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GENERAL ASPECTS OF SOLAR CELLS AND PHOTOVOLTAIC SYSTEMS (PV) USED IN GREECE

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ABSTRACT: General information and details about solar radiation is given. Reasons for and against the use of solar energy for covering the energy needs of various human activities are discussed. A short presentation of the physics of solar cells is provided. The multiple use of photovoltaic systems in various areas of Greece and the development perspectives are presented.

1. INTRODUCTION

The increasing energy needs of civilized societies necessitate the development of alternative energy sources. The photovoltaic conversion of solar energy into electricity promises to provide high-quality energy at low cost and most importantly without pollution. In this perspective, improvements in the efficency of solar cells and the electronic components that assist the easy use of the produced energy is required. The present paper is especially focused on the various applications of the photovoltaic systems in Greece.

2. SOLAR ENERGY

The radiative energy output from the sun derives from nuclear fusion reaction. In every second, about 6×10^{11} kgr of H_2 is converted to He, with a net mass loss of about 6×10^{11} kgr, which is converterd through the Einstein relation ($E = mc^2$) to 4×10^{20} Joule. In every year, the amount of solar energy on the earth surface is about 4×10^{17} kWh. This amount is ~ 50.000 times larger than the present energy needs of the whole earth. The energy is emitted primarily as Electromagnetic radiation in the ultraviolet to infrared and radio spectral region $0.2\mu < \lambda < 3\mu$. The total mass of sun is now ~ 2×10^{30} kgr and a reasonable stable life with a nearly constant radiative energy output of over 10 bilion (10^{10}) years, is projected [1].

3. GENERAL ASPECTS FOR THE USE OF SOLAR ENERGY

Reasons for and against the use of solar energy are given below:
a) it is an endless source of clear energy,
b) it is provided in a certains period,
c) its intensity is not stable. It depends on the meteorological conditions,
d) intensity is relative slow and the collection for thermal purposes needs large surfaces,
e) since the energy is provided not continuosly (interuption through the night, or due the cloudness conditions) there is a necessity for storage,
f) components of advanced technology (and therefore expensive) are required for the proper and beneficial use of the producive electric energy.

4. THE SOLAR ENERGY TRANSFORMATIONS

The solar energy could be directly transform to the following energy forms, mechanical, chemical, thermal and electric. The latter two forms are of interest here. Thermal energy produced from solar energy could be used in two ways: firstly, for heat applications which do not concern the present study and secondly, by transforming the heat energy to electric. In the later case the photon energy of the solar radiation is used to increase the temperature of one part of the setting. In turn the thermal heterogeneity of the setting produces an electromotive force between its poles. The achievment of the direct transformation of solar to electric energy is based on three phenomena :
1. thermionic emission (Edison effect),
2. thermoelectric effect (Seebeck effect),
3. photovoltaic effect (internal photoelectric effect).
Case (3) is the most important and widely used in the industry.

5. THE SOLAR CELL

We note that generally, solar energy could be transform to electric energy, under certain conditions, when the photons of the solar radiation disturbs the thermodynamic equilibrium of a certain part of a setting consisting from different metals or different semiconductors in contact. It is much easier to disturb the thermodynamic equilibrium in a semiconductor than in a metal. This explain the wide use of semiconductors in solar to electric power processes.
A conventional solar cell, for example a p-n junction has a simple band gap E_g. When the cell is exposed to the solar spectrum, a photon with energy less than Eg makes no contribution to the cell output. A photon with energy greater than Eg, contributes an energy Eg to the cell output, whereas the excess energy over Eg is turn to heat. Upon colission, an electron from the valence band is injected to the conduction band. Thus pairs of electrons and holes are produced in the junction region. Under the influnce of the junction voltage these free carries are pushed aside from the junction. If the p-n diode is connected with an external circuit then an electric current is created (photocurrent). The intensity of the current is directly propotional to the intensity of the solar radiation. If there is no an external electric circuit, then in the poles of the solar cell a photovoltaic voltage is developed with a value propotional to the intensity of the solar radiation. In Fig.1a the energy-band diagramme of a p-n junction is illustrated, in Fig.1b the equivalent circuit of a solar cell is given, and in Fig.1 (right) current-voltage characteristics are provided [2]. Additionally, Fig.2 (left) is a schematic illustration of a solar cell, whereas Fig.2 (right) gives the structure of the solar cell.

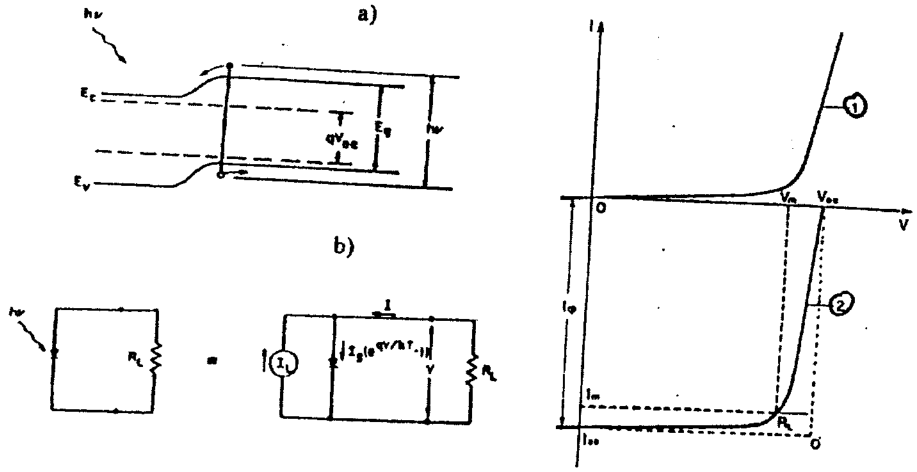

Fig.1 Energy-band diagram of a p-n junction solar cell under solar irradiation (a), idealized equivalent circuits of a solar cell (b) and right current-voltage characteristics of a solar cell (1) in light and (2) in dark.

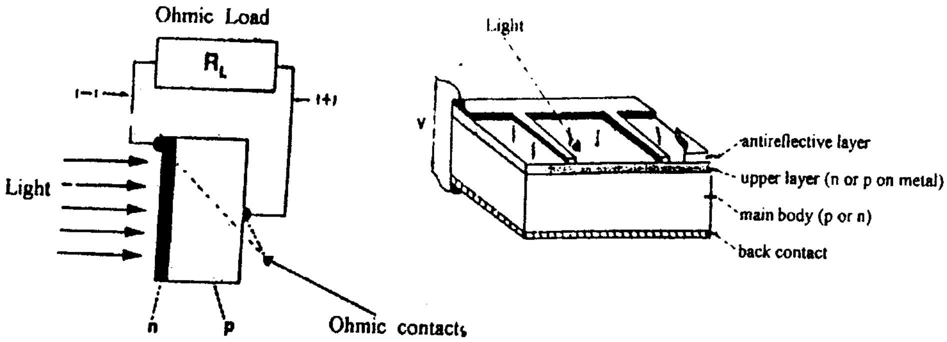

Fig.2 Schematic illustration of a solar cell (left) and structure of a solar cell (right).

6. TECHNICAL ASPECTS OF SOLAR CELLS

The basic problems of the physics and technology of the solar cells are mainly related to the following two questions: which contact is more efficient and which is the better material for the (PV) structure. The most commonly used materials for solar cells are: Si, AsGa, InP, CdTe and Cu_2S. However, modern technology uses widely Si for p-n solar cells. The advantages of Si are the following :

1. Si is the cheepest semiconductor material
2. Si is abandant in nature, harmless and safe,
3. the metalurgical process of Si is well-known and developed,
4. the technology of p-n production with Si is well-known,
5. Si (after AsGa) is the best material that matches with the solar spectrum.

The manufacting process of Si solar-cells is illustrated in Fig.3.

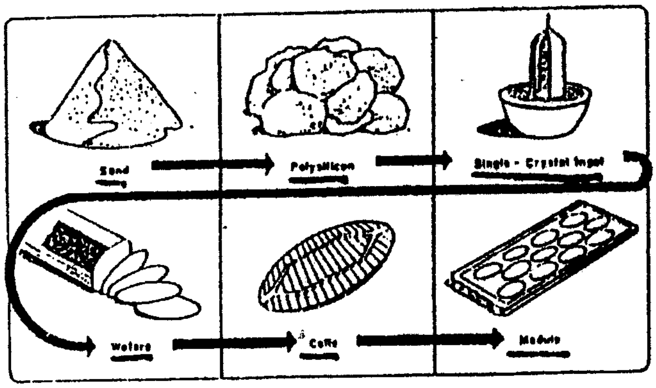

Fig.3 Solar-cell-manufacturing process from Si.

It is important to notice at this point that after thermal and other energy losses only 12-18% of solar energy is transformed to electric energy in the present state-of-the-art silicon solar cells.

7. ELECTRONIC SUPPORT FOR (PV) SYSTEMS

The following electronic components are commonly used in conjuction with PV systems:

a) dc-dc converters,
b) circuits for increasing the voltage,
c) circuits for decreasing the voltage,
d) circuits for polarity inversion,
e) control circuits,
f) regulators for batteries load,
g) dc-ac convertors (inverters).

8. SOLAR CELLS APPLICATIONS

PV systems are generally used to provide electricity in order to cover the needs of a house or a small settlement. Normally, PV systems are used in combination with wind-generators and they act satisfactorily for rural or isolated areas where the cost for connection with the usual lines of provision of electric power is very high.

On the other hand, the production of electricity from solar radiation is a far more expencive process than those related to normal sources of electric energy (e.g. petrol, coal, etc). A remarkable growth of the demand of PV cells will be achieved if the energy cost is reduced substantially. This aim will be attained by raising the efficiency of solar cells, improving their properties or making new materials and developing further the electronic support of the systems.

9. APPLICATIONS OF PV SYSTEMS AND USES IN GREECE (2)

1. To provide electric power to cover the everyday needs of small settlements e.g.:
   a) Saint Rumeli (Island of Crete), for the production of electricity
   b) Island of Kythnos, for the production of electricity (PV+ wind-generators)
2. Rural applications Island of Karpathos - PV systems are used to pump water from great depths for water provision, to improve the yield of sterile lands
3. A general use by the army Navy to provide electricity for the needs of the light-houses (Beacons) e.g. Port of Rethymnon (Island of Crete)
4. Electricity provision for the needs of any kind of telecommunication instalations (transmitters, etc) and radio and television relay stations in mountains or/and isolated regions

10. OTHER USES OF PV SYSTEMS IN GREECE

1. Water-heaters (geysers)
2. Aphalatosis (provision of drinking-water after removing the salt from the sea water)
3. Desiccation of grapes (drying)
4. Energy provision for small house equipments (e.g. furnaces, refrigirators, solar clocks, etc.)

11. CONCLUSIONS

In the course of the electricity generation from solar energy a lot of attention is devoted to photovoltaic conversion. The energy provided from PV systems could be used for covering the everyday needs of small settlements in isolated areas. The use of solar cells in Greece becomes evident since, on the one hand Greece is a rural country with many islands and isolated areas and on the other hand the sunny period is very long during each year. The use of PV systems will be extended in less sunny areas when technology will be able to produce more effective solar cells.

REFERENCES

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HAUPTANWENDUNGEN VON SOLARZELLEN UND PHOTOVOLTAISCHEN SYSTEMEN IN GRIECHENLAND

In der Arbeit stellen wir allgemaine Daten über Solarenergii vor. Wir präsentieren die Ursachen und Erwartungen, die die Anwendung von Solarenergii zur Deckung von verschiedenen menschlichen Aktivitäten mit sich bringt. Eine kurze Einführung in der Physik der Solarzelle wird dargestellt. Verschiedene Anwendungen und Zukunft von Photovoltaischen Systemen in Griechenland wird ebenfalls präsentiert.