Our Solar System Essay, Research Paper

Solar cells today are mostly made of silicon, one of the most common elements on Earth.The crystalline silicon solar cell was one of the first types to be developed and it is still the mostcommon type in use today. They do not pollute the atmosphere and they leave behind no harmfulwaste products. Photovoltaic cells work effectively even in cloudy weather and unlike solarheaters, are more efficient at low temperatures. They do their job silently and there are nomoving parts to wear out. It is no wonder that one marvels on how such a device wouldfunction. To understand how a solar cell works, it is necessary to go back to some basic atomicconcepts. In the simplest model of the atom, electrons orbit a central nucleus, composed ofprotons and neutrons. each electron carries one negative charge and each proton one positivecharge. Neutrons carry no charge. Every atom has the same number of electrons as there areprotons, so, on the whole, it is electrically neutral. The electrons have discrete kinetic energylevels, which increase with the orbital radius. When atoms bond together to form a solid, theelectron energy levels merge into bands. In electrical conductors, these bands are continuous butin insulators and semiconductors there is an “energy gap”, in which no electron orbits can exist,between the inner valence band and outer conduction band [Book 1]. Valence electrons help tobind together the atoms in a solid by orbiting 2 adjacent nucleii, while conduction electrons,being less closely bound to the nucleii, are free to move in response to an applied voltage orelectric field. The fewer conduction electrons there are, the higher the electrical resistivity ofthe material. In semiconductors, the materials from which solar sells are made, the energy gap Eg isfairly small. Because of this, electrons in the valence band can easily be made to jump to theconduction band by the injection of energy, either in the form of heat or light [Book 4]. Thisexplains why the high resistivity of semiconductors decreases as the temperature is raised or thematerial illuminated. The excitation of valence electrons to the conduction band is bestaccomplished when the semiconductor is in the crystalline state, i.e. when the atoms arearranged in a precise geometrical formation or “lattice”. At room temperature and low illumination, pure or so-called “intrinsic” semiconductorshave a high resistivity. But the resistivity can be greatly reduced by “doping”, i.e. introducinga very small amount of impurity, of the order of one in a million atoms. There are 2 kinds ofdopant. Those which have more valence electrons that the semiconductor itself are called”donors” and those which have fewer are termed “acceptors” [Book 2]. In a silicon crystal, each atom has 4 valence electrons, which are shared with aneighbouring atom to form a stable tetrahedral structure. Phosphorus, which has 5 valenceelectrons, is a donor and causes extra electrons to appear in the conduction band. Silicon sodoped is called “n-type” [Book 5]. On the other hand, boron, with a valence of 3, is anacceptor, leaving so-called “holes” in the lattice, which act like positive charges and render thesilicon “p-type”[Book 5]. The drawings in Figure 1.2 are 2-dimensional representations of n-and p-type silicon crystals, in which the atomic nucleii in the lattice are indicated by circles and

the bonding valence electrons are shown as lines between the atoms. Holes, like electrons, willremove under the influence of an applied voltage but, as the mechanism of their movement isvalence electron substitution from atom to atom, they are less mobile than the free conductionelectrons [Book 2]. In a n-on-p crystalline silicon solar cell, a shadow junction is formed by diffusingphosphorus into a boron-based base. At the junction, conduction electrons from donor atoms inthe n-region diffuse into the p-region and combine with holes in acceptor atoms, producing alayer of negatively-charged impurity atoms. The opposite action also takes place, holes fromacceptor atoms in the p-region crossing into the n-region, combining with electrons andproducing positively-charged impurity atoms [Book 4]. The net result of these movements is thedisappearance of conduction electrons and holes from the vicinity of the junction and theestablishment there of a reverse electric field, which is positive on the n-side and negative onthe p-side. This reverse field plays a vital part in the functioning of the device. The area inwhich it is set up is called the “depletion area” or “barrier layer”[Book 4]. When light falls on the front surface, photons with energy in excess of the energy gap(1.1 eV in crystalline silicon) interact with valence electrons and lift them to the conductionband. This movement leaves behind holes, so each photon is said to generate an “electron-holepair” [Book 2]. In the crystalline silicon, electron-hole generation takes place throughout thethickness of the cell, in concentrations depending on the irradiance and the spectral compositionof the light. Photon energy is inversely proportional to wavelength. The highly energetic photonsin the ultra-violet and blue part of the spectrum are absorbed very near the surface, while theless energetic longer wave photons in the red and infrared are absorbed deeper in the crystal andfurther from the junction [Book 4]. Most are absorbed within a thickness of 100 m. The electrons and holes diffuse through the crystal in an effort to produce an evendistribution. Some recombine after a lifetime of the order of one millisecond, neutralizing theircharges and giving up energy in the form of heat. Others reach the junction before their lifetimehas expired. There they are separated by the reverse field, the electrons being acceleratedtowards the negative contact and the holes towards the positive [Book 5]. If the cell is connectedto a load, electrons will be pushed from the negative contact through the load to the positivecontact, where they will recombine with holes. This constitutes an electric current. In crystallinesilicon cells, the current generated by radiation of a particular spectral composition is directlyproportional to the irradiance [Book 2]. Some types of solar cell, however, do not exhibit thislinear relationship. The silicon solar cell has many advantages such as high reliability, photovoltaic powerplants can be put up easily and quickly, photovoltaic power plants are quite modular and canrespond to sudden changes in solar input which occur when clouds pass by. However there arestill some major problems with them. They still cost too much for mass use and are relativelyinefficient with conversion efficiencies of 20% to 30%. With time, both of these problems willbe solved through mass production and new technological advances in semiconductors.