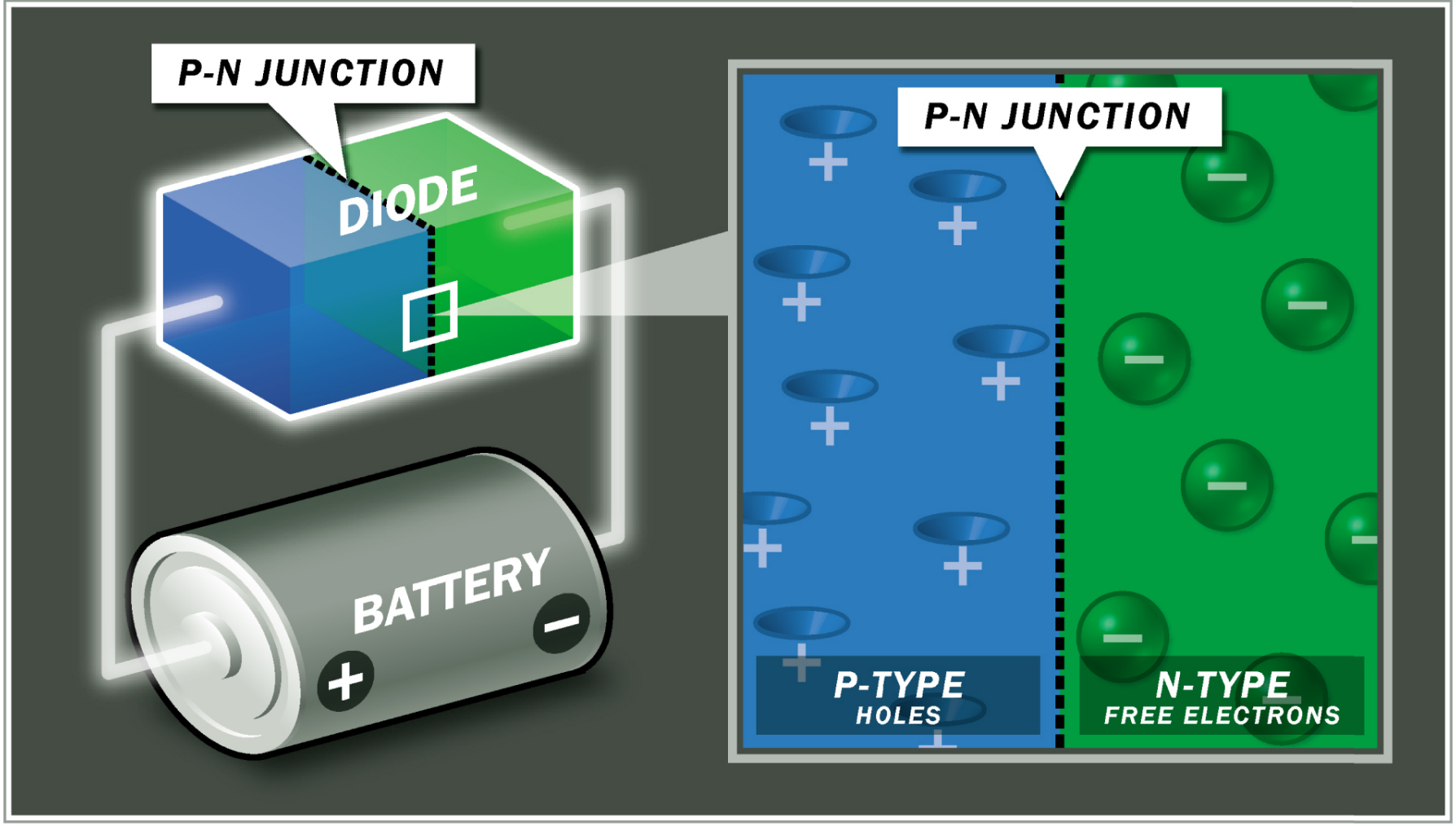


The P-N Junction and Light Emission

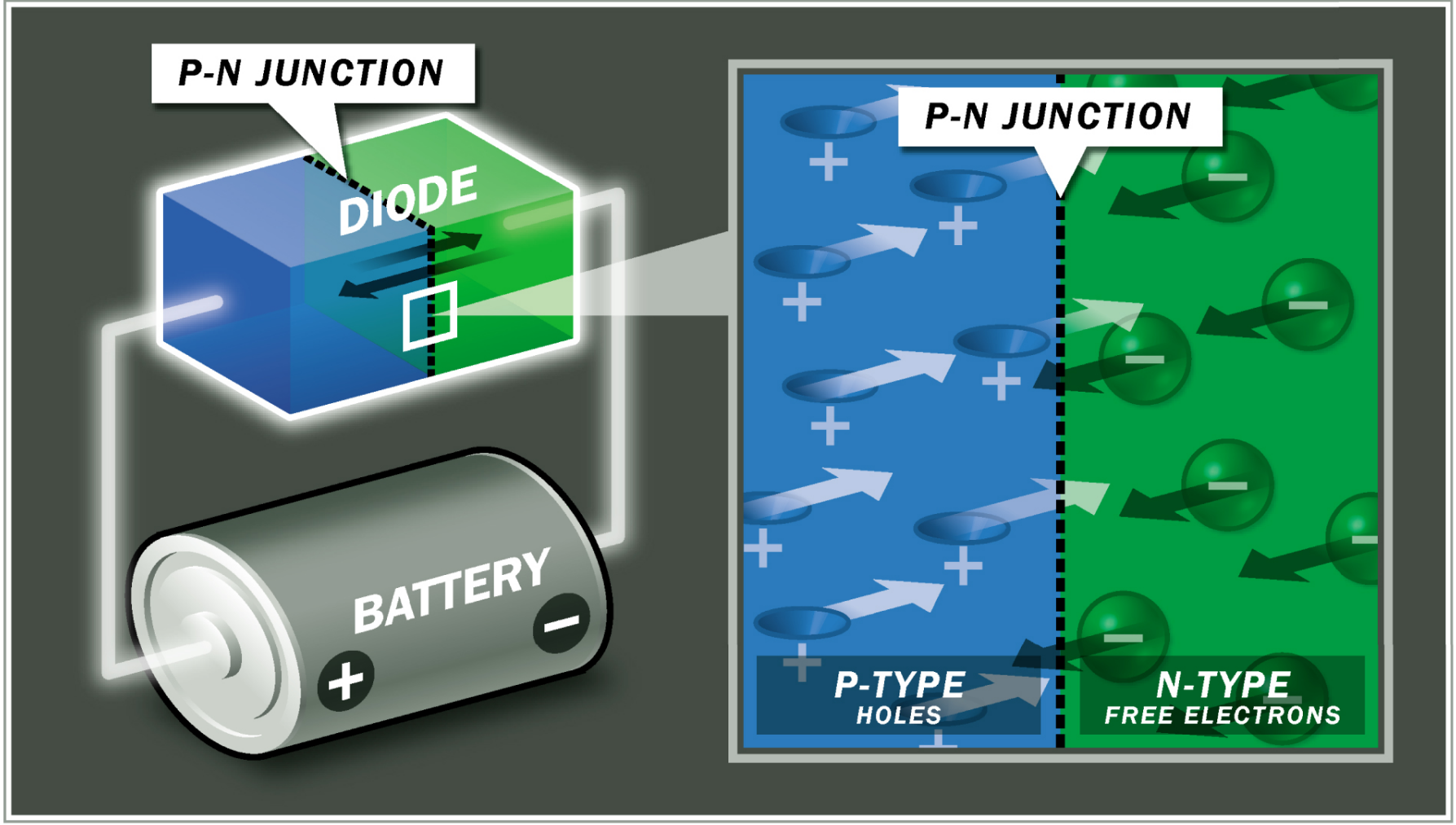
Current flows from battery.



The P-N Junction and Light Emission

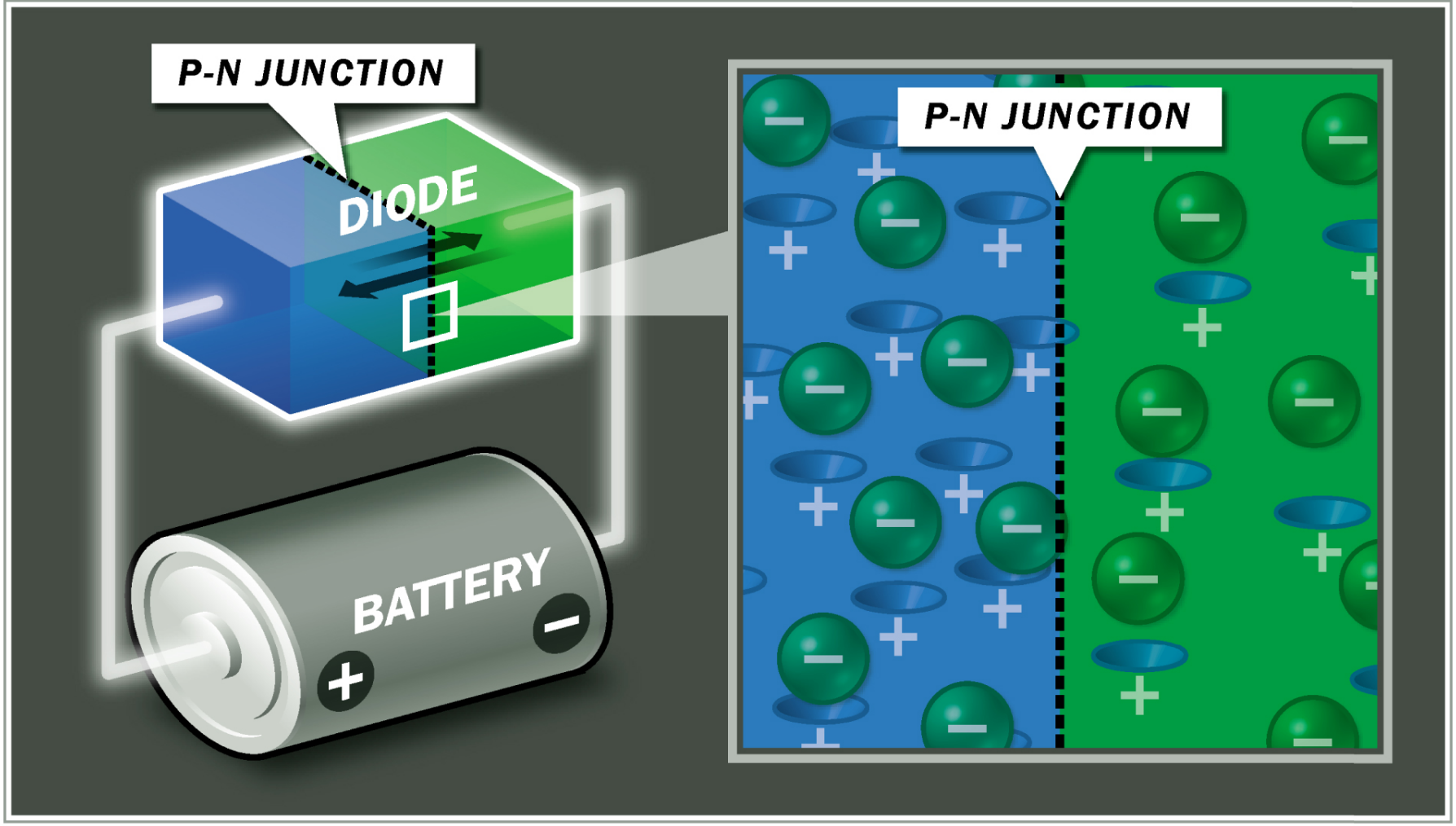
***HOLES** move toward **FREE ELECTRONS** across P-N Junction.*

***FREE ELECTRONS** move toward **HOLES** across P-N Junction.*



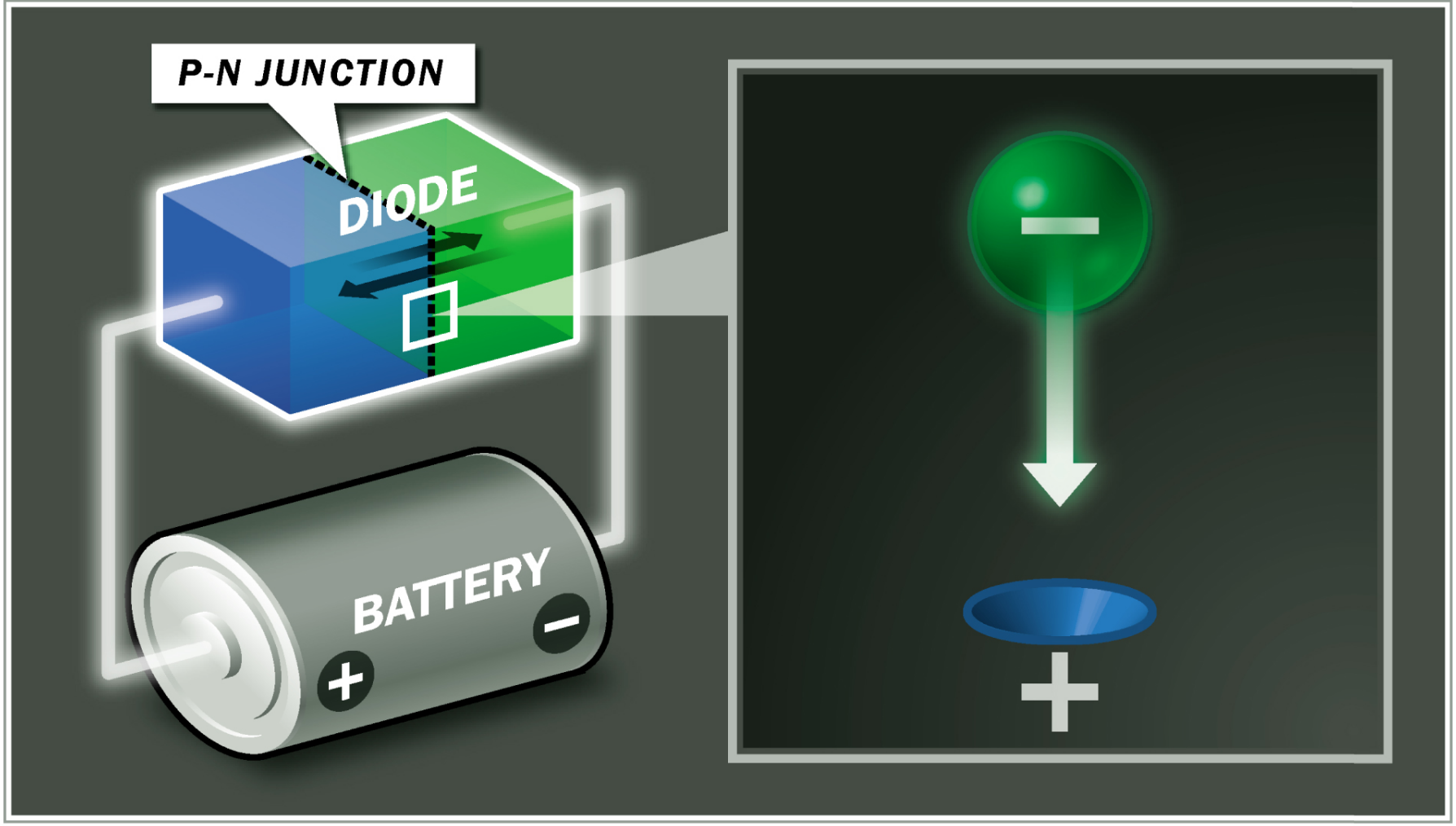
The P-N Junction and Light Emission

HOLES** exist at a lower energy orbital than **FREE ELECTRONS.



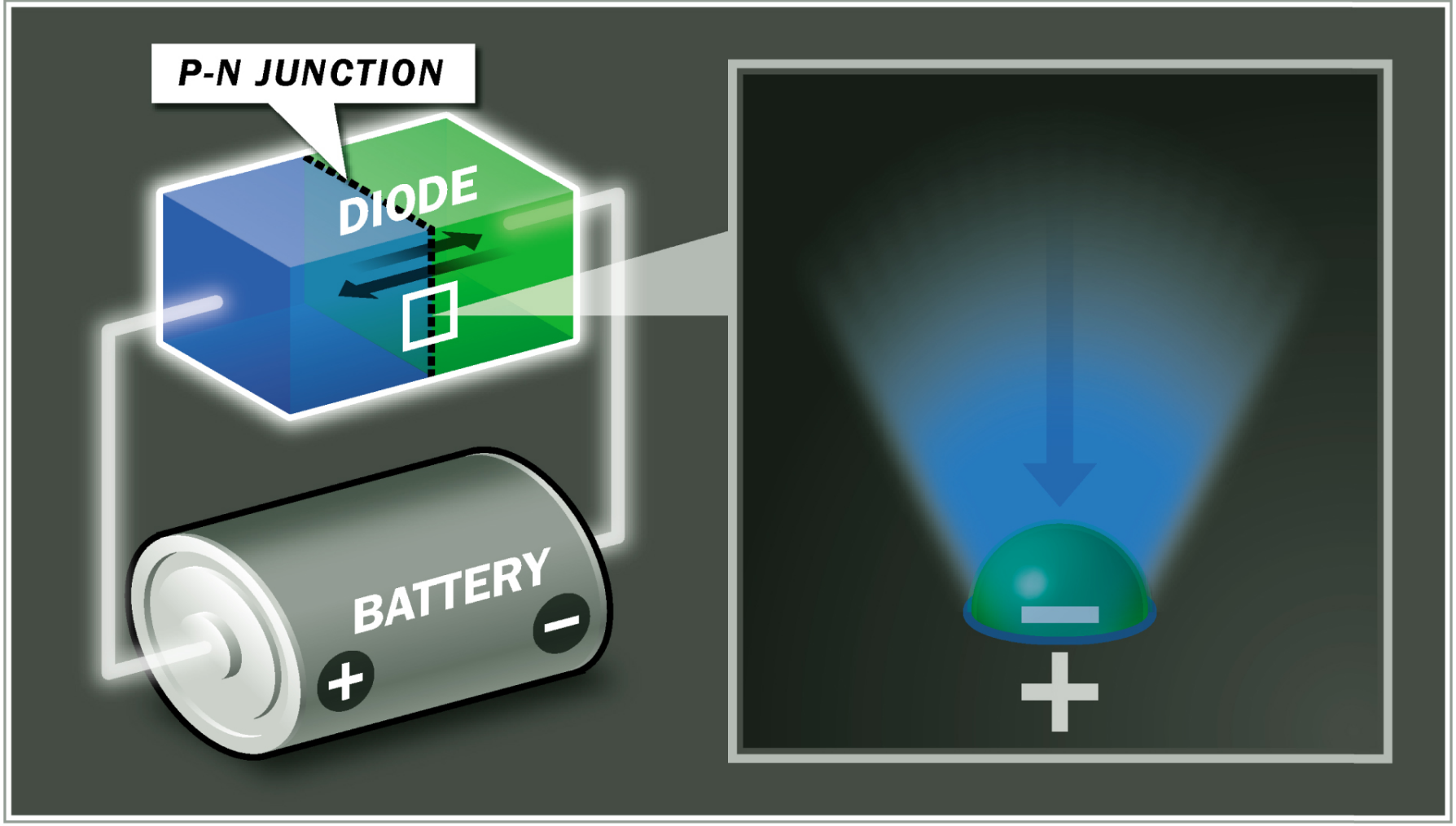
The P-N Junction and Light Emission

*When a **FREE ELECTRON** "falls into a **HOLE**", it loses energy, which is emittted as a light photon.*



The P-N Junction and Light Emission

A greater energy drop (bigger "fall") releases a higher-energy photon which is characterized by a higher frequency.



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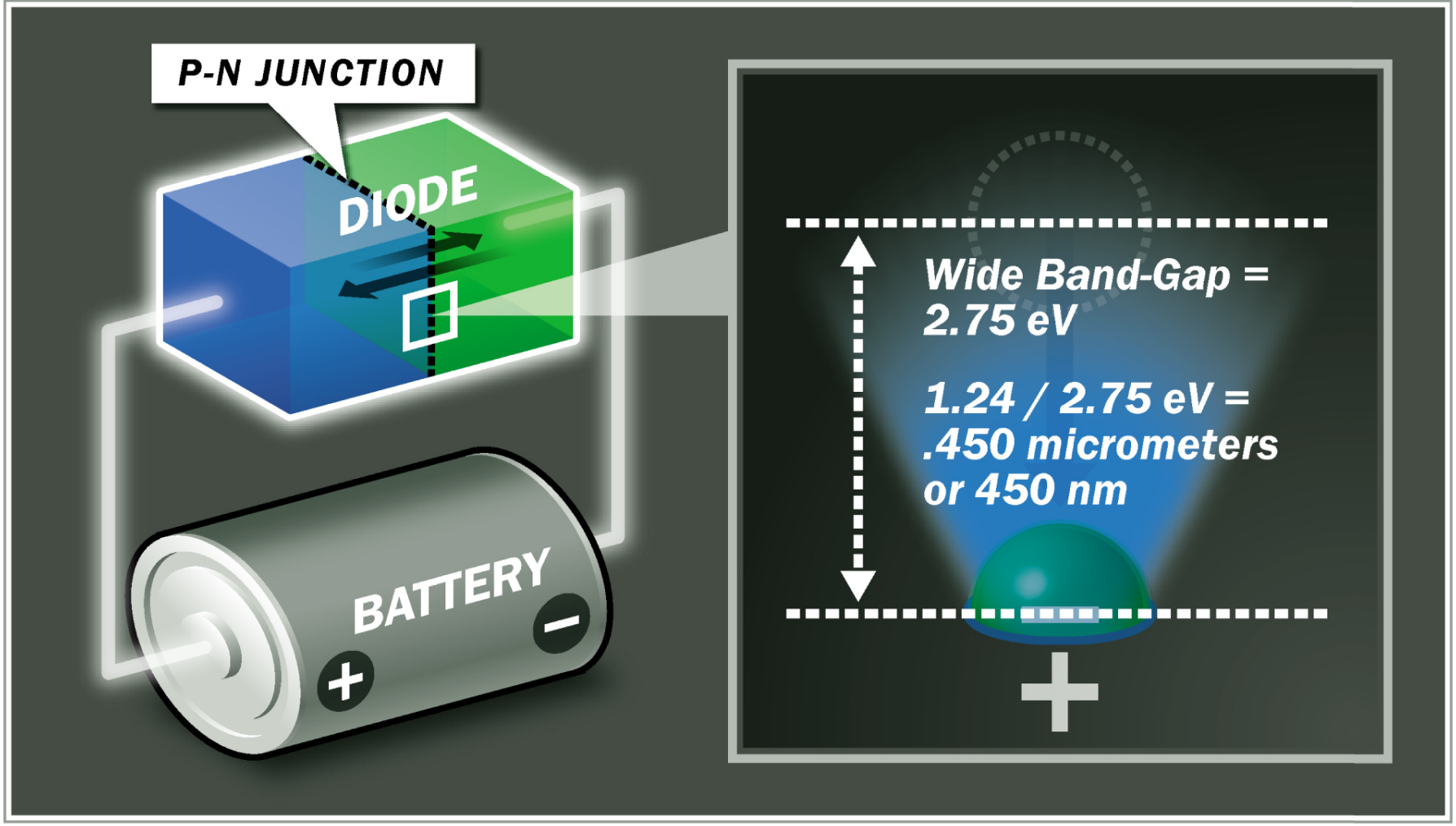
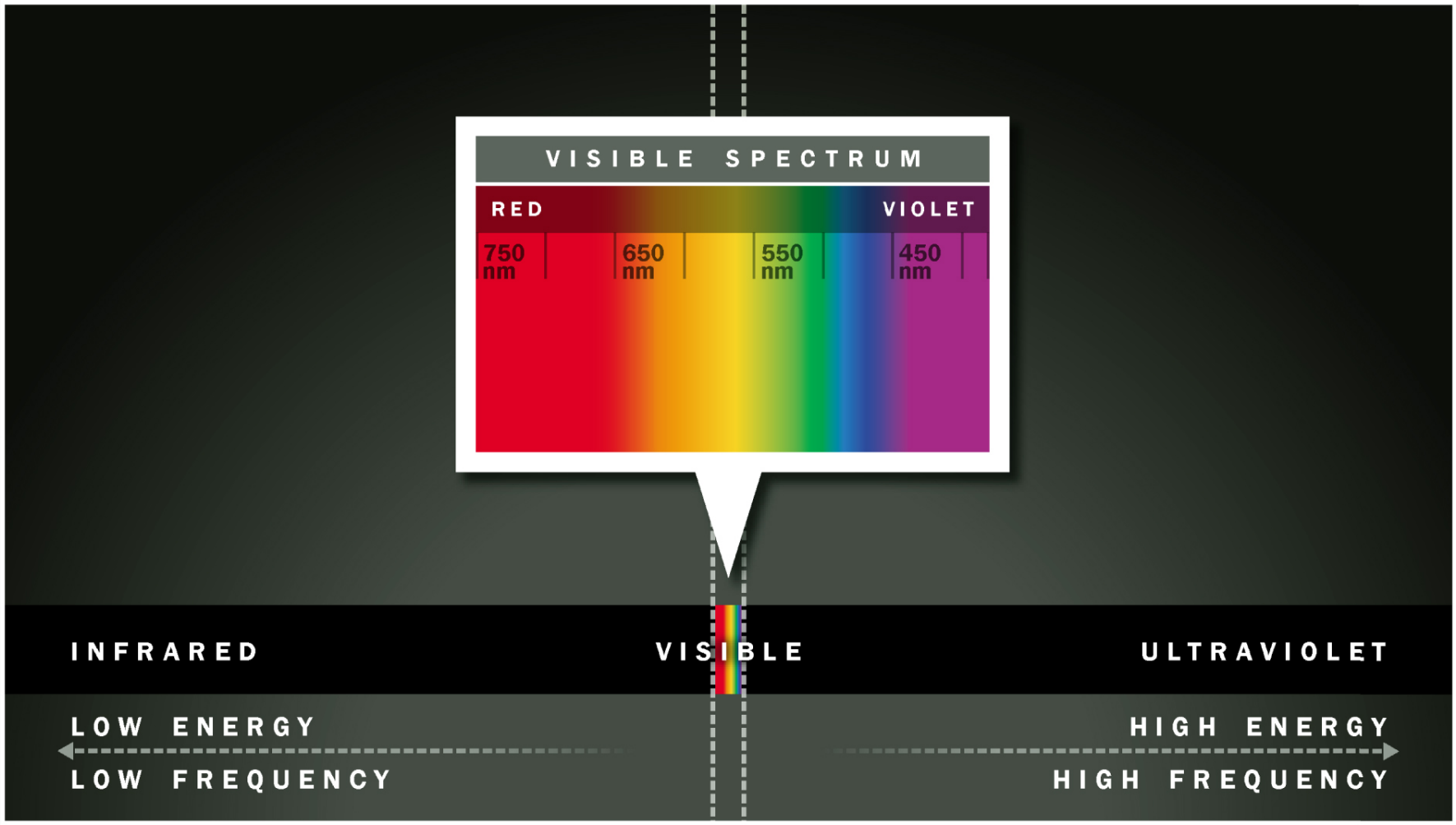


The Light Spectrum and Visible Light



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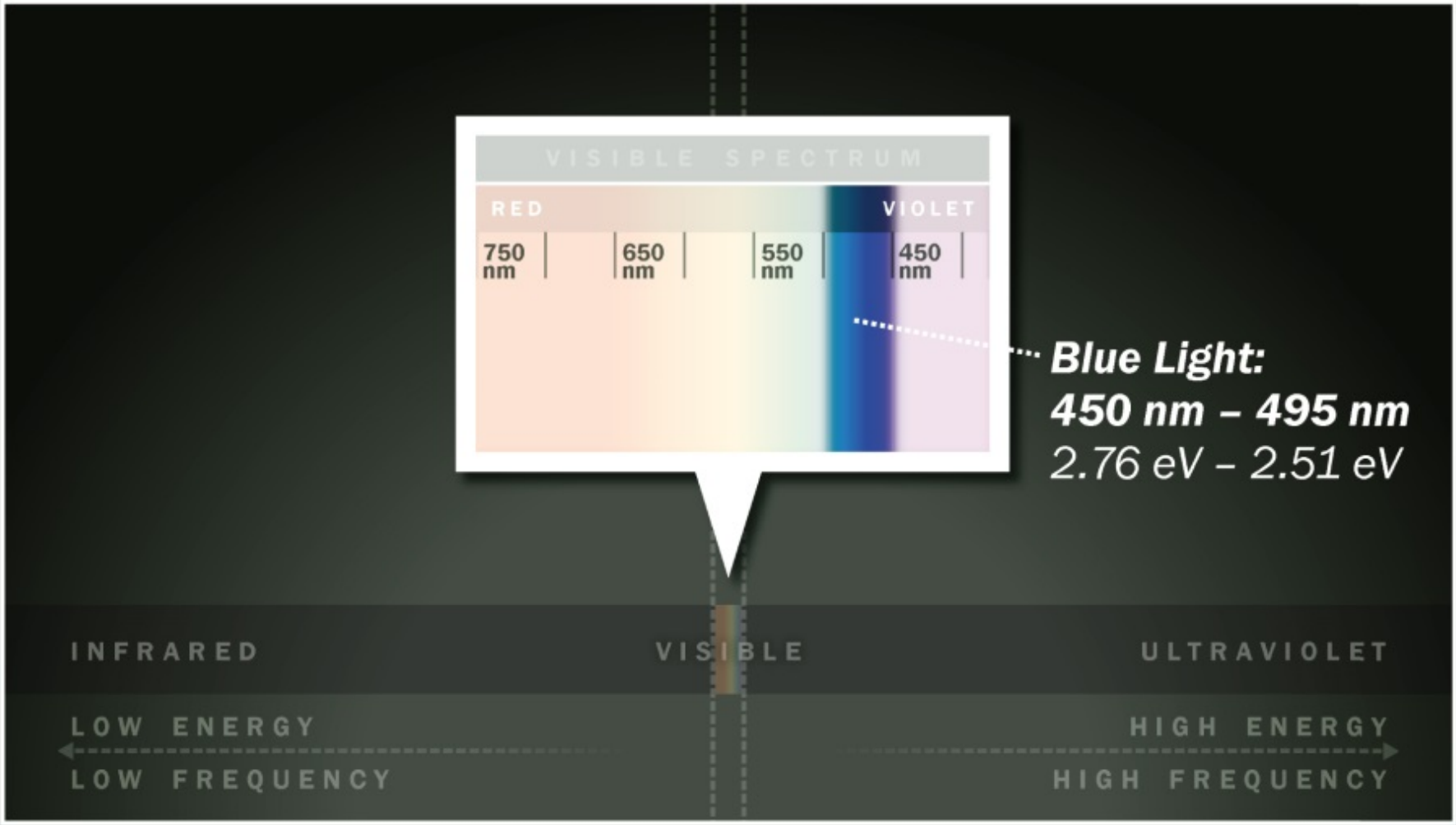
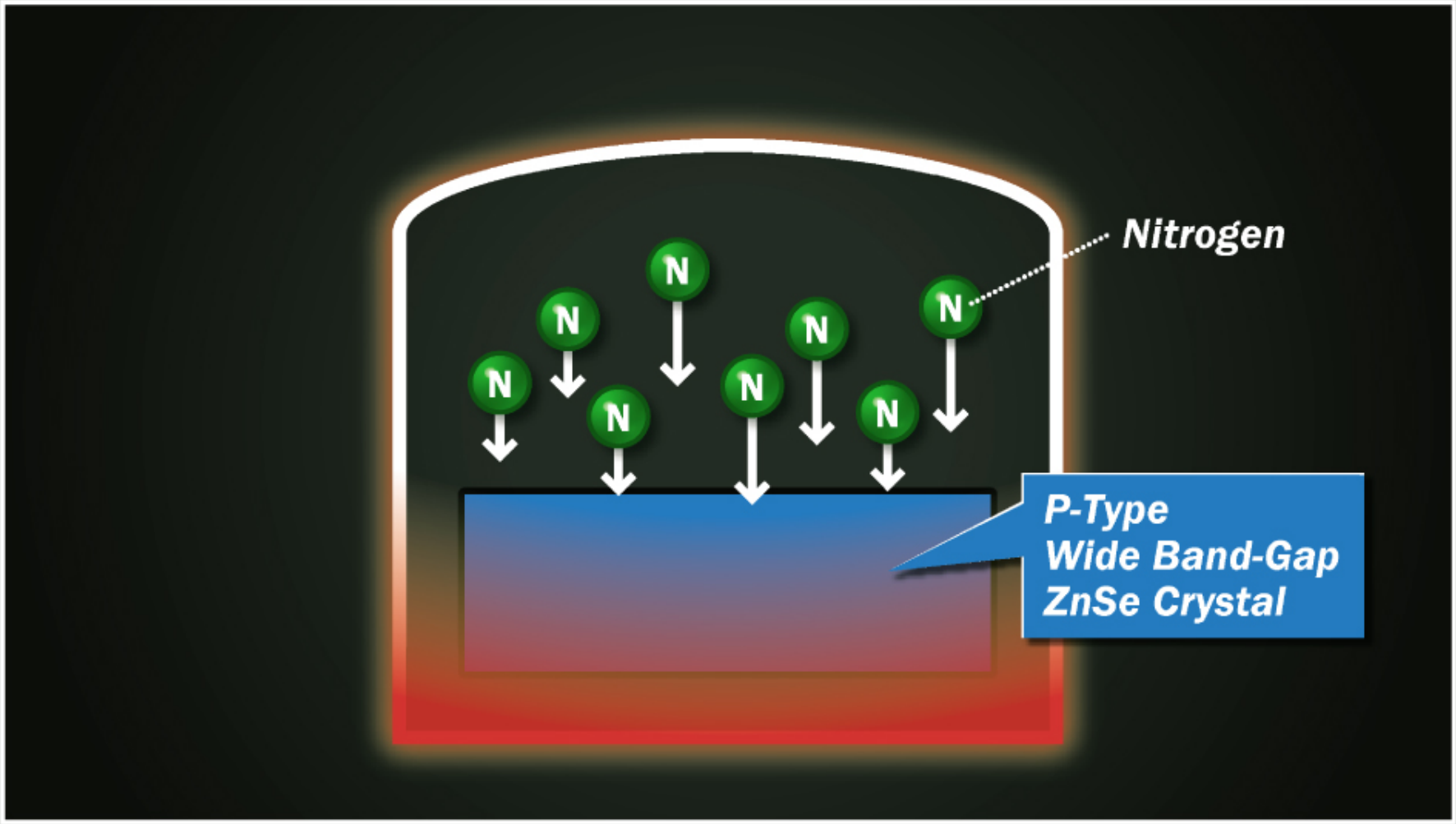
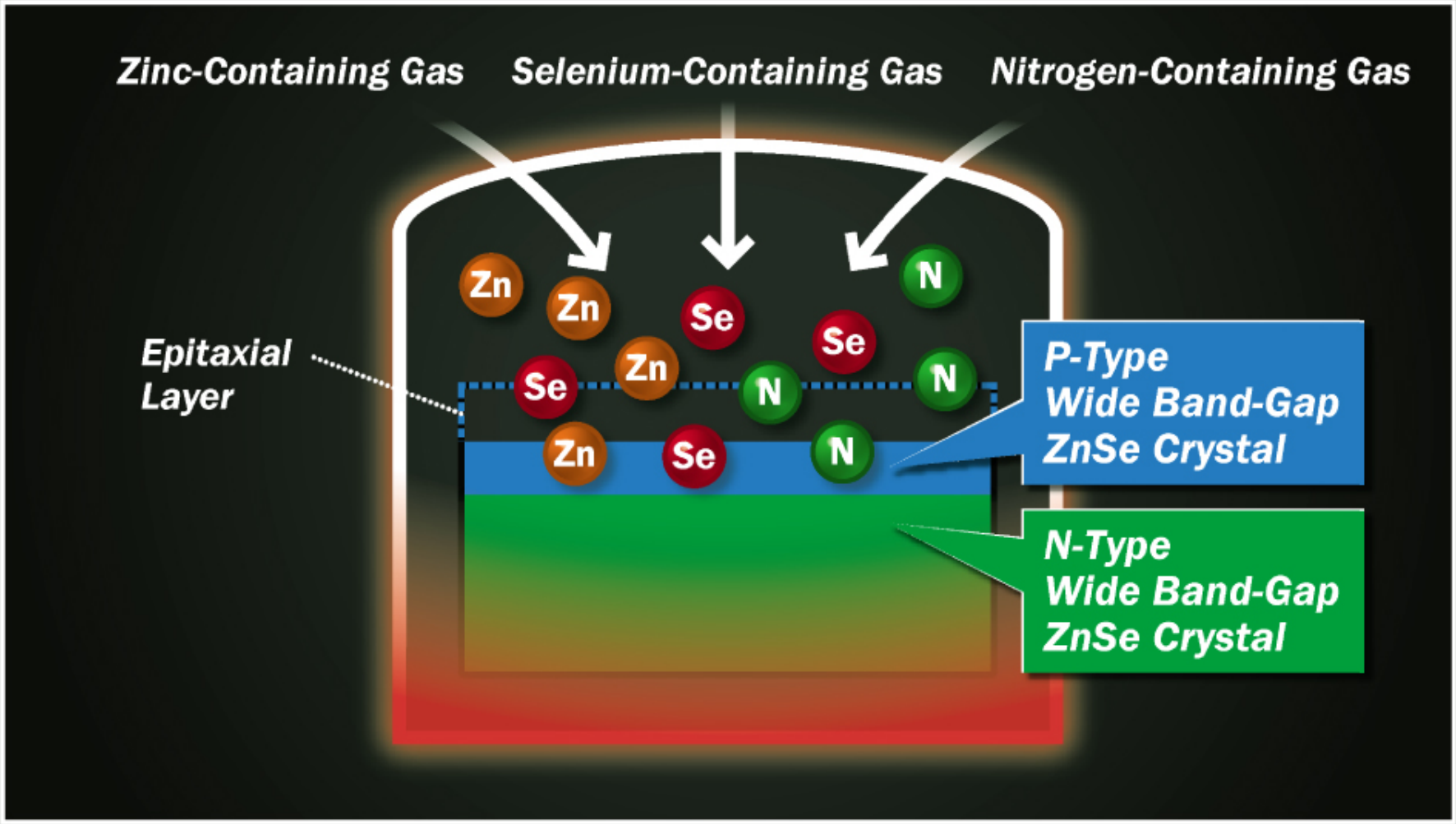


Doping Methods:

Diffusion or Implantation into an Existing Wide Band-Gap Crystal

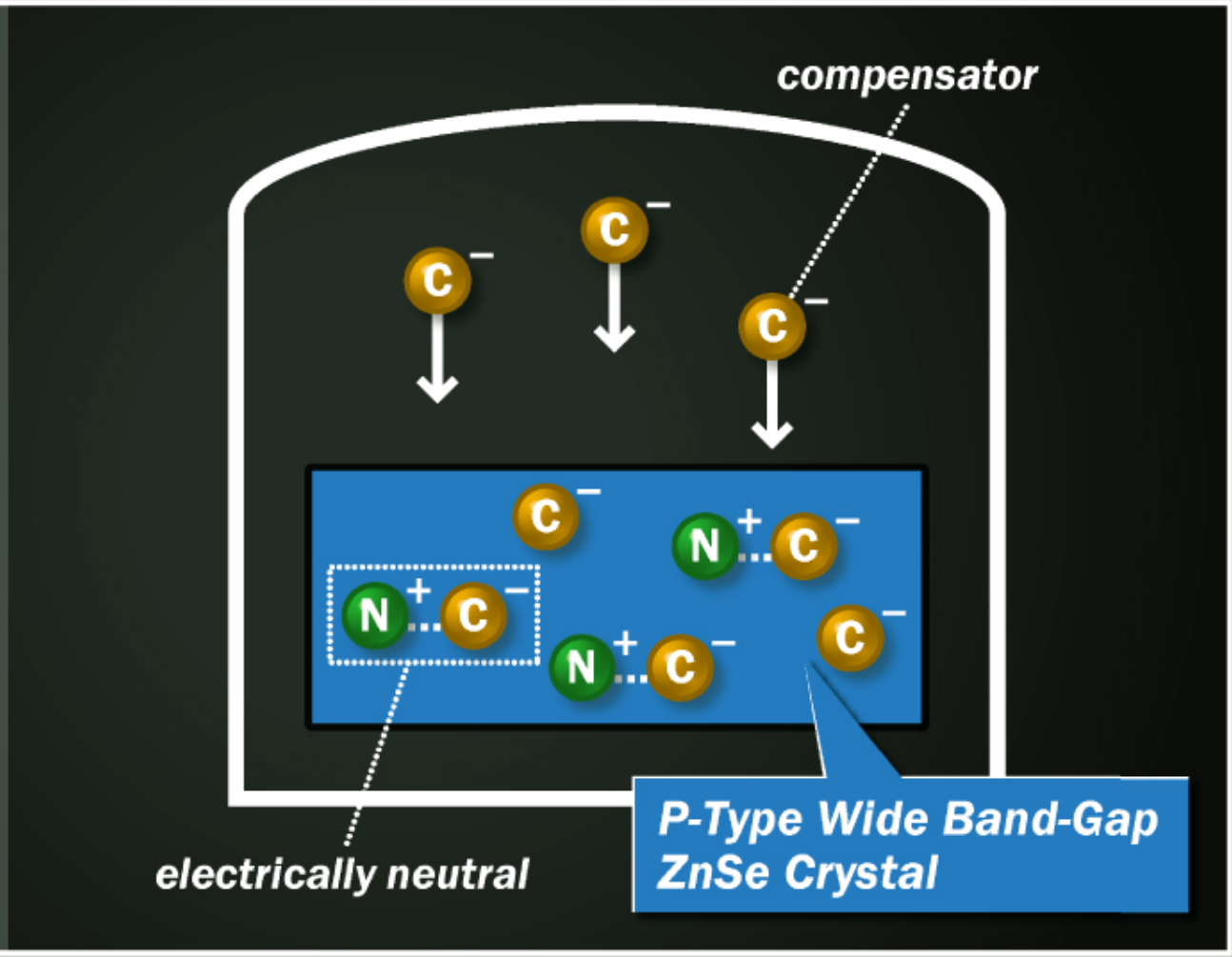


Doping Methods:
Growth (MOCVD)



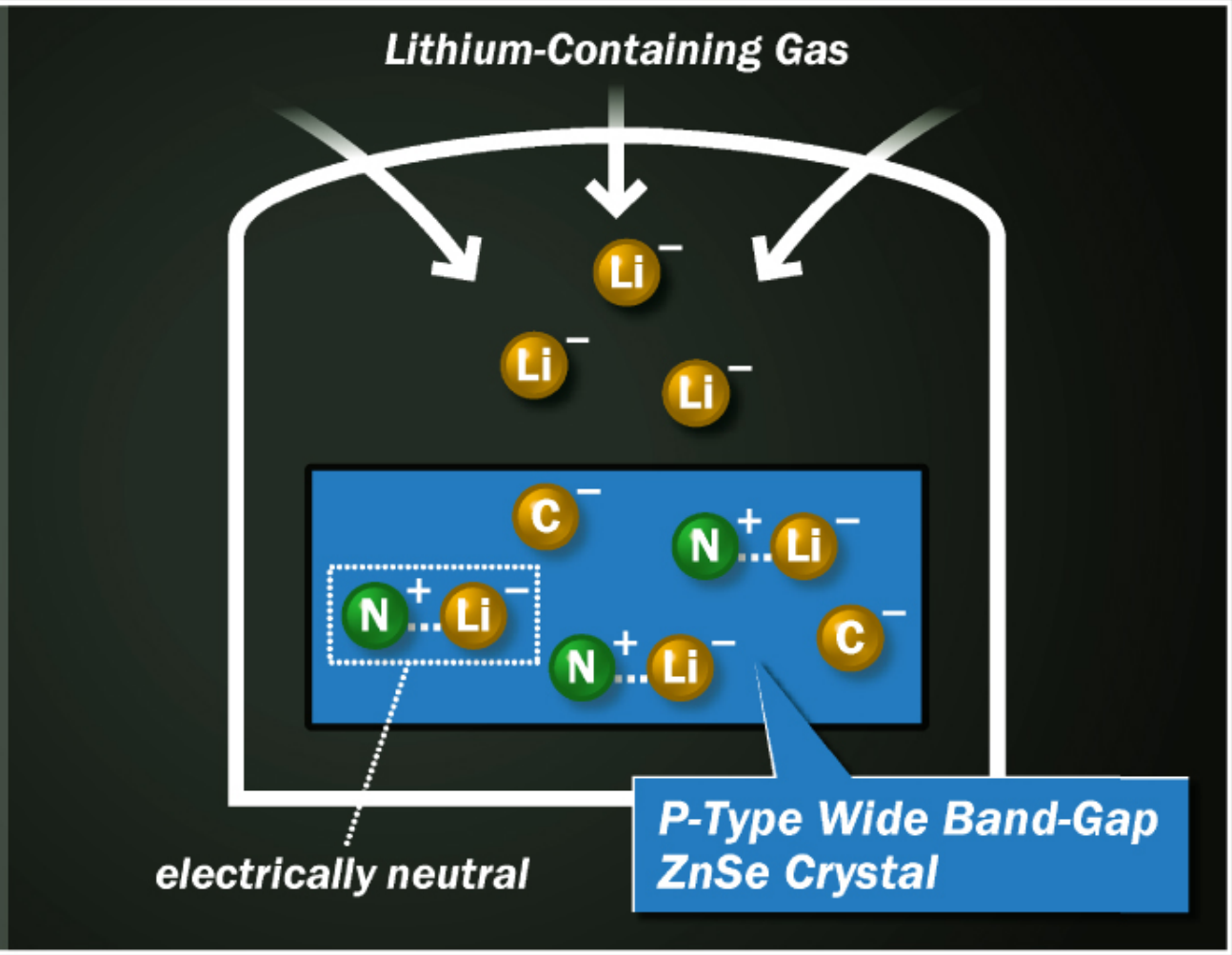
The Problem According to Dr. Neumark

Compensator impurities neutralize the dopant.



The Solution According to Dr. Neumark — Part 1

Add lithium ('618 Patent) or hydrogen ('499 Patent) to P-type crystal material.



The Solution According to Dr. Neumark — Part 2

Heat to remove lithium.