Copper Indium Gallium DiSelenide – CIGS Photovoltiac Solar Technology

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Photovoltaics (PV) systems produce electricity when exposed to sunlight. Sunlight is composed of particles of energy called photons. When sunlight strikes a PV material, photons will either pass through, be reflected, or be absorbed. If the photon is absorbed, its energy will be transferred to an electron in an atom of the PV material. With its new found energy, the electron is able to escape from its normal position in orbit around that atom. In this way, the electron can become part of, and augment, the current in an electrical circuit. This “photovoltaic effect” is the basic physical process through which sunlight is converted into electricity.(Fig. 1 & 2)

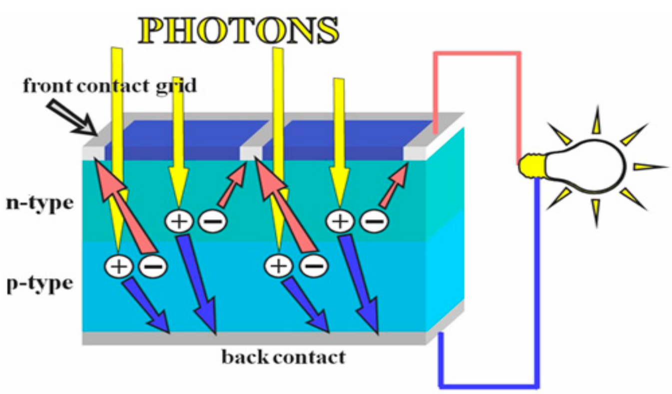
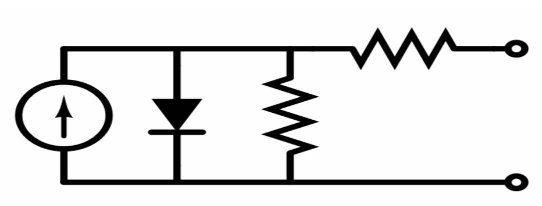


Fig. 1

The primary building block of a PV system is the PV cell. A typical PV cell is about 3” X 3” and very thin. By itself, a single PV cell produces only a small amount of electricity. Fortunately, it is easy to increase the total power in a PV system by connecting several cells to form larger units called modules. Modules, in turn, can be connected to form even larger units know as arrays, which can be interconnected to produce more power, and so on. In this way, a PV system can be built to meet almost any power need, no matter how small or great.



The Equivalent Circuit of a Solar Cell

Fig. 2

Thin Film PV Overview

All commercially viable PV products are made using one of two groups of technologies; Crystalline Silicon or Thin-film materials. Traditional Crystalline Silicon is by far the most common solar cell material for commercial applications.

This is because:

- It has been in use for more than 50 years, and its manufacturing processes are well known. Those processes are now largely in the public domain.
- The raw material used, silicon, is very abundant (it’s the second most abundant element in the Earth’s crust – second only to oxygen)

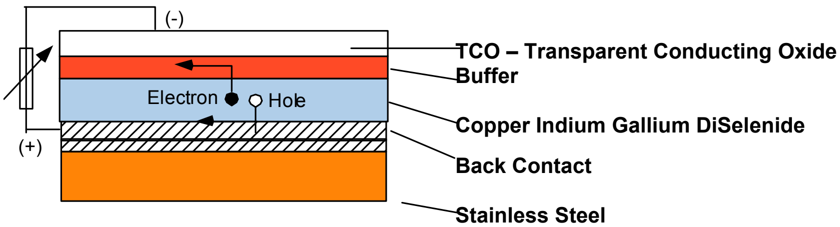
Although raw silicon is readily available, the silicon used in solar cells must be refined to an extremely high purity (99.9999 percent) – far more refined than most prescription medicines. Refining to this degree makes the silicon quite expensive.

There are two basic forms of crystalline silicon PV:

- Single-crystalline silicon, which is more efficient at creating electricity from sunlight but is more expensive to manufacture
- Poly-crystalline silicon, which is less efficient at creating electricity from sunlight, but is less expensive to manufacture.

Like computer chips, PV devices are made from semiconductors. Accordingly, many of the lessons learned developing computer technologies have been applied to improving PV. One of the scientific discoveries of the computer semiconductor industry that has shown great potential for the PV industry is thin-film technology.

Rather than growing, slicing, and treating a crystalline ingot, as with crystalline silicon, a PV material can be created by sequentially depositing thin layers of the different materials into a very thin structure. The resulting thin-film devices require very little semiconductor material and have the added advantage of being easy to manufacture.



CIGS Thin Film Layers

Thin film technologies using several materials systems and novel deposition techniques have been proposed, from "printed" CIGS using feedstock formulated as ink, to organic or dye-sensitized absorbers. Despite claims made for particular approaches, the low cost potential of thin film PV stems from only 3 factors; i) greatly reduced use of materials, notably semiconductors, ii) inexpensive deposition and processing methods, and iii) low cost substrate materials.

CIGS PV Solar Technology Overview

CIGS create more electricity from the same amount of sunlight than does other thin-film PV and therefore has a higher "conversion efficiency". CIGS conversion efficiency is also very stable over time, meaning its performance continues unabated for many years. The performance of many other PV materials can rapidly decline with use. Copper Indium diSelenide ($CuInSe_2$) has an extremely high absorption that allows 99 percent of available light to be absorbed in the first micron of the material. This makes it an optimal, effective PV material. Adding small amounts of Gallium to the $CuInSe_2$ boosts its light-absorbing band gap, which makes it more closely match the solar spectrum, thereby improving the voltage and the efficiency of the PV cell. CIGS cells have reached efficiencies of more than 19 percent – much higher than other thin-film PV. CIGS also has a demonstrated ability to pass appropriate environmental certification and waste-handling requirements.

CIGS Flexible Solar Cells

Continuous roll-to-roll coating of all thin film PV layers on flexible substrates for CIGS was pioneered by Global Solar Energy (GSE) in 1995 as perhaps the lowest cost deposition method available. Some proponents of ink-printed methods and organic PV have recognized the advantages of roll-to-roll coating, and have also advocated the use of non-vacuum deposition methods to reduce costs. However, at least 3 thin film layers are required in any of the thin film approaches (a front transparent contact, an absorber layer and a back contact) and vacuum-based methods are typically used for the front and back contacts regardless of the specific absorber or semiconductor. As for the absorber layer, vacuum deposition has provided the highest efficiency thin film PV. Particularly in the case of CIGS, vacuum deposition methods offer the greatest flexibility and control over semiconductor composition and morphology, and thus also conversion efficiency. Significantly, vacuum deposition of CIGS is not costly in a roll-to-roll format – the capital equipment cost for this step at GSE (amortized over the useful equipment life) amounts to about $0.0002/kwh cost in the product, yet the advantages are substantial.

CIGS Products in the Market

Global Solar Energy, Inc. uses a proprietary process for depositing (CIGS) on a flexible substrate. While other companies produce CIGS on glass, GSE is the only company to date producing CIGS on a flexible substrate and distributing foldable and glass products using this process.

References:

1. Scale-Up at GSE; (file_id – wiedeman_GSE_"Scale-Up_at_GSE") DOE Solar Energy Technologies Program (SETP) Meeting, April 17-19, 2007 Denver, CO
2. Dr. Jeffrey Britt Ph.D., VP of Technology, Global Solar Energy, Inc.