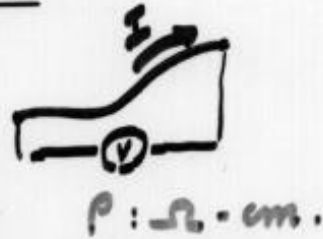


3. SEMICONDUCTOR ELECTRONICS

RESISTIVITY:

$$V = RI$$

$$R = \rho \frac{L}{A}$$



ρ DETERMINES THE CLASSIFICATION OF MATERIALS:

INSULATORS

$$\rho > 10^8 \Omega \cdot \text{cm}$$

SEMICONDUCTORS

$$10^3 < \rho < 10^8 \Omega \cdot \text{cm}$$

CONDUCTORS (METALS)

$$\rho < 10^{-3} \Omega \cdot \text{cm}$$

3.1. PHYSICS OF SEMICONDUCTOR MATERIALS

BAND MODEL OF SOLIDS

no \bar{e}



CONDUCTION BAND

E_G : BAND GAP

FULL OF \bar{e}



VALENCE BAND

$T=0K$

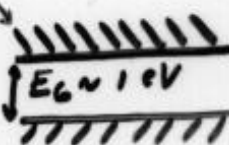
INSULATORS

SEMICONDUCTORS

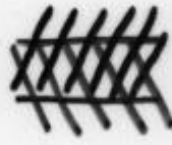
METALS



← EMPTY



$E_G \sim 1eV$



$E_G \sim 10eV$

← FULL

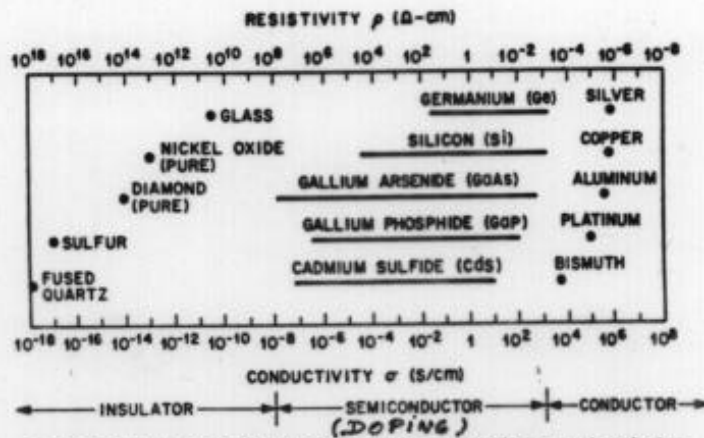


Fig. 1 Typical range of conductivities for insulators, semiconductors, and conductors.

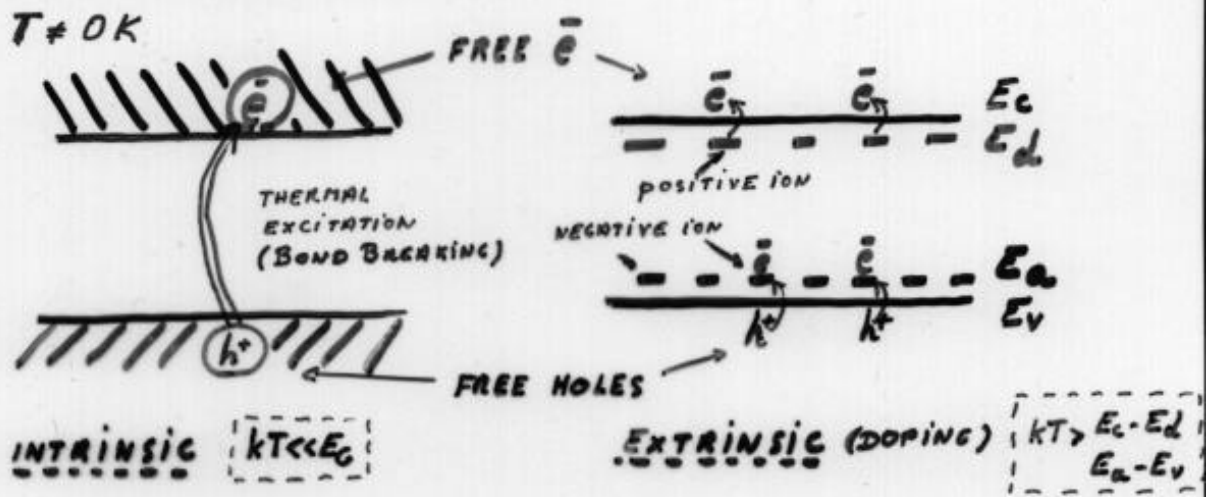
Table 1 Portion of the Periodic Table Related to Semiconductors

Period	Column II	III	IV	V	VI
2		B Boron	C Carbon	N Nitrogen	
3	Mg Magnesium	Al Aluminum	Si Silicon	P Phosphorus	S Sulfur
4	Zn Zinc	Ga Gallium	Ge Germanium	As Arsenic	Se Selenium
5	Cd Cadmium	In Indium	Sn Tin	Sb Antimony	Te Tellurium
6	Hg Mercury		Pb Lead		

Table 2 Element and Compound Semiconductors

Element	IV-IV Compounds	III-V Compounds	II-VI Compounds	IV-VI Compounds
Si	SiC	AlAs	CdS	PbS
Ge		AlSb	CdSe	PbTe
		BN	CdTe	
		➔ GaAs	ZnS	
		GaP	ZnSe	
		GaSb	ZnTe	
		➔ InAs		
		➔ InP		
		InSb		

CONDUCTION PROCESSES



FOR Si : DONORS : SUBSTITUTIONAL IMPURITIES : GROUP V

ACCEPTORS : SUBSTITUTIONAL IMPURITIES : GROUP III

N-TYPE : DONOR CONCENTRATION > ACCEPTOR CONCL.

\bar{e} : MAJORITY CARRIERS : n

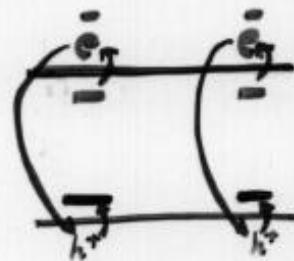
h : MINORITY CARRIERS : p

P-TYPE : ACCEPTOR CONCENTRATION > DONOR CONCL.

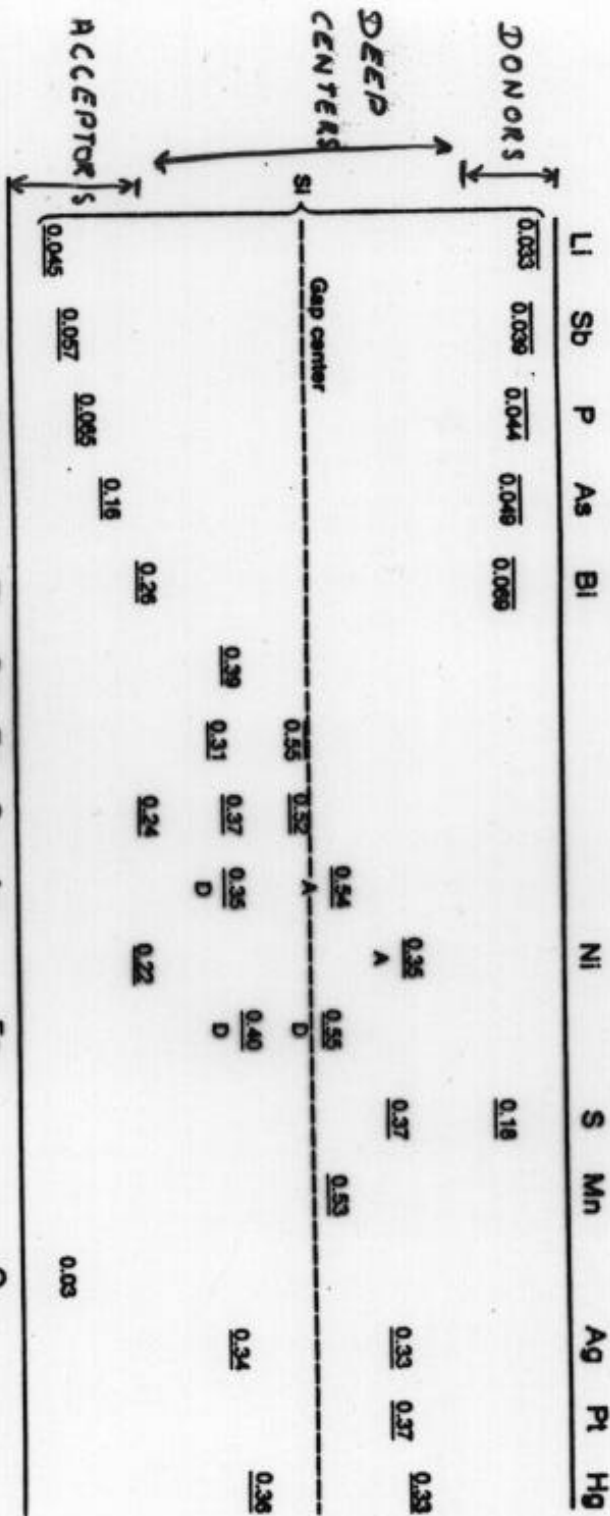
\bar{e} : MINORITY CARRIERS : n

h : MAJORITY CARRIERS : p

COMPENSATION : $N_d = N_a$



Energy Levels of Elemental Impurities in Si*



* a plot of n_i versus T at higher temperatures is given in Figure 2.10.
 † The levels below the gap center are measured from the top of the valence band and are acceptor levels unless indicated by *D* for donor level. The levels above the gap center are measured from the bottom of the conduction band and are donor levels unless indicated by *A* for acceptor level.¹⁰