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Amorphous Silicon–based Solar Cells

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12.1 OVERVIEW

12.1.1 Amorphous Silicon: The First Bipolar Amorphous Semiconductor

Crystalline semiconductors are very well known, including silicon (the basis of the integrated circuits used in modern electronics), Ge (the material of the first transistor), GaAs and the other III-V compounds (the basis for many light emitters), and CdS (often used as a light sensor). In crystals, the atoms are arranged in near-perfect, regular arrays or *lattices*. Of course, the lattice must be consistent with the underlying chemical bonding properties of the atoms. For example, a silicon atom forms four covalent bonds to neighboring atoms arranged symmetrically about it. This “tetrahedral” configuration is perfectly maintained in the “diamond” lattice of crystal silicon.

There are also many *noncrystalline* semiconductors. In these materials the chemical bonding of atoms is nearly unchanged from that of crystals. Nonetheless, a fairly small, disorderly variation in the angles between bonds eliminates the regular lattice structure. Such noncrystalline semiconductors can have fairly good electronic properties – sufficient for many applications. The first commercially important example was xerography [1, 2], which exploited the *photoconductivity* of noncrystalline selenium. As do all semiconductors, selenium absorbs those photons from an incident light beam that have photon energies exceeding some threshold energy. The photon that is absorbed generates a positively charged “hole” and a negatively charged electron that are separated and swept away by the large electric fields used in xerography.

However, solar cells require that photogenerated electrons and holes be separated by relatively modest electric fields that are “built-in” to the device, and selenium and many other noncrystalline semiconductors proved unsuitable for making efficient cells.