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TRANSMITTING ENERGY WITH LASERS AS MEANS FOR INJECTION ON FADING SATELLITES

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***Abstract:** The article discusses the results achieved after radiation of a solar panel with CO2 laser and covers the short circuit, the floating voltage, and the efficiency. The theoretical deriving of the most appropriate laser wavelength, referred to the maximum transformation of laser energy into electrical energy for mono crystal silicon is presented. The volt-ampere characteristics of the photo receiver are described*

Introduction

The research of the influence of the laser radiation on photo voltage systems is important, providing energy for existing satellites in the end of their life, due to reduction of the energy system [1]. This type of radiated laser energy has a great commercial value [2]. The laser radiation is preferable because of the high efficiency of the silicon cells under monochromatic lightening [3], and the possibility of increasing the energy, in order to produce more energy outcome per area [4].

Exposition

Laser with Carbon Dioxide

The most appropriate laser for injection on fading satellites is CO2 – laser, where the amplification is approximately = 1006 nm, i.e. this is the closest value provided for the maximum of the transformation of the laser energy into electric energy for the silicon semi-conductor.

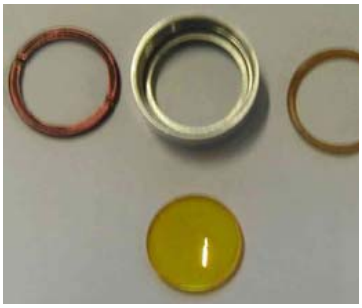
CO2 – lasers generate a broad range of lines in the scope between 900 nm up to 1100 nm. The strongest amplification is at 1060 nm. They are characterized with strong efficiency, reaching up to 20 % for well constructed models.

- The laser used (Model L 1000) has:
- longitudinal smoldering discharge and fast longitudinal channel;
- Output power by specification - 1000 watts;
- Laser environment – carbon dioxide;
- Mod –TEM01;
- Diameter of the output ray – 15mm;
- Beam divergence – 2 mRad;
- Polarisation – circular.

The CO2 has more homogeneous and active environment and provides more qualitative and direct radiation. It has better mode structure and better focusing [5].

Picture 1. General view of the CO2 laser

Picture 2. Transverse view of the CO2 laser



Picture 3. Defocusing lens

Solar Panel

The silicon is the main semi-conductor material for photoelectric transformation of the solar energy [6].

The direct transformation of the solar energy into electric energy can be achieved with solar batteries, consisting of multitude of photo elements, through the so called photovoltaic effect [7].

The model of the used solar panel is:

- 685-SP-120-12 V;
- Voltage – 12 V;
- Current Voc – 120 μA;
- Voltage (MAX) Voc – 16 V;
- Current (MAX) Isc;
- Size 15.9 x 27.8 x 1.7 cm.

The solar panel consists of 36 consequently connected photo elements, which aim at the increasing of the output voltage.

Resistors

- R1 = 33 кΩ;
- R2 = 77 кΩ;
- R3 = 143 кΩ;
- R4 = 308 кΩ;
- R5 = 406 кΩ;
- R6 = 503 кΩ;
- R0 = 0; R = ∞

Meanings

- Rel – Electric power;
- Rl – laser power of the successive line of generation;
- η, % - efficiency;
- η = Rel /Rl.100;
- Rel = I.U – electric power.

Experiment

In front of the CO2 laser a defocusing lens is set, that allows a spot with diameter 5 cm and 25 cm. The photo converter is set at 150 cm distance from the lens. Ampere meter, voltmeter and resistors for measuring of the current are plugged into the photo converter.

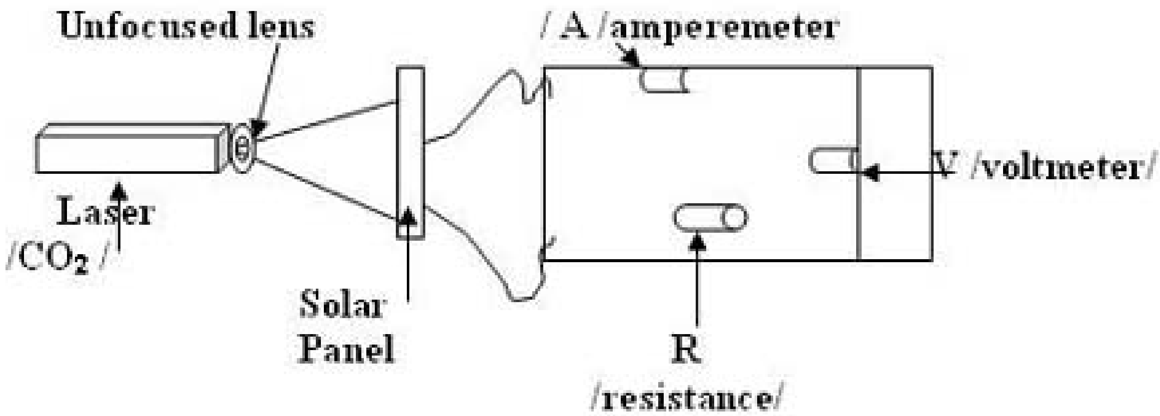


Figure 1. Scheme of the experimental setting

Results

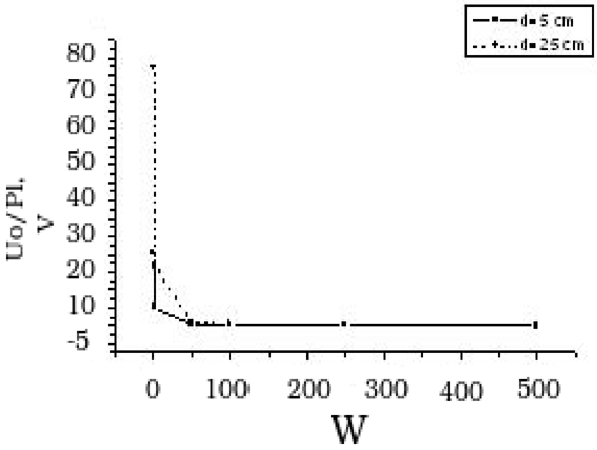


Figure 2. Dependency of Uo/Pl from the power at various diameters of the laser spot

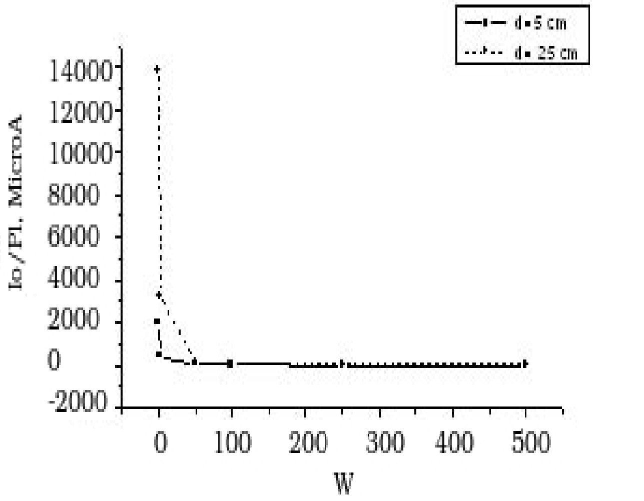


Figure 3. Dependency of the Io/Pl from the power at various diameters of the laser spot.

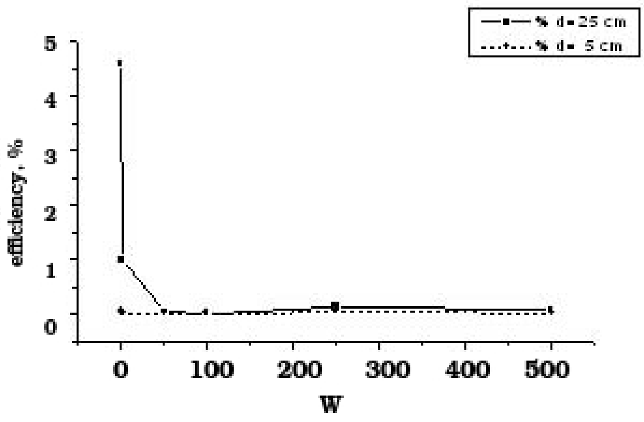


Figure 4. Dependency of the efficiency at various diameters of the laser spot

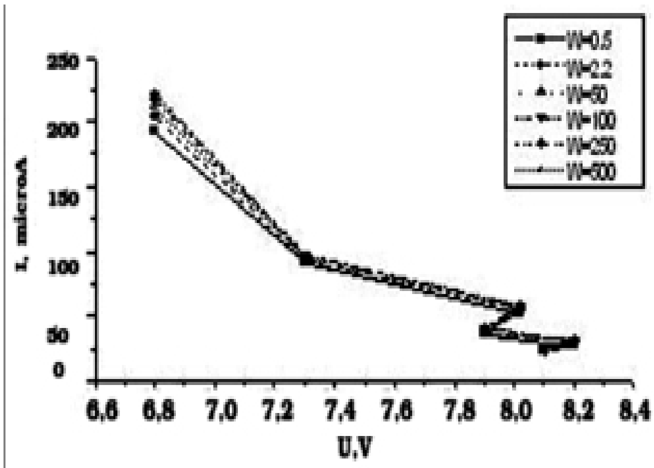


Figure 5. Volt-ampere characteristics for CO2 laser at various power and diameter of 5 cm.

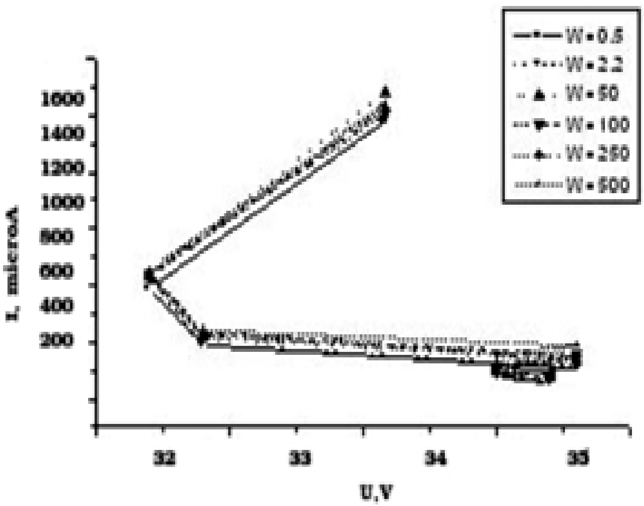


Figure 6. Volt-ampere characteristics for CO2 laser at various power and diameter of 25 cm.

Analisis of the Results

The following quantities can be brought into use, that characterize the panel's quality to transform the laser light into electric one, depending on the diameter of the laser spot and the power of the laser emission. These are the ratio between the floating voltage and the laser's power U0/Pl, and the current I0/Pl, that results from the short circuit. During laser radiation at 0.5 W the floating voltage for a 25 cm spot is 3.6 times greater than the one for a 5 cm diameter spot. The values for the short circuit current for a spot of 25 cm are approximately 7 times bigger. As the laser power increases there is no significant increase of the floating voltage and the short circuit current – 36 V and 7 mA for 25 cm and 12 V and 1 mA for 5 cm at 0.5 up to 500 W power.

The values of the electric power of the solar panel at 0.5 W radiation are more than 38 times bigger at 25 cm diameter of the laser spot than these at 5 cm, for resistance R = 33kΩ.

The difference between the electric power at 5 and 25 cm increases with the increase of the resistance and at R= 503 kΩ the electric power is 85 times bigger. This ratio (P5cm- P25cm), is preserved more or less unchanged at every value of the laser's power.

The efficiency, which is the most important characteristic of the researched system, varies from 8,98 % for 25 cm diameter of the spot to 0,2 % for 5 cm diameter of the spot at R = 33kΩ. The efficiency gradually decreases with the increase of the resistance reaching 3,02 % for 25 cm and 0,03 % for 5 cm.

With the gradual increase of the laser's power from 0,5 W to 500 W the electrical power of the photo converter increases as well with approximately 3 mW, but thus reducing the efficiency. The lowest efficiency values of the photo converter are achieved at the highest level of the laser emission's power (Fig. 4).

The volt-ampere characteristic of the photo element, at 5 cm laser spot diameter (Fig. 5) shows relative nonlinearity. Certain saturation is indicated at the higher voltage values. For 25 cm laser spot the volt-ampere characteristic is S-shaped, and the saturation is measured again at the lower current and the higher voltage values. Nonlinearity probably results from the raised temperature of the selective coverage, which causes emission of heat, thus increasing the resistance causing the current to stop decreasing linearly, but keep same values (Fig. 6).

Conclusions

The analysis of the results shows that the usage of a wavelength, close to the theoretically deduced one, increases the photo element efficiency. In the same time the results suggest that for producing high efficiency higher power is not necessary.

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