MPHYCC-7 ELECTRONICS I

Unit 1: SEMICONDUCTOR

Dr. Kumar Balwant Singh

Department of Physics, L. S. College, Muzaffarpur,

B. R. A. Bihar University, Muzaffarpur-842001

Email: kbsphysics@yahoo.co.in

Whatsapp: 9835033155

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What distinguishes electrical conductivity of semiconductors from metals and insulators is basically what defines semiconductors as a separate class of solids. First and foremost, in contrast to metals and insulators, electrical conductivity of semiconductors can be controlled by orders of magnitude (Fig. 1) by introduction of alien elements (doping). Furthermore, conductivity of semiconductors can be controlled by two types of carrier: negative electrons or positive holes. In addition, it depends on temperature, illumination, as well as electric and magnetic fields. Very importantly, and again in contrast to metals and insulators, when adequately processed, semiconductors can emit visible radiation. These outstanding characteristics allow a myriad of highly functional devices, both electronic and photonic to be made using semiconductors.

What materials display semiconductor properties?

In the Periodic Table of the Elements (Fig. 2a) a section singled out in Fig. 2b is often referred to as a "semiconductor periodic table". All inorganic semiconductors either elemental in group IV, or compound synthesized from the elements from the group IV (e.g.,

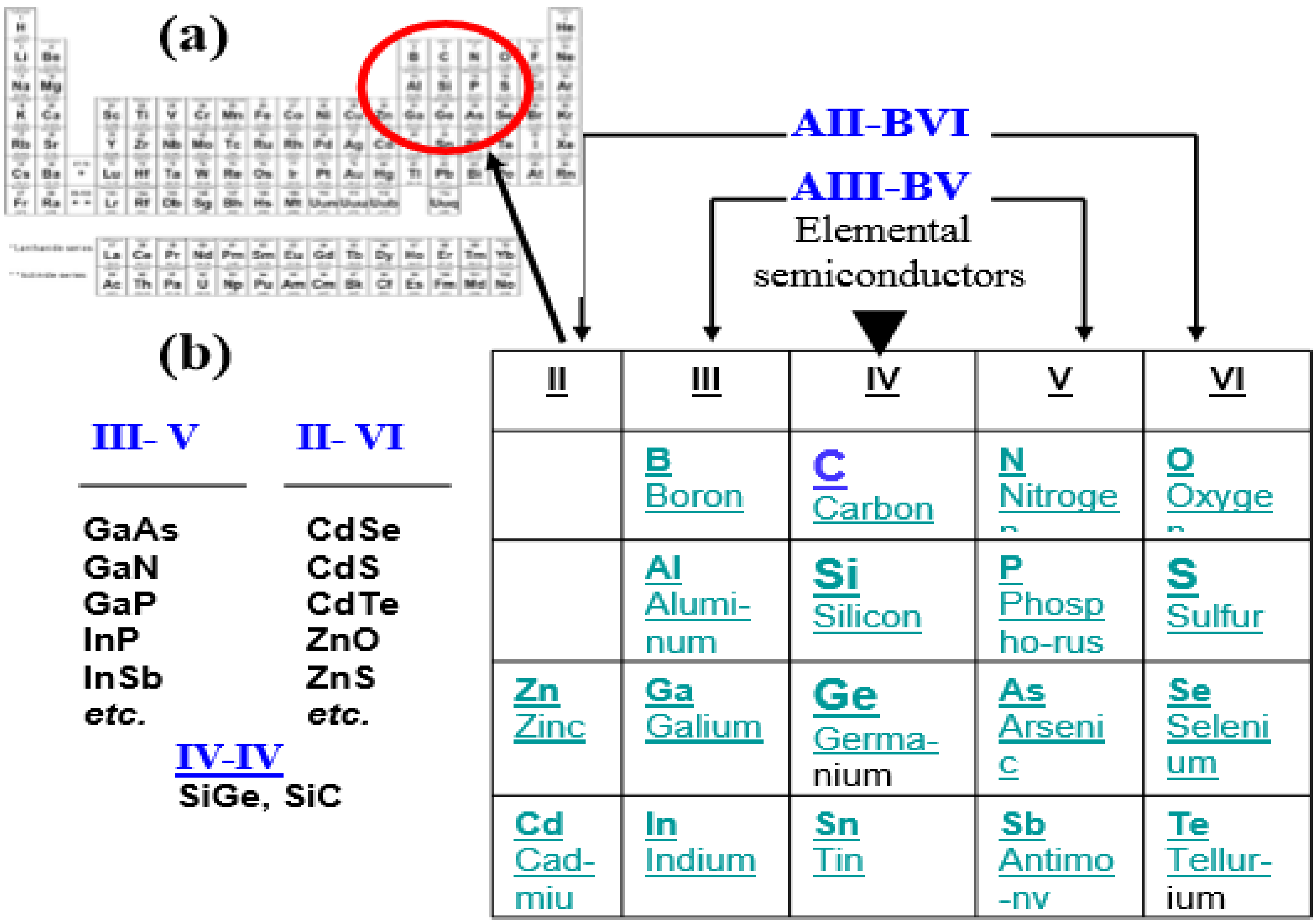

Fig. 2 Materials displaying semiconductor properties

silicon carbide, SiC), groups III and V (e.g., gallium arsenide, GaAs), as well as groups II and VI (e.g., cadmium selenide, CdSe) originate from this section of the periodic table.

In addition to a range of inorganic semiconductors identified in Fig. 2b, selected organic compounds form a very distinct class of semiconductors featuring unique properties and offering a range of novel applications (see discussion later in this overview).

Semiconductors can be subdivided into classes featuring diversified properties based on the chemical composition, fundamental physical properties, as well as the extent of an order in the three-dimensional arrangements of atoms. In this last case ordered (crystalline) and disordered (non-crystalline, or amorphous) semiconductors are distinguished. In addition, the nano-ordered semiconductors featuring a highly ordered structure within extremely confined geometries, such as nanowires, nanotubes, and quantum dots, can be singled out.

Silicon (see Fig. 2b) is by far the most important and the most widely used semiconductor material. Its use continues to grow not only through the needs of ever progressing microprocessor and memory integrated circuit technology, but also through the growing needs of solar cells (photovoltaics) and Micro-Electro-Mechanical Systems (MEMS) applications. Among compound semiconductors, gallium (Ga) compounds with group V elements (Fig. 2b), gallium nitride (GaN) and gallium arsenide (GaAs) in particular, are the most important due to their usefulness in a range of electronic and photonic applications.

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