

Classroom Photocopying Permission

Chapters from Teaching General Chemistry: A Materials Science Companion.
Copyright © 1993 American Chemical Society. All Rights Reserved.
For reproduction of each chapter for classroom use, contact the American
Chemical Society or report your copying to the Copyright Clearance Center, Inc.,
222 Rosewood Drive, Danvers, MA 01923.

Experiments from Teaching General Chemistry: A Materials Science Companion. Copyright © 1993 American Chemical Society. All Rights Reserved. Multiple copies of the experiments may be made for classroom use only, provided that the following credit line is retained on each copy: "Reproduced with permission from *Teaching General Chemistry: A Materials Science Companion*." You may edit the experiments for your particular school or class and make photocopies of the edited experiments, provided that you use the following credit line: "Adapted with permission from *Teaching General Chemistry: A Materials Science Companion*."

Overhead Masters

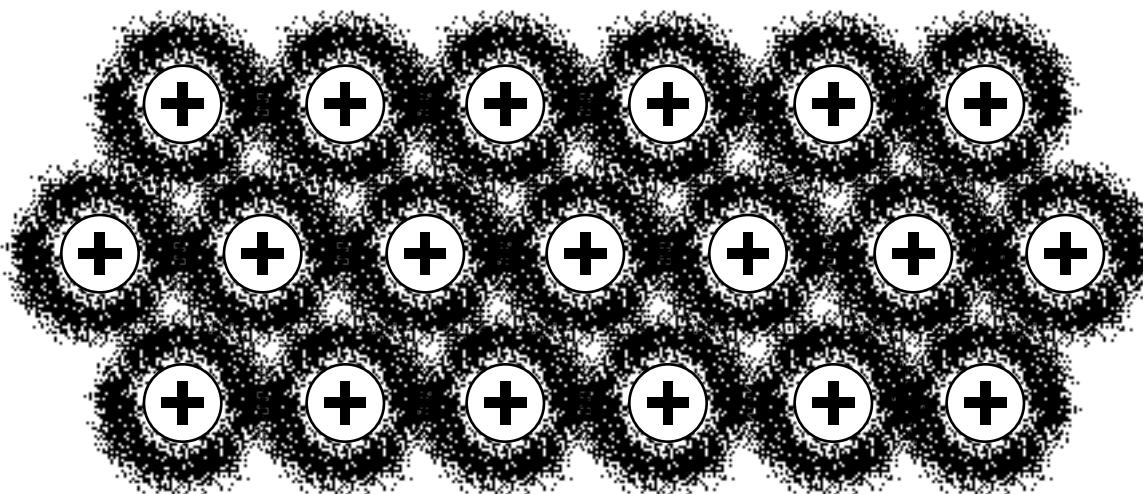
Multiple copies of the overhead masters may be made for classroom use only, provided that the extant credit lines are retained on each copy: "© 1993 American Chemical Society. Reproduced with permission from *Teaching General Chemistry: A Materials Science Companion*" or "© 1995 by the Division of Chemical Education, Inc., American Chemical Society. Reproduced with permission from *Solid-State Resources*."

Laboratory Safety

DISCLAIMER

Safety information is included in each chapter of the Companion as a precaution to the readers. Although the materials, safety information, and procedures contained in this book are believed to be reliable, they should serve only as a starting point for laboratory practices. They do not purport to specify minimal legal standards or to represent the policy of the American Chemical Society. No warranty, guarantee, or representation is made by the American Chemical Society, the authors, or the editors as to the accuracy or specificity of the information contained herein, and the American Chemical Society, the authors, and the editors assume no responsibility in connection therewith. The added safety information is intended to provide basic guidelines for safe practices. Therefore, it cannot be assumed that necessary warnings or additional information and measures may not be required. Users of this book and the procedures contained herein should consult the primary literature and other sources of safe laboratory practices for more exhaustive information. See page xxv in the Text 0 Preface file in the Companion Text folder for more information.

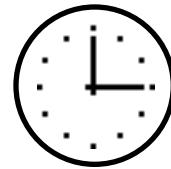
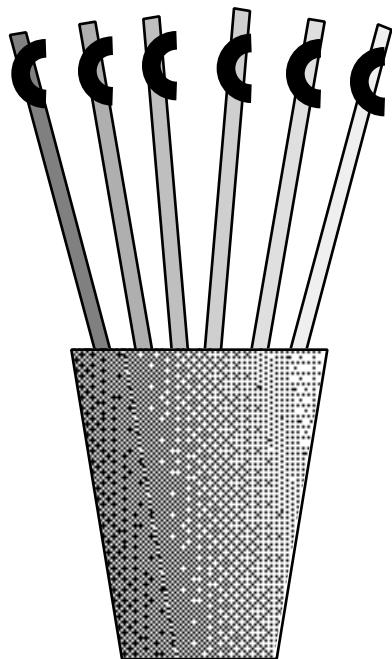
Metallic Sea of Electrons



Electrons are not bonded to any particular atom and are free to move about in the solid.

- High electrical conductivity
- High thermal conductivity
- High reflectivity of visible light

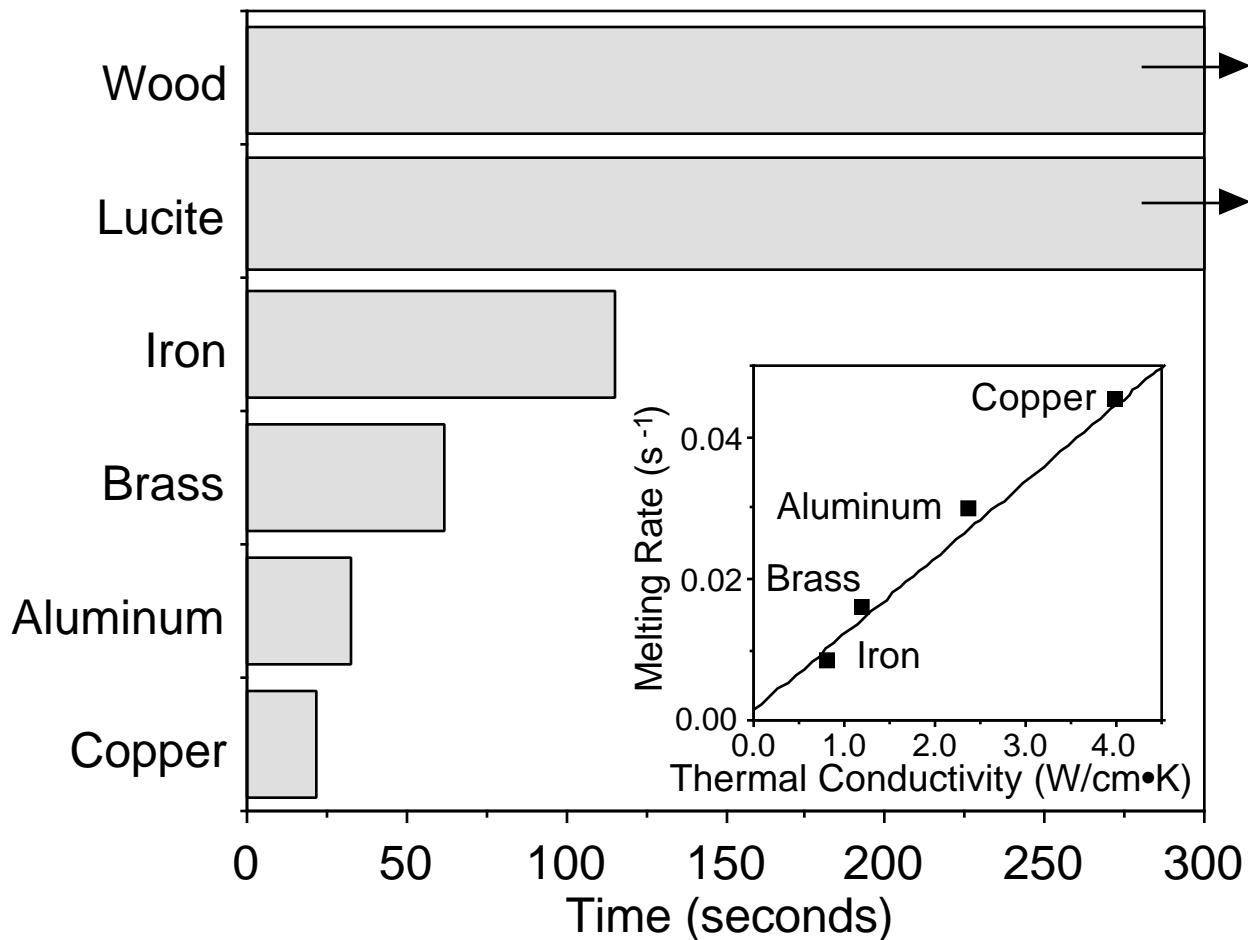
Thermal Conductivity



Put equal size rods of material into a foam cup.

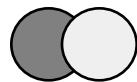
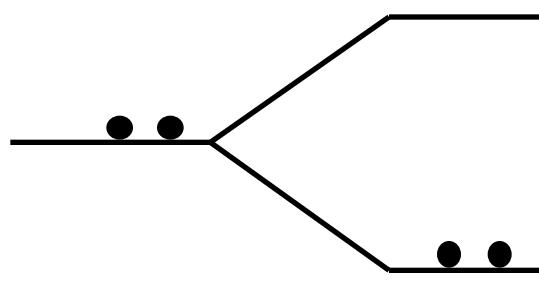
Use butter to glue macaroni near end of rod.

Add hot water and record time for macaroni to fall.

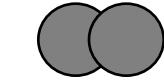
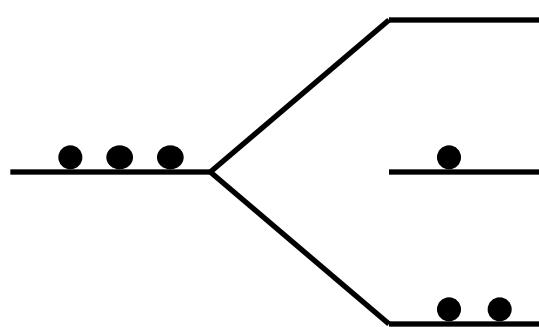


Bonds to Bands

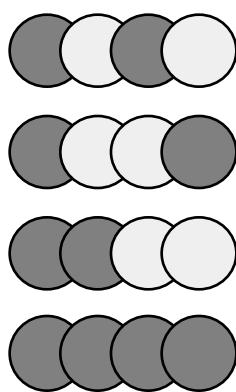
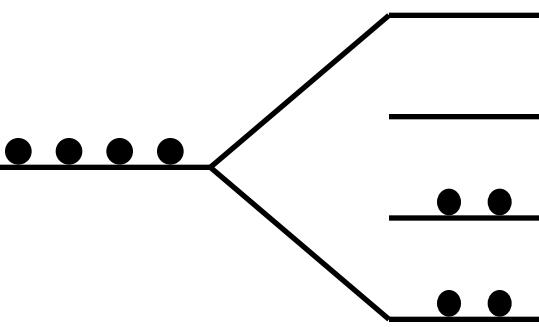
M_2



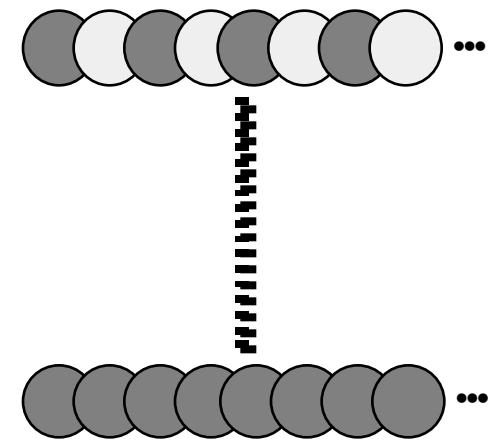
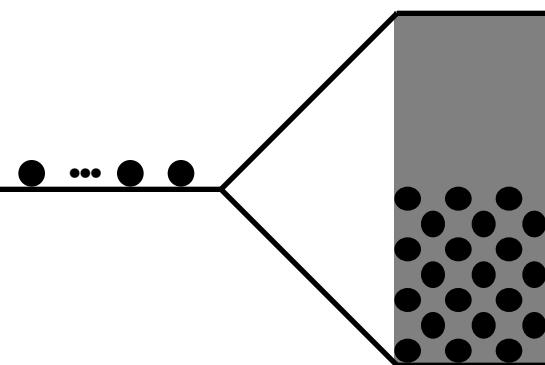
M_3



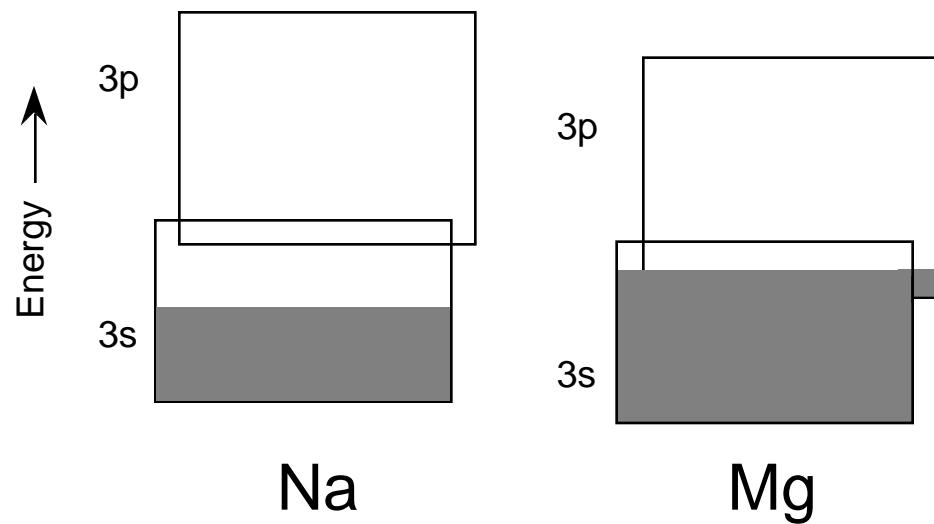
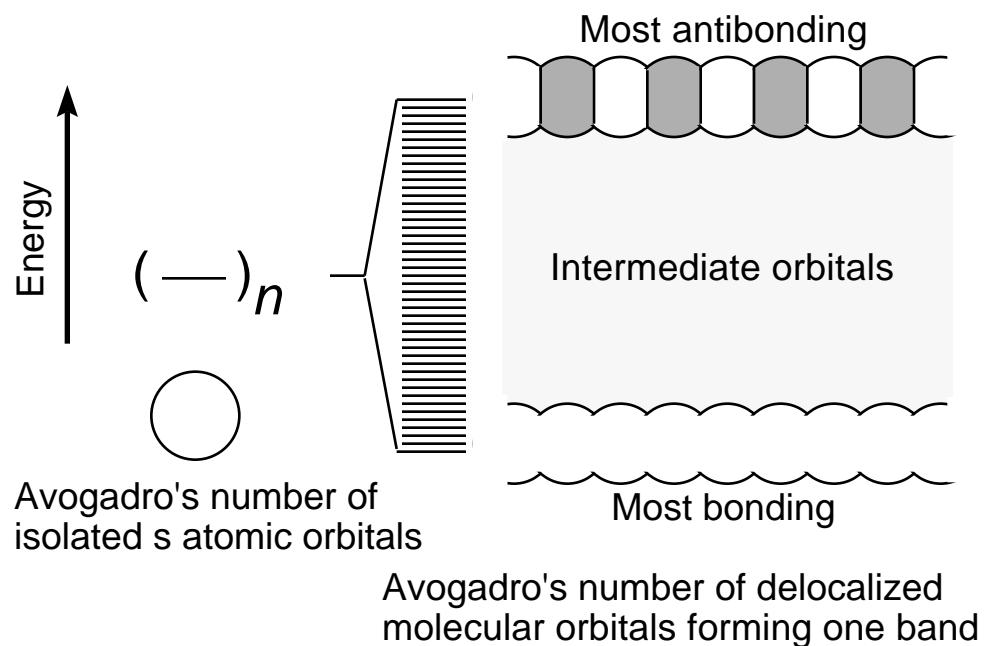
M_4



M_n

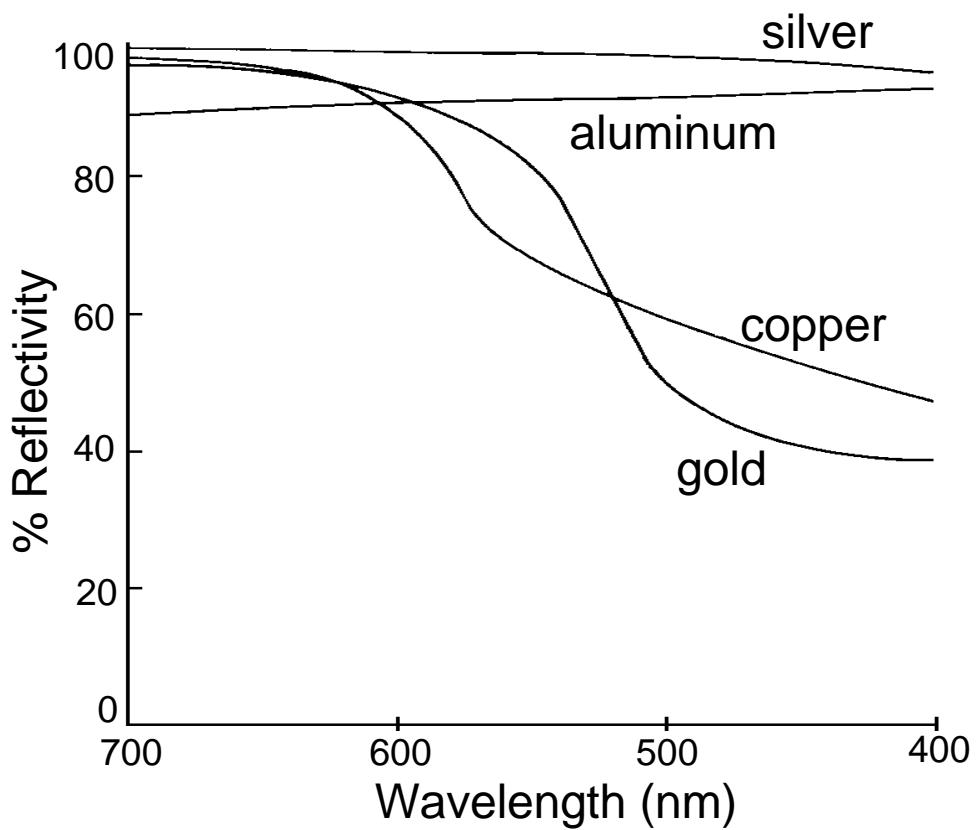
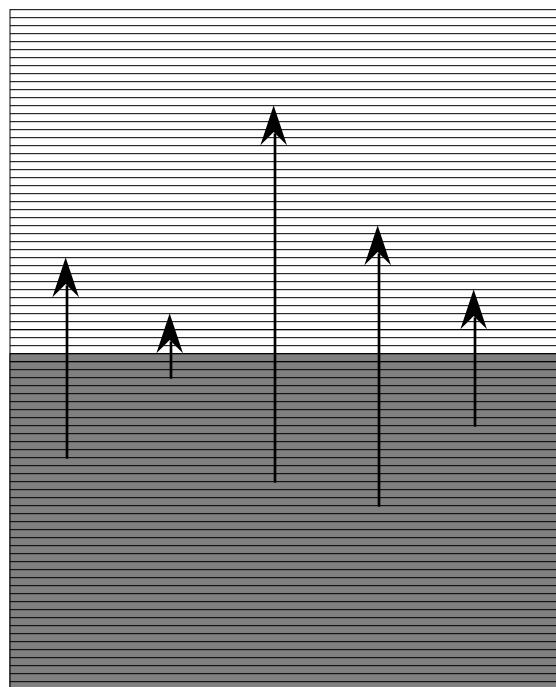


Bands



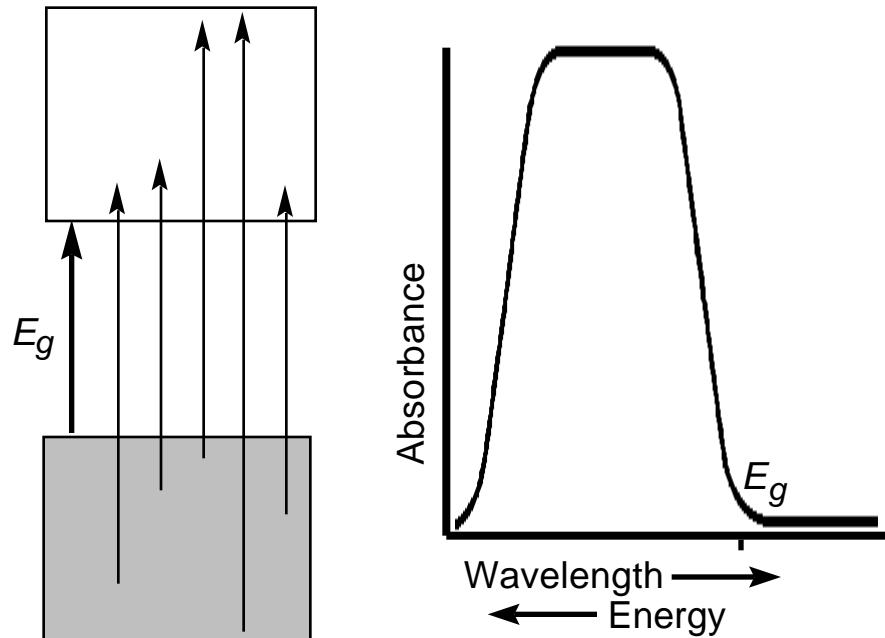
Optical Properties of Metals

Some possible electronic transitions in a half-filled band of a metal.

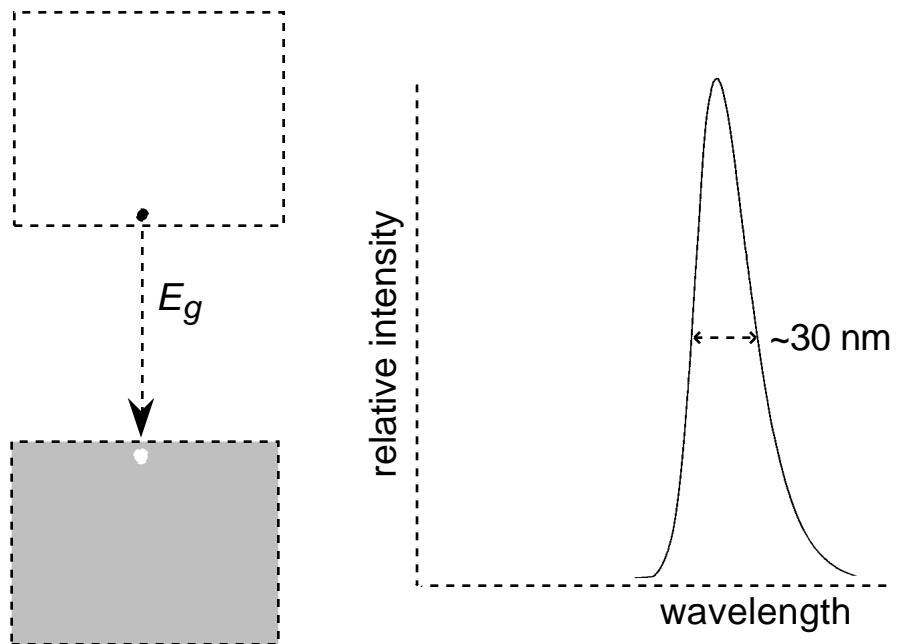


Optical Properties of Semiconductors

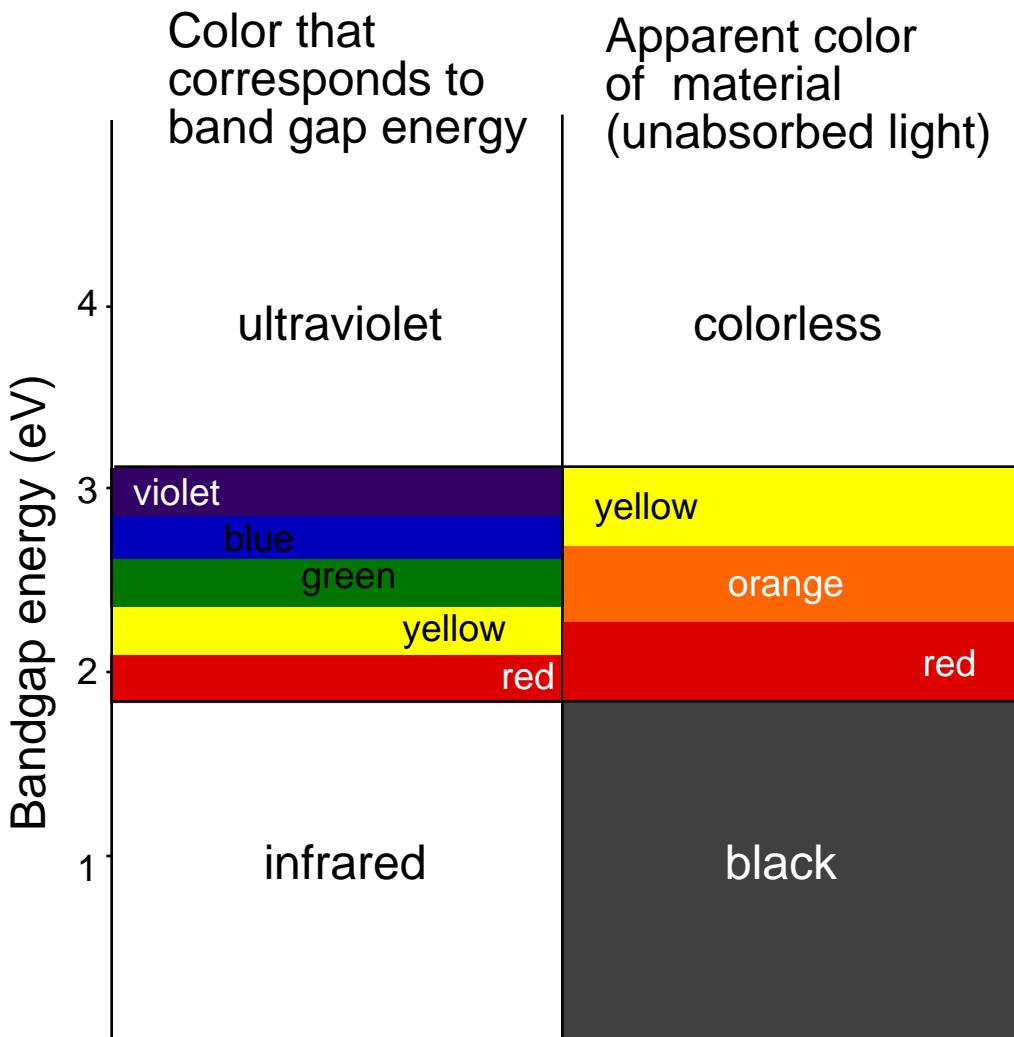
Absorption



Emission



Band Gap Energy and Color

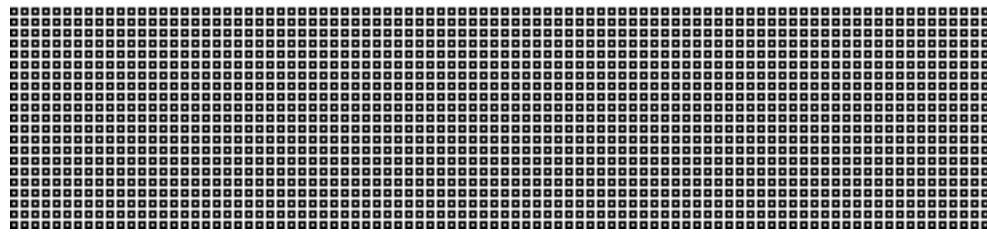
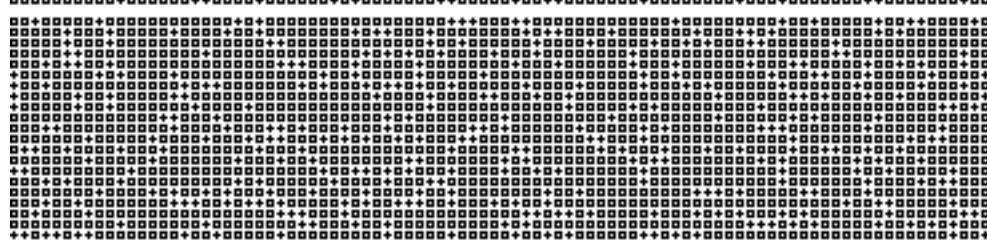
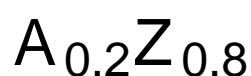
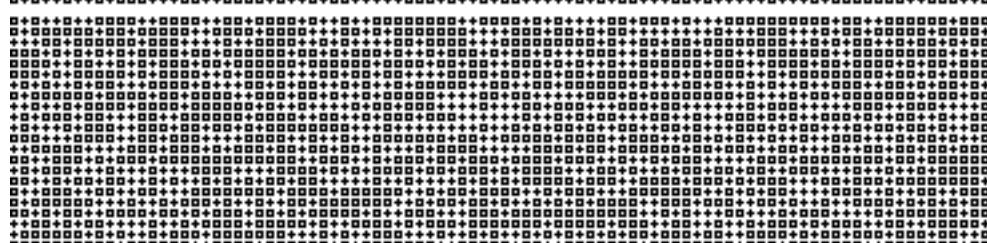
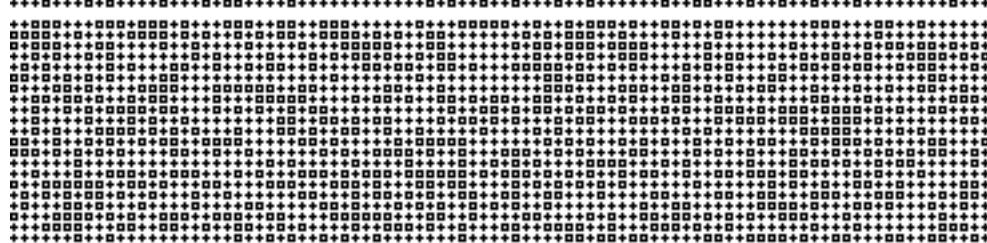
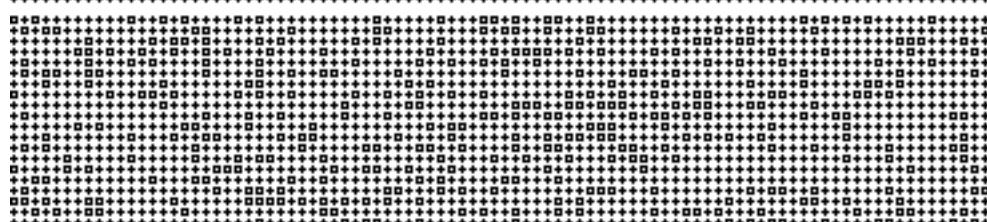
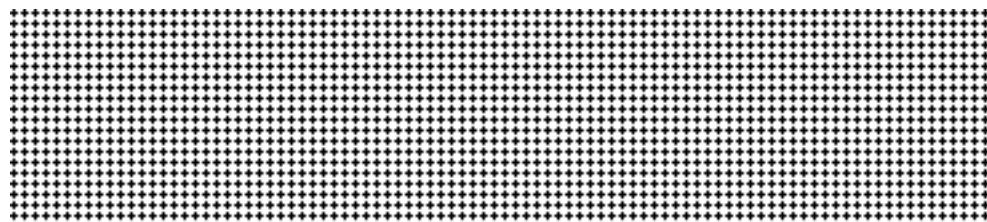
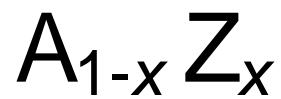


Band Gap and Periodic Properties

Element	Unit Cell, Å	D_0 , kJ/mol	E_g , eV	(, nm)
C	3.57	346	5.5	(230)
Si	5.43	222	1.1	(1100)
Ge	5.66	188	0.66	(1900)
-Sn	6.49	146	< 0.1	(12,000)

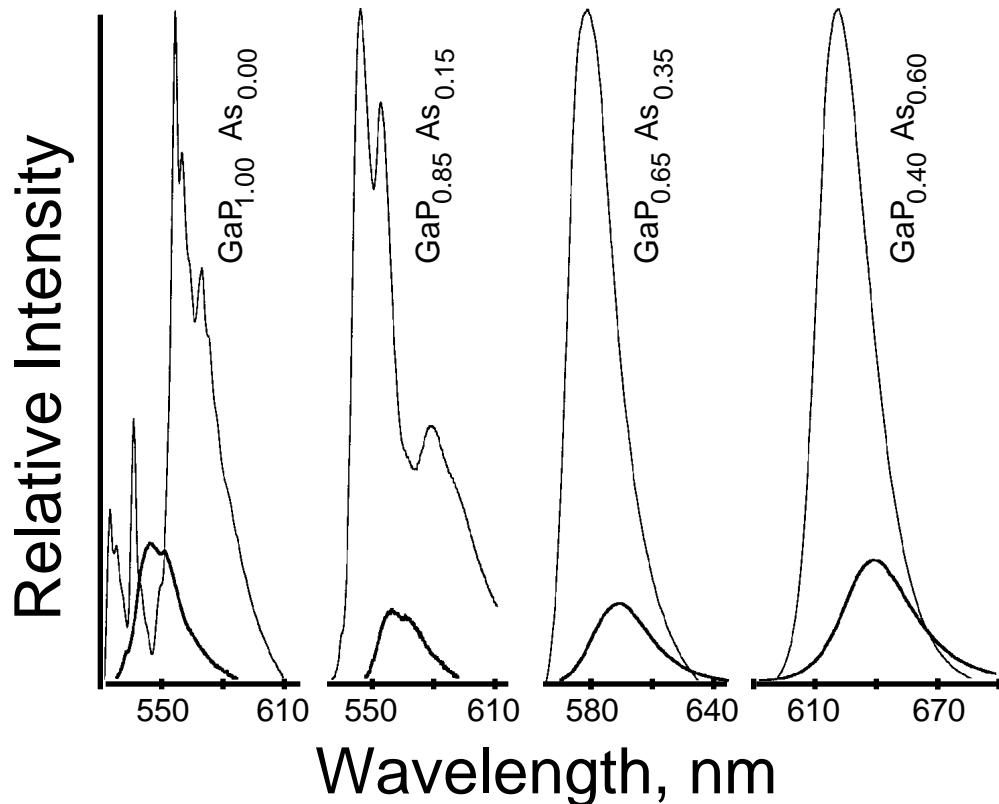
Material	Unit Cell, Å	E_g , eV	(, nm)
Ge	5.66	0.0	0.66 (1900)
GaAs	5.65	0.4	1.42 (890)
ZnSe	5.67	0.8	2.70 (460)
CuBr	5.69	0.9	2.91 (430)

Solid Solutions



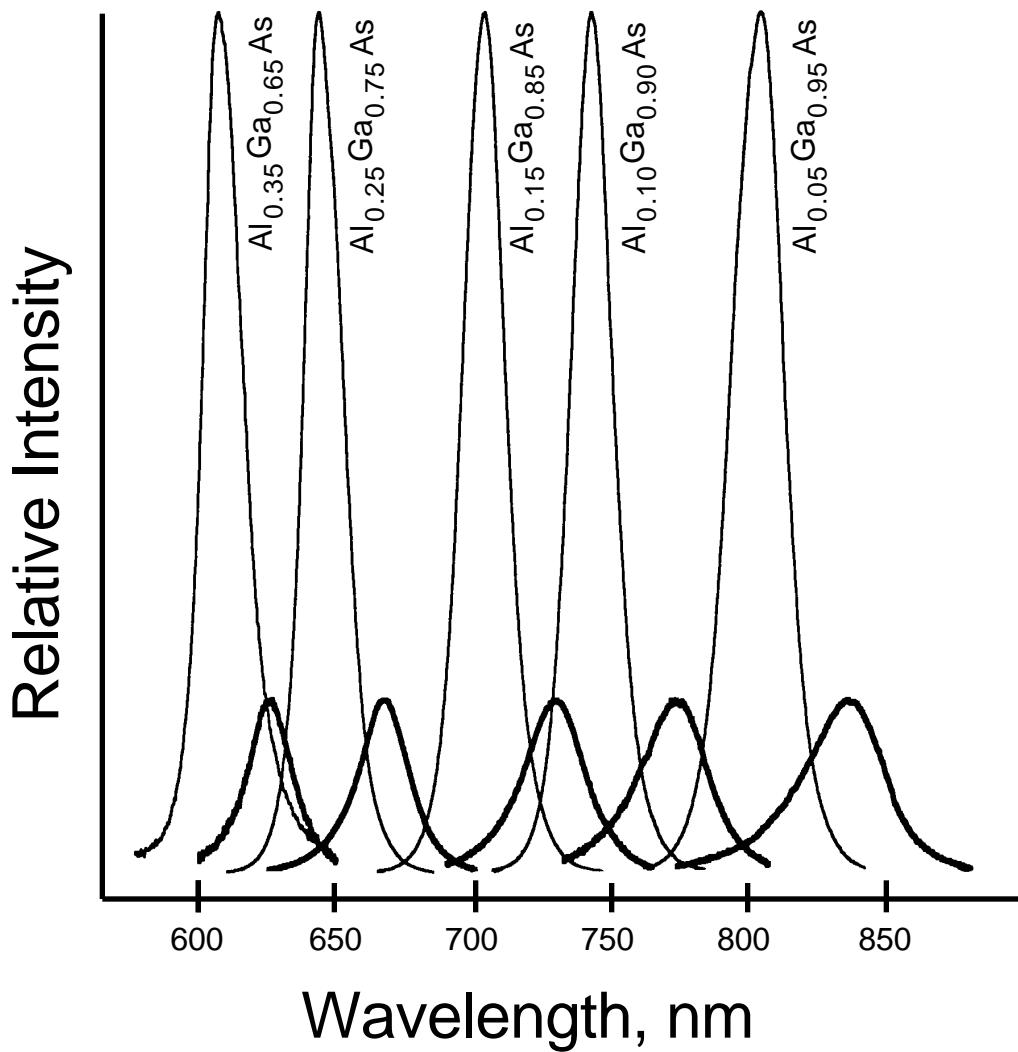
$\text{GaP}_x\text{As}_{1-x}$ LED Spectra

Recorded at 300 K and at 77 K (brighter)

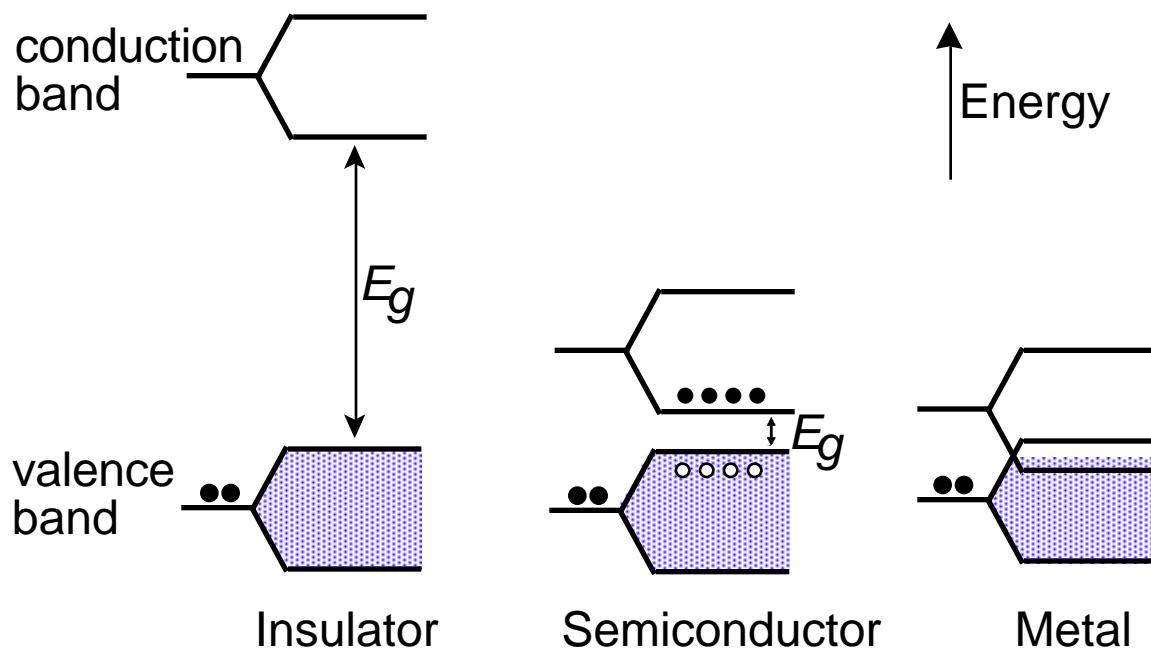
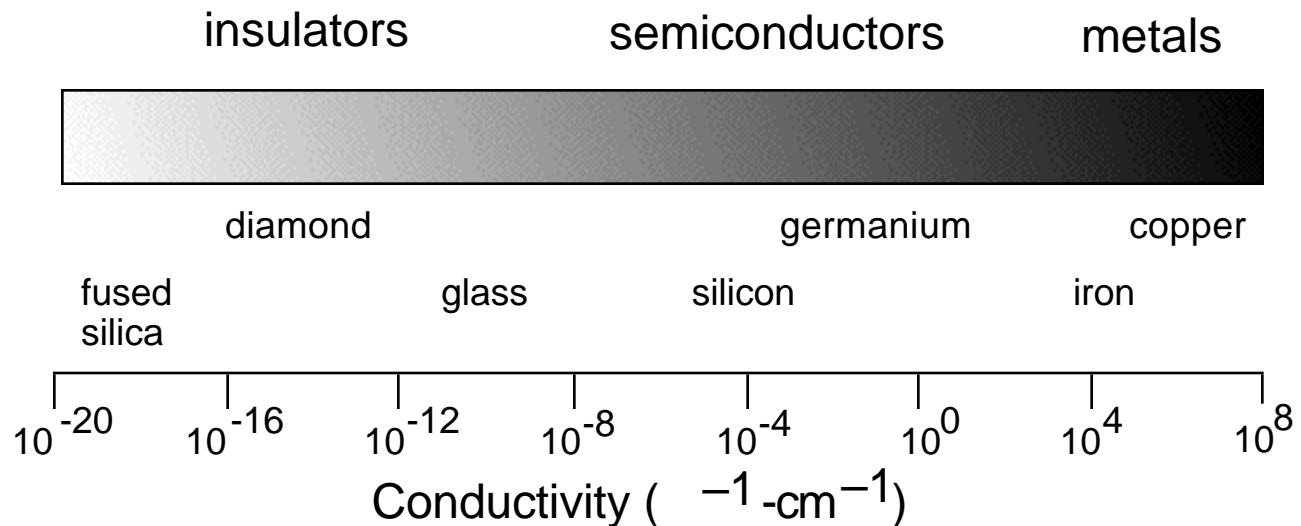


$\text{Al}_x\text{Ga}_{1-x}\text{As}$ LED Spectra

Recorded at 300 K and at 77 K (brighter)



Electrical Conductivity



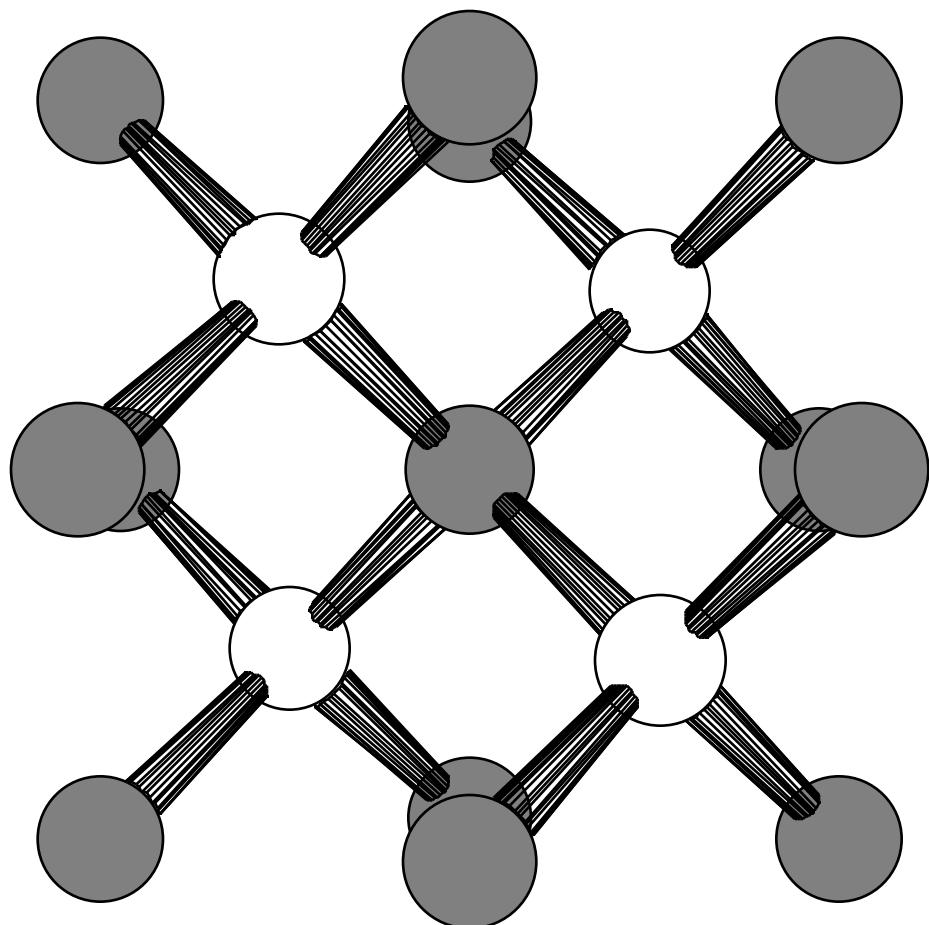
Conductivity of metals decreases with temperature as atomic vibrations scatter free electrons.

Conductivity of semiconductors increases with temperature as the number of carriers increase.

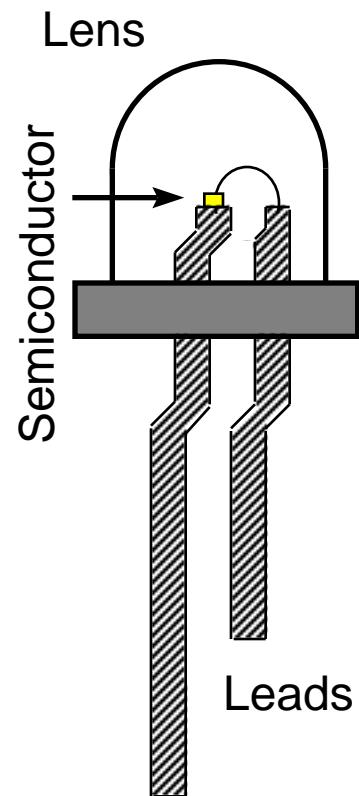
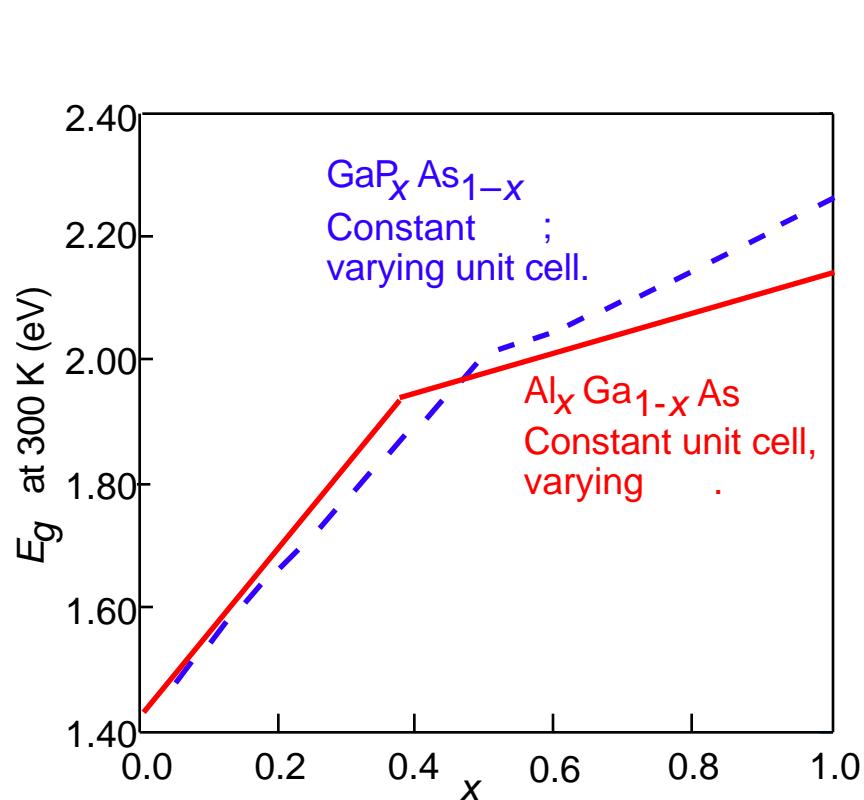
Semiconductors

		13	14	15	16	17
11	12	B	C	N	O	F
		Al	Si	P	S	Cl
Cu	Zn	Ga	Ge	As	Se	Br
Ag	Cd	In	Sn	Sb	Te	I
Au	Hg	Tl	Pb	Bi	Po	At

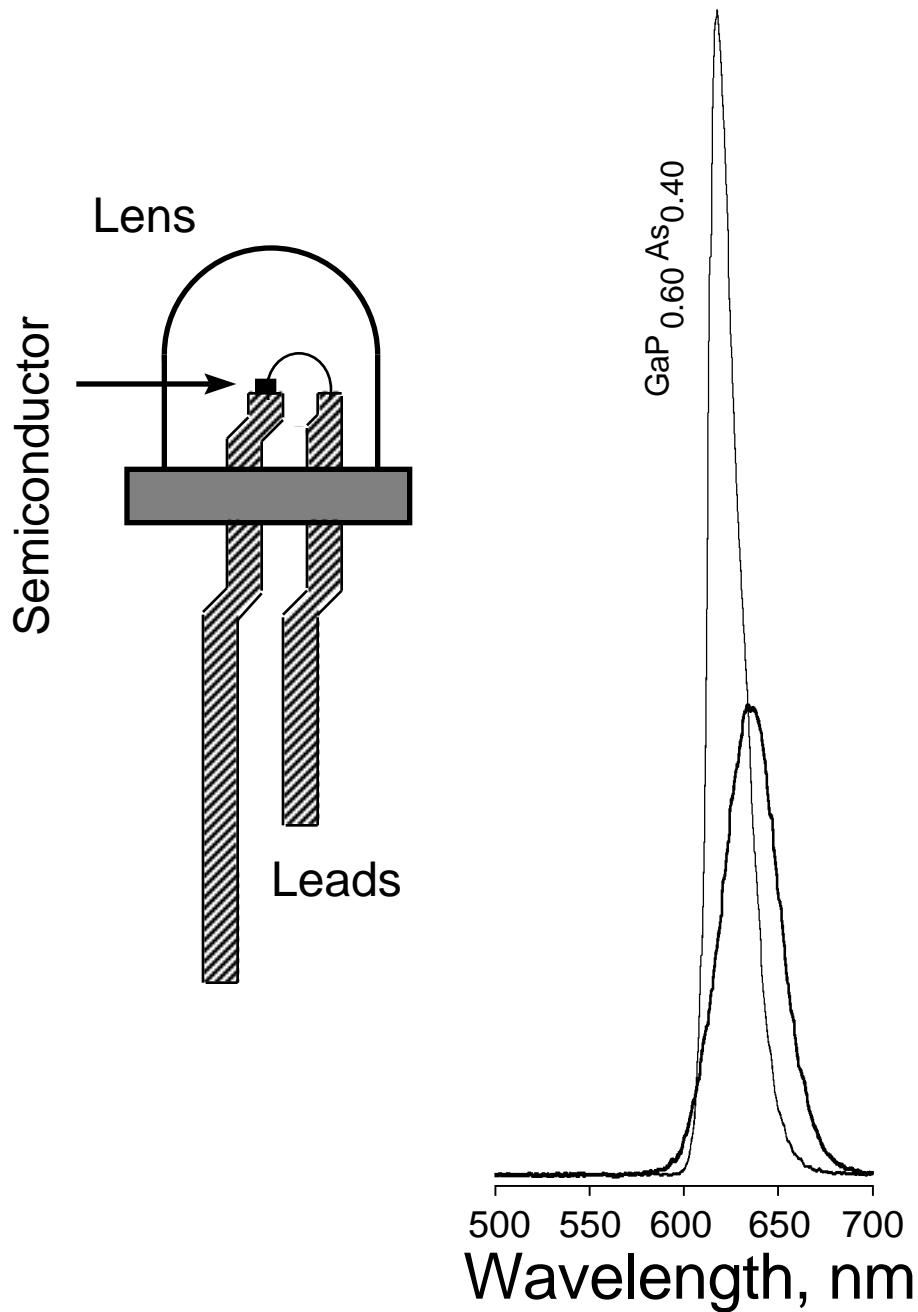
Similar shading indicates complementary pairs that preserve the total valence electron count for AZ stoichiometry. In the zinc blende structure each AZ atom is four coordinate.



Light-Emitting Diodes (LEDs)



GaP_{0.60}As_{0.40} LED



Decreasing temperature moves atoms closer together and holds bonding electrons tighter. Replacing such an electron releases more energy.

When the LED is cooled, emission of light becomes more efficient (less energy is lost to vibrations).

Composition	Predicted Relative E_g	Color Emitted	Wavelength (relative spacing)	Energy (relative voltage)
$\text{GaP}_{0.40}\text{As}_{0.60}$	4	red	1	4
$\text{GaP}_{0.65}\text{As}_{0.35}$	3	orange	2	3
$\text{GaP}_{0.85}\text{As}_{0.15}$	2	yellow	3	2
$\text{GaP}_{1.00}\text{As}_{0.00}$	1	green	4	1

Thermal Conductivity of Diamond



Diamond

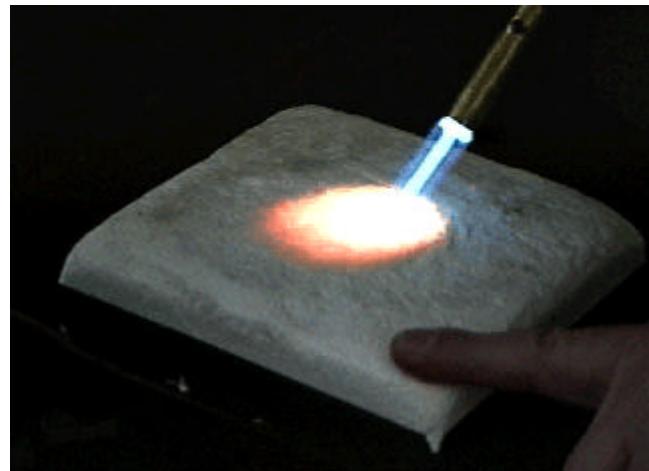


Aluminum



Diamond (left) and Aluminum (right)

Poor Heat Conductivity of Shuttle Tile



Resistance of 150 Meters of Fine Copper Wire

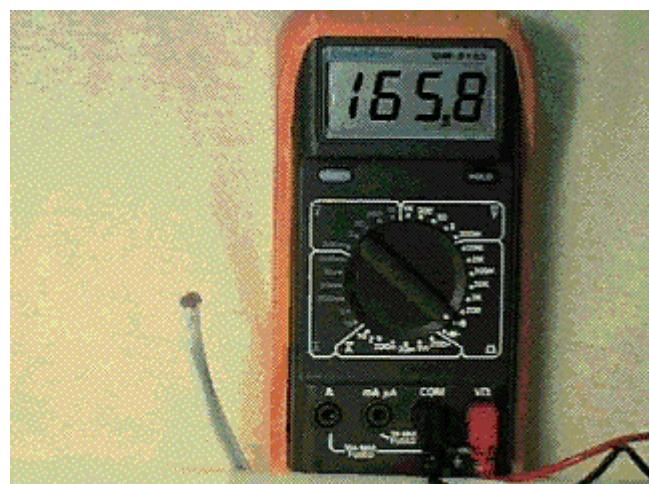
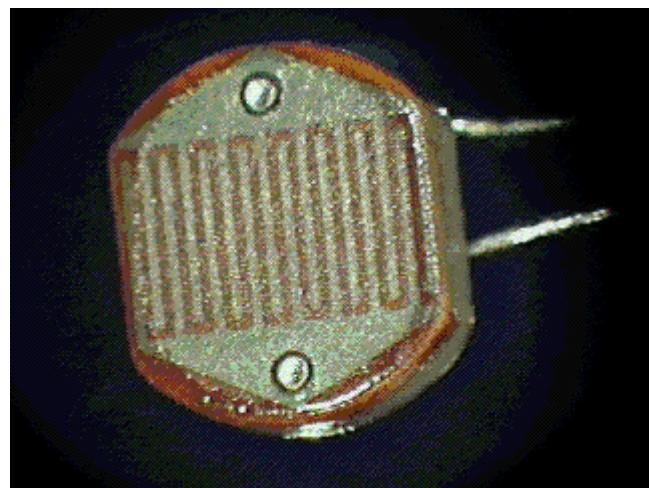


Room temperature



Cool in liquid nitrogen

Resistance of CdS Semiconductor



illuminated



shaded

Light Emitting Diode (LED)

