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INSPIRING CREATIVE AND INNOVATIVE MINDS

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Semiconductor materials





PERIODIC TABLE OF THE ELEMENTS

<http://www.ktf-split.hr/periodni/en/>

PERIOD	GROUP	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII B	9 VIII B	10 VIII B	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA	
1		1.0079 H HYDROGEN																	4.0026 He HELIUM	
2		6.941 Li LITHIUM	9.0122 Be BERYLLIUM											10.811 B BORON	12.011 C CARBON	14.007 N NITROGEN	15.999 O OXYGEN	18.998 F FLUORINE	20.180 Ne NEON	
3		22.990 Na SODIUM	24.305 Mg MAGNESIUM											26.982 Al ALUMINIUM	28.086 Si SILICON	30.974 P PHOSPHORUS	32.065 S SULPHUR	35.453 Cl CHLORINE	39.948 Ar ARGON	
4		39.098 K POTASSIUM	40.078 Ca CALCIUM	44.956 Sc SCANDIUM	47.867 Ti TITANIUM	50.942 V VANADIUM	51.996 Cr CHROMIUM	54.938 Mn MANGANESE	55.845 Fe IRON	58.933 Co COBALT	58.693 Ni NICKEL	63.546 Cu COPPER	65.39 Zn ZINC	69.723 Ga GALLIUM	72.64 Ge GERMANIUM	74.922 As ARSENIC	78.96 Se SELENIUM	79.904 Br BROMINE	83.80 Kr KRYPTON	
5		85.468 Rb RUBIDIUM	87.62 Sr STRONTIUM	88.906 Y YTRIUM	91.224 Zr ZIRCONIUM	92.906 Nb NIOBIUM	95.94 Mo MOLYBDENUM	(98) Tc TECHNETIUM	101.07 Ru RUTHENIUM	102.91 Rh RHODIUM	106.42 Pd PALLADIUM	107.87 Ag SILVER	112.41 Cd CADMIUM	114.82 In INDIUM	118.71 Sn TIN	121.76 Sb ANTIMONY	127.60 Te TELLURIUM	126.90 I IODINE	131.29 Xe XENON	
6		132.91 Cs CAESIUM	137.33 Ba BARIUM	57-71 La-Lu Lanthanide	178.49 Hf HAFNIUM	180.95 Ta TANTALUM	183.84 W TUNGSTEN	186.21 Re RHENIUM	190.23 Os OSMIUM	192.22 Ir IRIDIUM	195.08 Pt PLATINUM	196.97 Au GOLD	200.59 Hg MERCURY	204.38 Tl THALLIUM	207.2 Pb LEAD	208.98 Bi BISMUTH	(209) Po POLONIUM	(210) At ASTATINE	(222) Rn RADON	
7		(223) Fr FRANCIUM	(226) Ra RADIUM	89-103 Ac-Lr Actinide	(261) Rf RUTHERFORDIUM	(262) Db DUBNIUM	(266) Sg SEABORGIUM	(264) Bh BOHRIUM	(277) Hs HASSIUM	(268) Mt MEITNERIUM	(281) Uuu UNUNNIUM	(272) Uuu UNUNUNIUM	(285) Uub UNUNBIUM	(289) Uuq UNUNQUADIUM						

Legend for element classification:

- Metal
- Semimetal
- Nonmetal
- Alkali metal
- Alkaline earth metal
- Transition metals
- Lanthanide
- Actinide
- Chalcogens element
- Halogens element
- Noble gas

STANDARD STATE (25 °C; 101 kPa)

- Ne** - gas
- Fe** - solid
- Ga** - liquid
- Tc** - synthetic

(1) Pure Appl. Chem., 73, No. 4, 667-683 (2001)
Relative atomic mass is shown with five significant figures. For elements having no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.
However three such elements (Th, Pa, and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.

Editor: Aditya Vardhan (adivar@netlinx.com)

LANTHANIDE														
57 138.91 La LANTHANUM	58 140.12 Ce CERIUM	59 140.91 Pr PRASEODYMIUM	60 144.24 Nd NEODYMIUM	61 (145) Pm PROMETHIUM	62 150.36 Sm SAMARIUM	63 151.96 Eu EUROPIUM	64 157.25 Gd GADOLINIUM	65 158.93 Tb TERBIUM	66 162.50 Dy DYSPROSIUM	67 164.93 Ho HOLMIUM	68 167.26 Er ERBIUM	69 168.93 Tm THULIUM	70 173.04 Yb YTTERIUM	71 174.97 Lu LUTETIUM

ACTINIDE														
89 (227) Ac ACTINIUM	90 232.04 Th THORIUM	91 231.04 Pa PROTACTINIUM	92 238.03 U URANIUM	93 (237) Np NEPTUNIUM	94 (244) Pu PLUTONIUM	95 (243) Am AMERICIUM	96 (247) Cm CURIUM	97 (247) Bk BERKELIUM	98 (251) Cf CALIFORNIUM	99 (252) Es EINSTEINIUM	100 (257) Fm FERMIUM	101 (258) Md MENDELEVIUM	102 (259) No NOBELIUM	103 (262) Lr LAWRENCIUM



Conductivity

“Ability to conduct **electrical current**”

Conductor

metal (gold, platinum, copper, etc)

Insulator

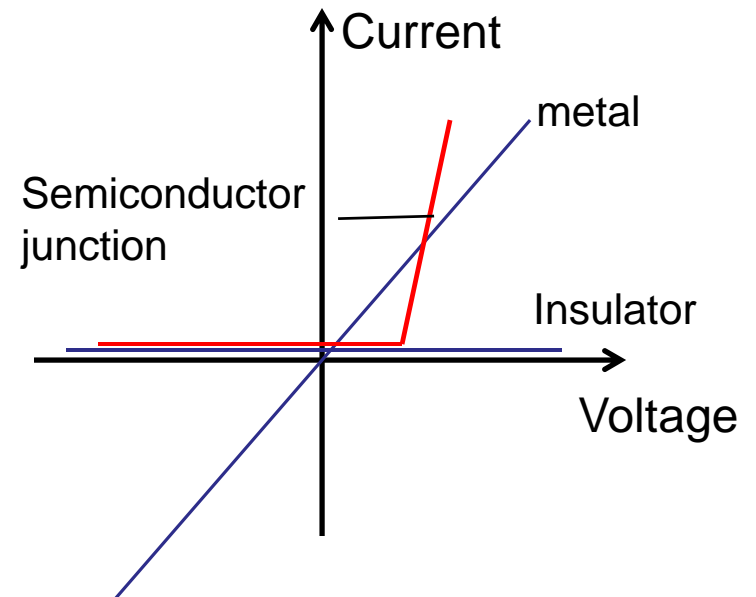
glass., wood, etc

“What make the material conducts electricity?”

Existing of **charge carrier**

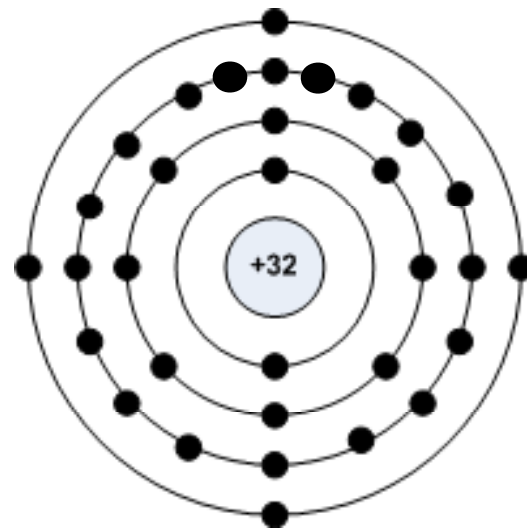
Semiconductor;

- material which has conductivity between that of conductor and insulator
- The conductivity can be controlled by adding impurities
- Using semiconductor, a structure which shows switching characteristics can be implemented

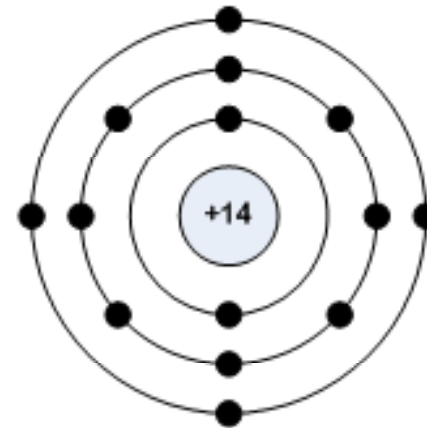




- Carbon (C), Silicon (Si), Germanium (Ge)
- Atomic structure of Ge and Si.



Ge

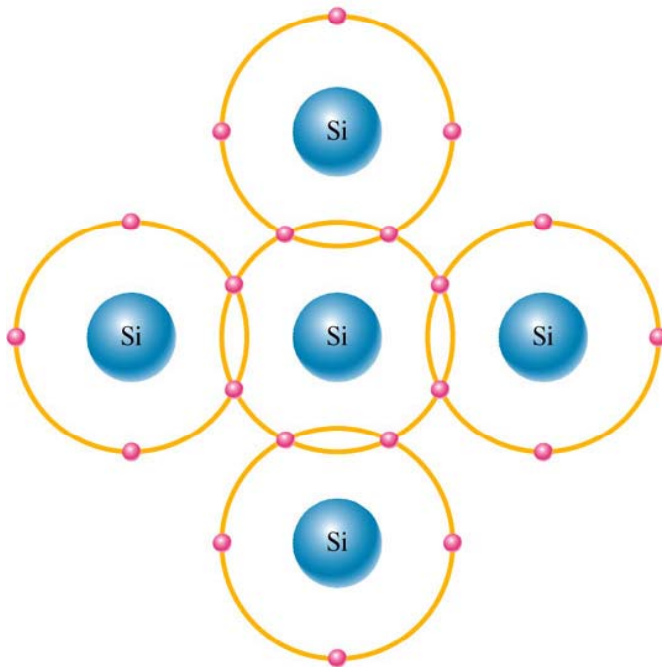


Si

Number of electrons in band n , $N_e = 2n^2$



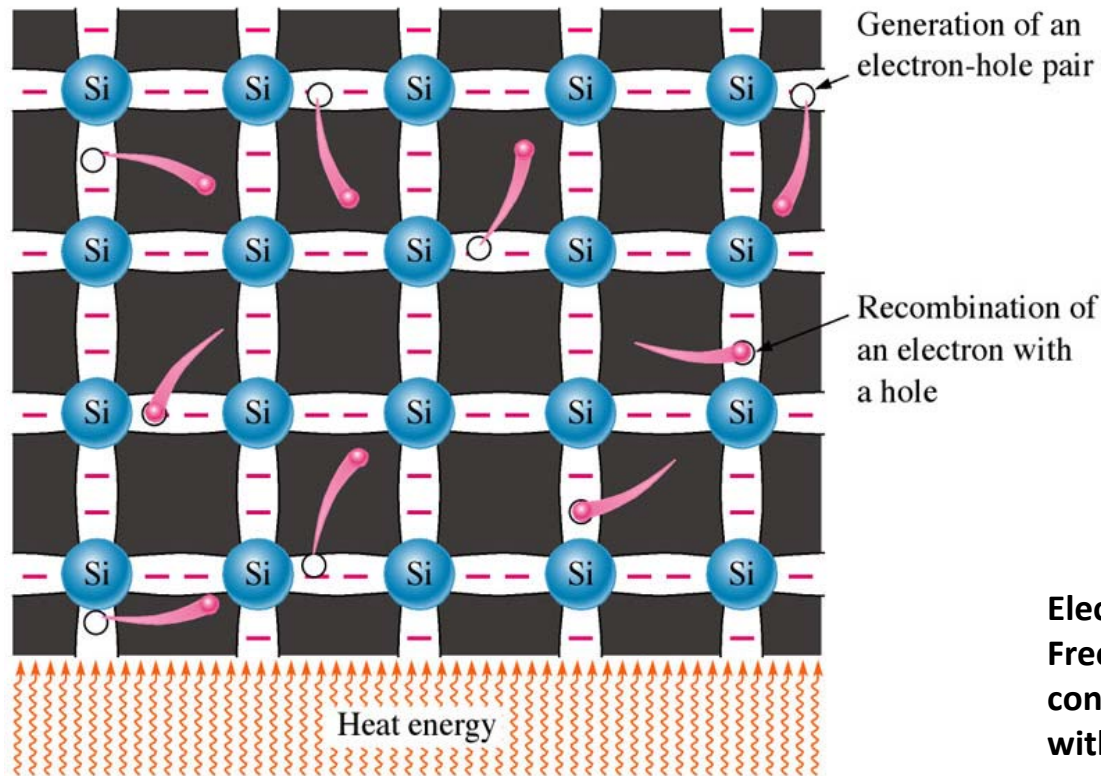
- Covalent bonding – the bonding of atoms, strengthened by the **sharing electrons**



The center atom shares an electron with each of the four surrounding atoms, creating a covalent bond with each. The surrounding atoms are in turn bonded to other atoms, and so on.



- Charge carriers in semiconductors – **electron and holes**



Electron-hole pairs in a silicon crystal. Free electrons are being generated continuously while some recombine with holes.



Intrinsic Semiconductor

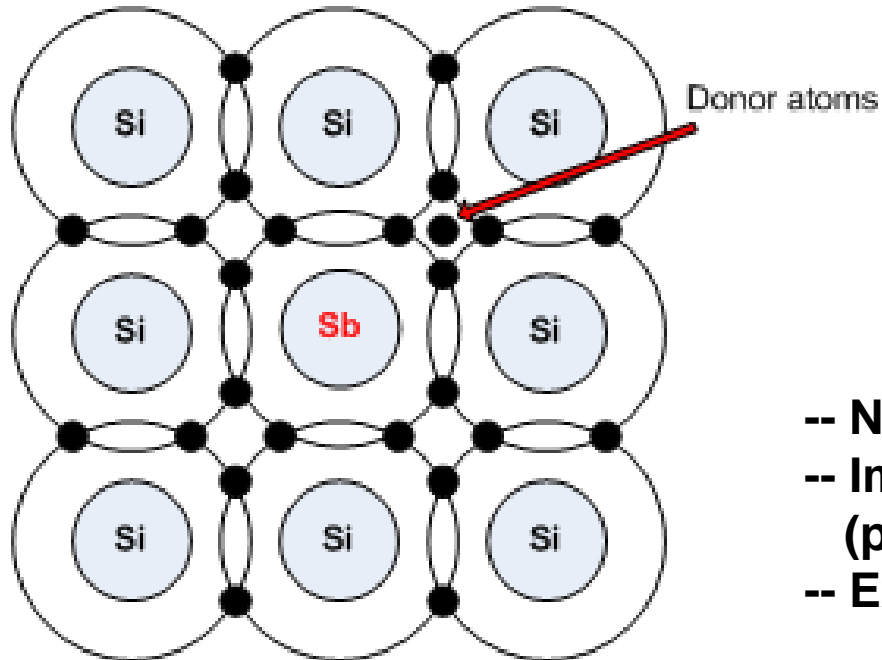
- Also known as **pure semiconductor**
- Eg: pure Si, Ge, C, Sn.
- Electron and hole concentrations are relatively small. Hence, very small current are possible.
- **Poor conductor** because the total number of **charge carriers are small**.



- Also known as **doped semiconductor**
- Electron and hole concentrations can be greatly increase by **adding controlled amounts of certain impurities into Intrinsic Semiconductor.**
- This process is called **doping.**
- Two types – N type and P type



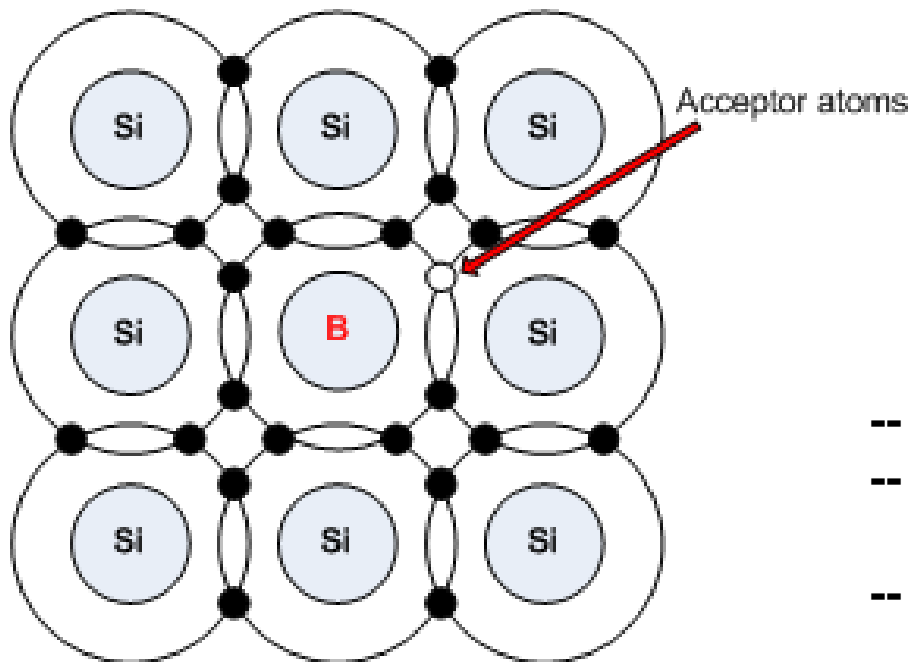
N - type



- N-type Silicon (majority electrons)
- Impurity with 5 valence electrons (pentavalent)
- Example Antimony, Arsenic, Phosphorous



P - type



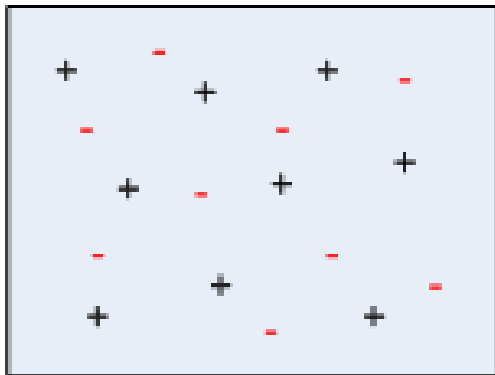
- P-type Silicon (majority holes)
- Impurity with 3 valence electrons (trivalent)
- Example Boron, Gallium, Indium



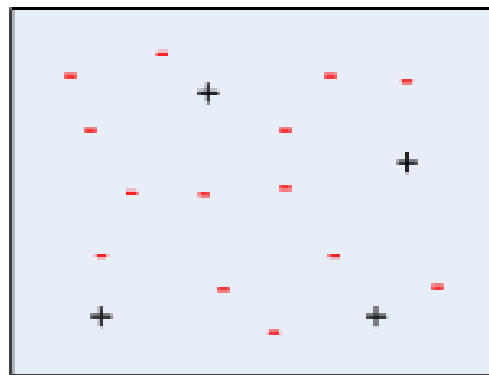
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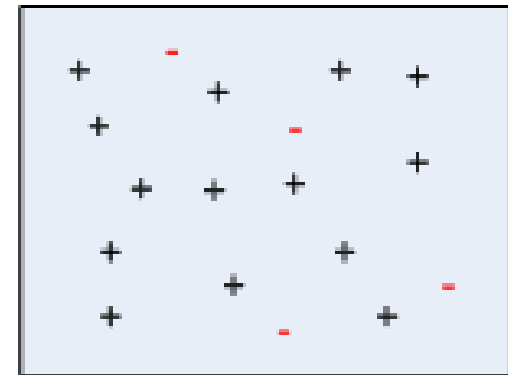
Charge Carriers



Pure Silicon
-- *almost* equal electrons
and holes



N-Type Silicon
-- Majority electrons
-- Minority holes



P-Type Silicon
-- Majority holes
-- Minority electrons