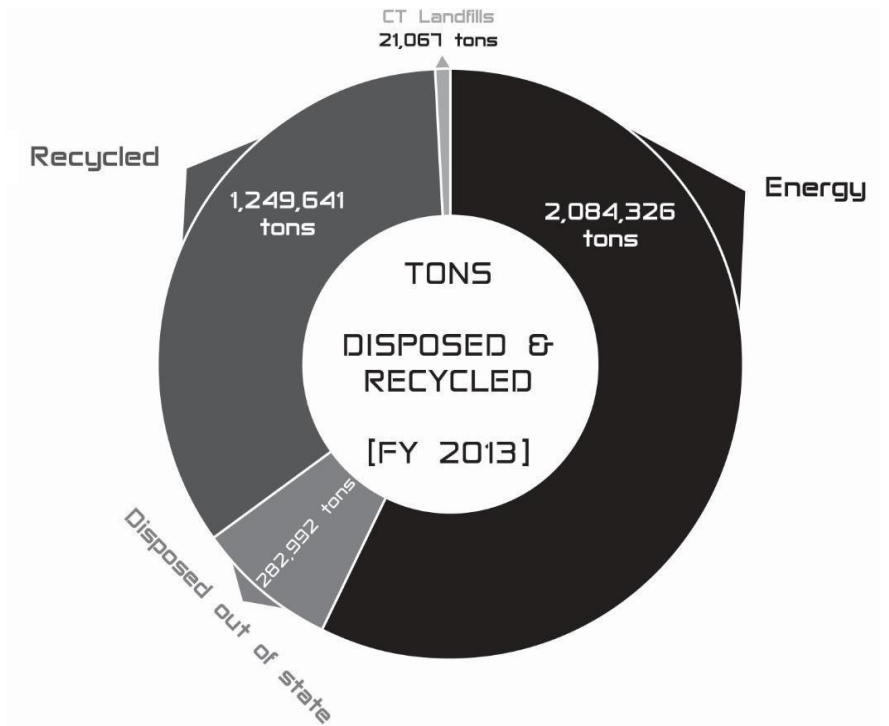
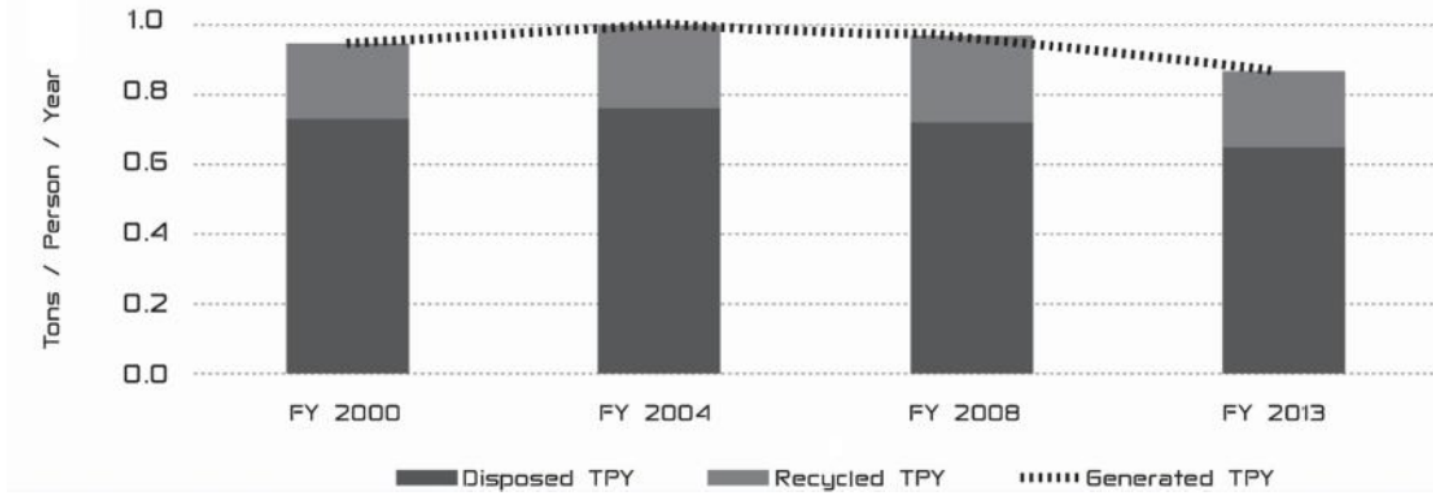


Green Cities and Garbage Death Rays



Connecticut Comprehensive Materials Management Strategy 2016 Highlights



- Connecticut disposes over 2 million tons of trash and nearly 1 million tons of Construction and Demolition Waste each year.
- Connecticut recycles 1.25 million tons, or about 35% of the total discarded material. This is close to the national average as estimated by the U.S. Environmental Protection Agency.
- 40% of disposed trash consists of organic materials that could be composted.
- Approximately 25% of municipal solid waste is packaging.
- Recycling saves taxpayers and businesses an estimated \$75 million in avoided disposal fees each year.
- Each CT resident produces an average of 1,300 pounds of waste per year.
- 87% of CT disposed MSW goes to CT's 5 waste-to-energy plants which generate electricity as a by-product. CT has the lowest rate of landfilling of any state.

[waste-to-energy plants](#)



InEnTec: Turning trash into valuable chemical products and clean fuels

Climate goals expand impact of MIT waste-processing spinoff that capitalizes on a process called plasma gasification.

Kathryn M. O'Neill | MIT Energy Initiative

January 6, 2021

▼ [PRESS INQUIRIES](#)



This InEnTec plant in Oregon will receive feedstock materials, such as medical and industrial waste, and — using InEnTec's plasma gasification process — will convert them into high-purity hydrogen for use in industry and fuel cell vehicles.

Photo: Jeffrey E. Surma/InEnTec

[InEnTec site](#)



RECYCLING WIND TURBINE BLADES



Companies seek ways to reuse
the retired giant structures
rather than bury them

MITCH JACOBY, C&EN STAFF

August 8, 2022

t = metric ton = 1000 kg
or 1.1 tons

Wind turbine blades
by the numbers

~6%

Percentage of the world's electricity
generated by wind energy in 2020

>110m

Length of today's longest wind
turbine blades

10,000–20,000

Number of wind turbine blades to be
retired in the US annually from 2030
to 2040

43 million
metric tons

Cumulative mass of all blades to be
decommissioned by 2050

Sources: International Energy Agency; Siemens
Gamesa Renewable Energy; *Waste Manage.*
2017, DOI: 10.1016/j.wasman.2017.02.007;
Resour., Conserv. Recycl. 2021, DOI: 10.1016/j.
resconrec.2021.105439.

Using shredded blades to make cement reduces the quantity of raw materials traditionally used by cement manufacturers and lowers emissions of greenhouse gases. One well-known way to reduce the CO₂ emissions is by substituting **silica-rich** materials for a portion of the limestone to make alternative types of cement.



Partially disassembled wind turbine blades arrive at Veolia North America's recycling facility in Missouri, where workers offload the decommissioned blades (left) and cut them (middle) for shredding. Veolia sends the shredded material (right) to customers who blend it with raw materials to make cement.

Recycling **fiberglass** blades to make cement

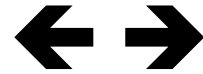
- reduces CO₂ emissions by 27% and consumption of water by 13%

Since burning the blade's resin generates useful heat, feeding a shredded 7 t blade to a kiln

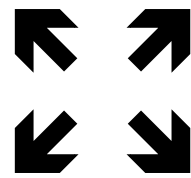
- reduces the amount of **coal** normally used by 5 t
- replaces 2.7 t of **silica**, 1.9 t of **limestone**, and nearly 1 t of additional minerals

SEMICONDUCTORS

PROPERTIES



PERFORMANCE

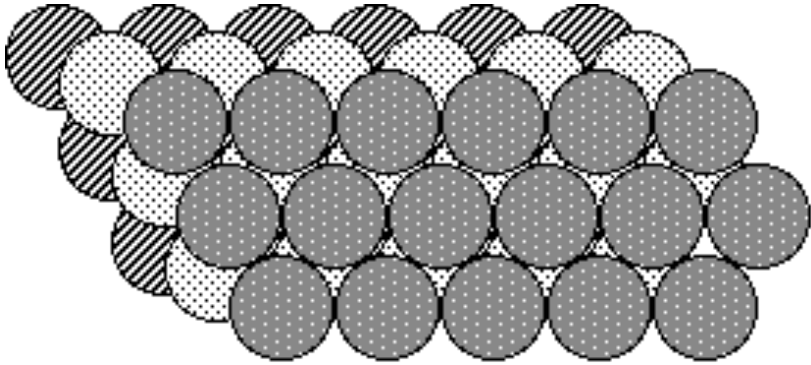


**COMPOSITION
& STRUCTURE**

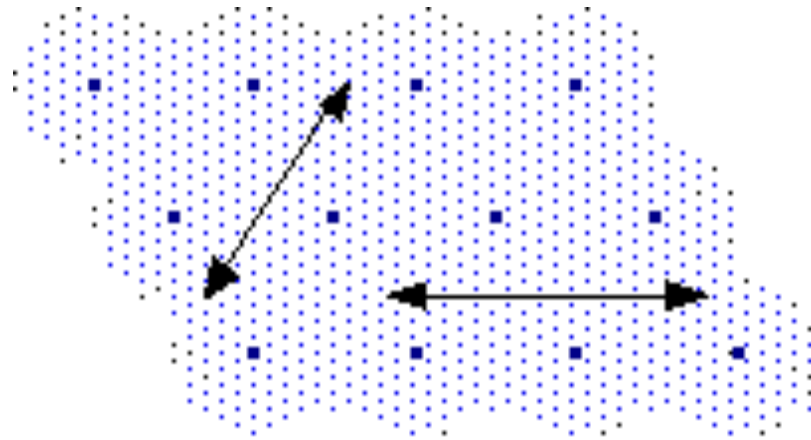


SYNTHESIS &
PROCESSING

Metals are Conductors




close packed crystals (Fig 2.2)



metallic bonds allow valence electrons to flow freely around nuclei (Fig 3.5)

Periodic Table of the Elements

	I																	VIII
1	1 H	II											III	IV	V	VI	VII	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og



 metal

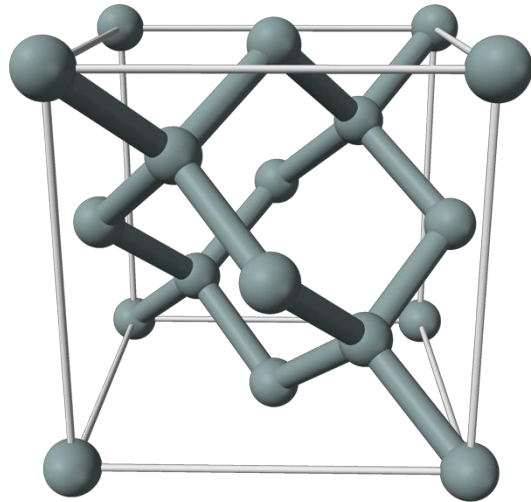
 semi-metal

 non-metal

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

Figure 1.14

Silicon is a semiconductor



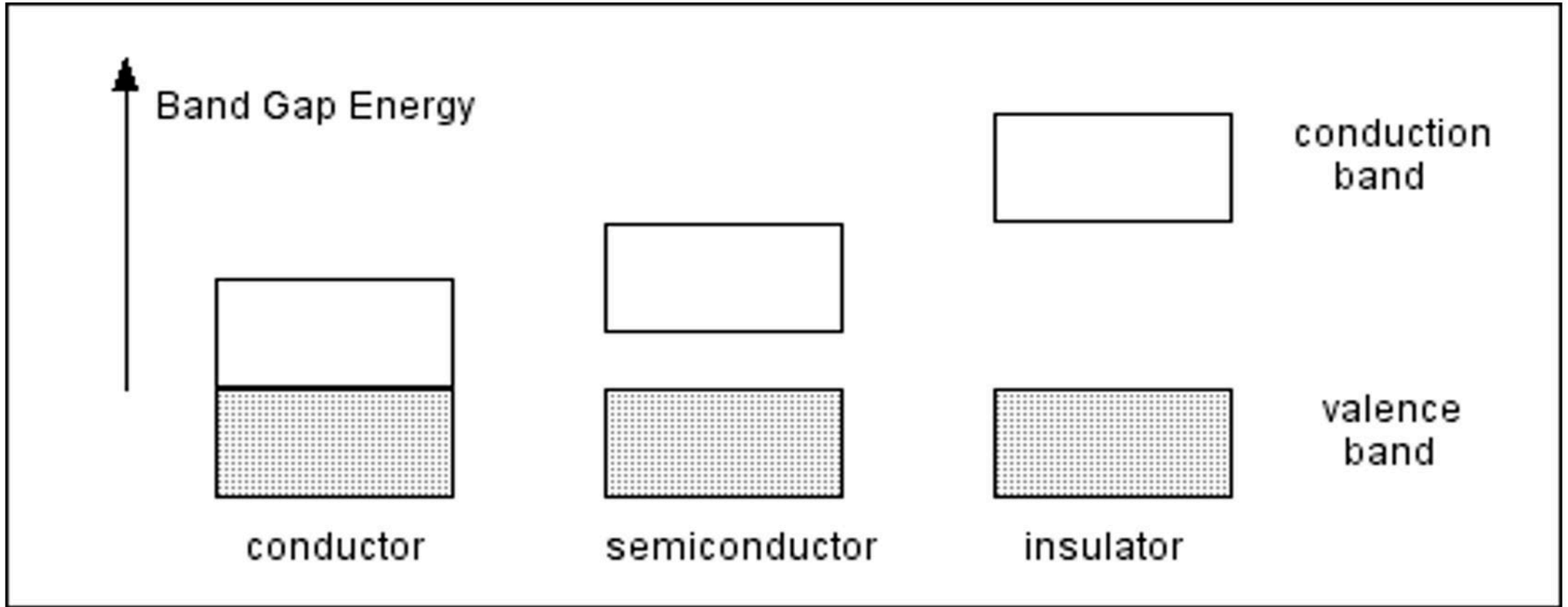


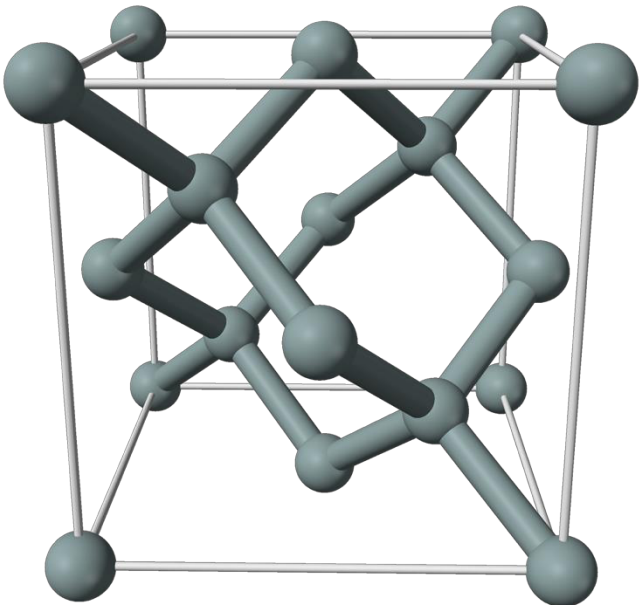
Figure 12.2 Band diagram showing electronic energy levels for different types of materials

Elements used in semiconductors																							
I	II																III	IV	V	VI	VII	VIII	
1 H																	5 B	6 C	7 N	8 O	9 F	10 Ne	
3 Li	4 Be																	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
11 Na	12 Mg																	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr						
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe						
55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn						
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og						

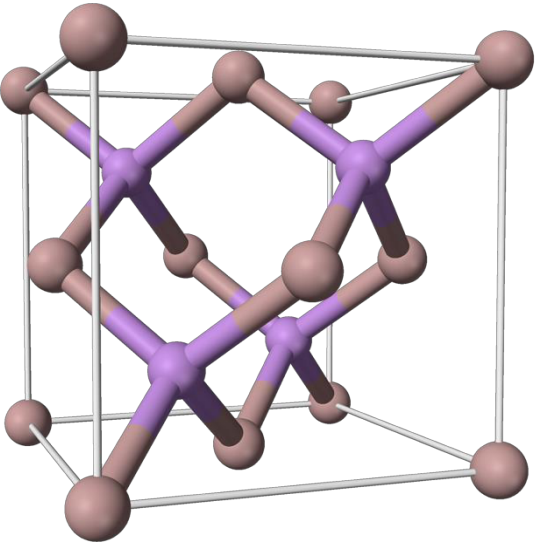
57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

Figure 12.4 The elements used in semiconductors are found on the border of metals and nonmetals

semiconductor can be a single element or a binary compound



Si or Ge



GaAs

Figure 12.3

I

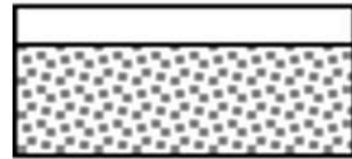
VIII

I		Elements used in semiconductors										VIII					
1	II											III	IV	V	VI	VII	2
H												B	C	N	O	F	He
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	103	104	105	106	107	108	109	110	111	112		114		116		
Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn		Fl		Lv		

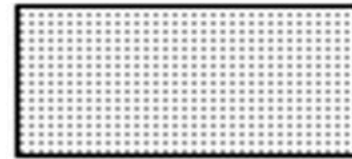
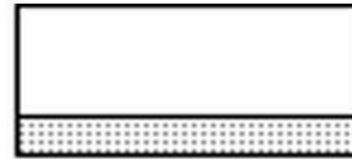
57	58	59	60	61	62	63	64	65	66	67	68	69	70
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
89	90	91	92	93	94	95	96	97	98	99	100	101	102
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No

working in a clean room





p-type

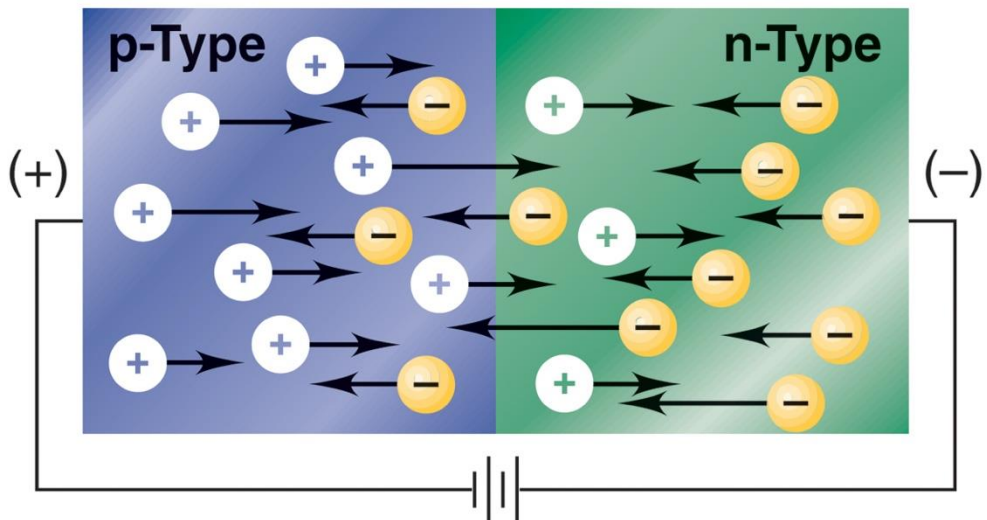


n-type

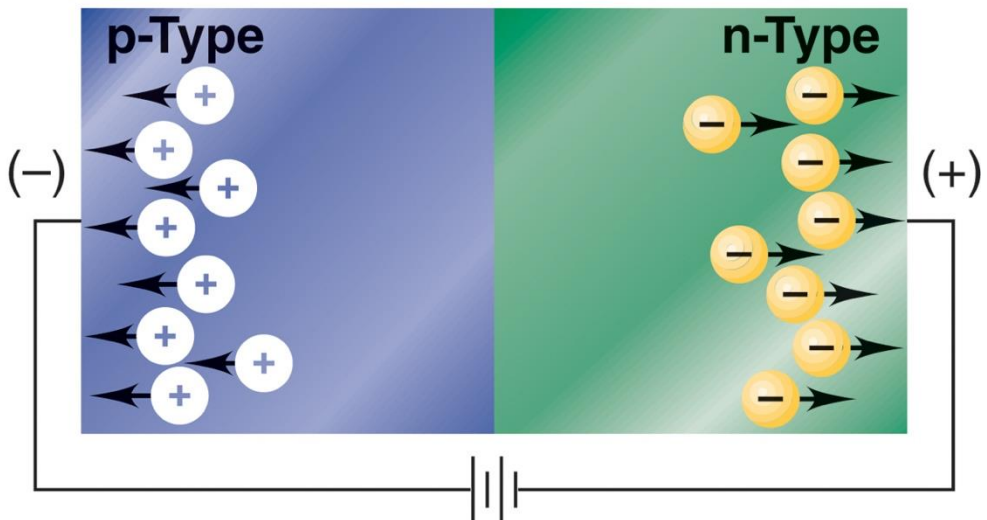
Figure 12.5 Band Diagrams for Doped Semiconductors

circuit element: diode

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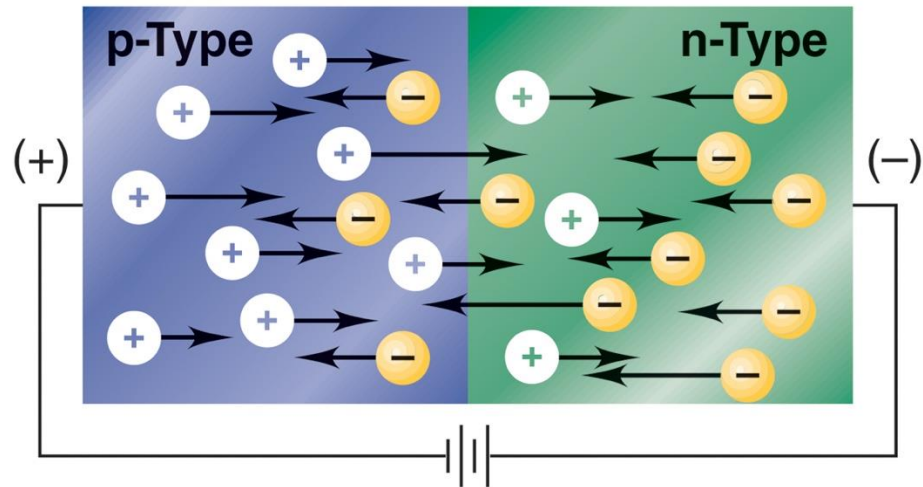
A Flow of electrons and holes creates a current.



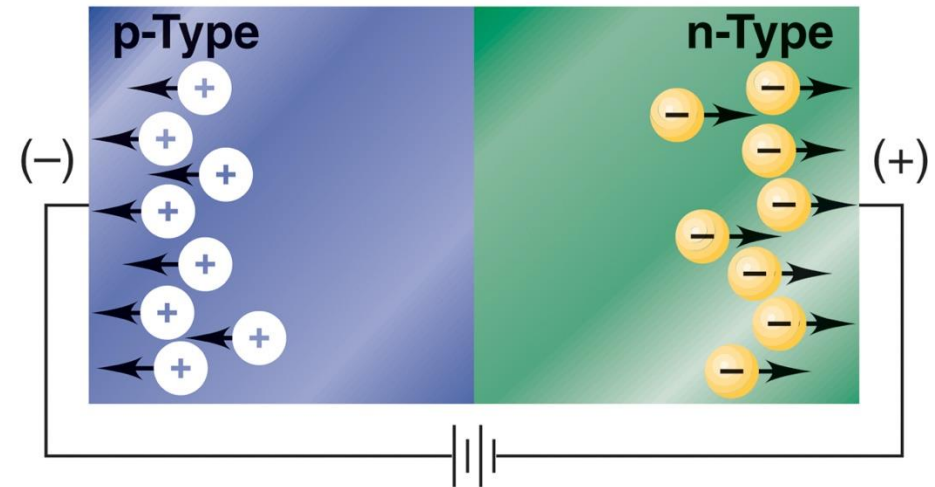
B No current.

transistors compared to diodes

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A Flow of electrons and holes creates a current.



B No current.

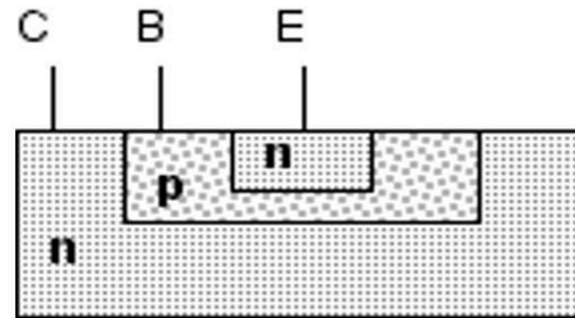


Figure 12.6 An npn transistor. C = collector, B = base, E = emitter.