11th International Conference on Renewable Electrical Power Sources

PROCEEDINGS

Editor Dr Milica Vlahović

Belgrade, November 02–03, 2023

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on Renewable Electrical Power Sources

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FOREWORD

The conditions created by the development of technologies in which modern man lives have led to a complex and paradoxical effect: that by removing obstacles on the way to a more comfortable, simpler, faster and more efficient life and way of working, man also generates numerous misfortunes, attracting dark clouds of threats to the survival of the planet and humanity. The question that concerns and affects all of us - all people, all living beings, systems in which life takes place, large and small, strong and weak - boils down to the problem of the negative impact of man on the environment; this issue invites us to an urgent solution by looking at the causes, proposing solutions, evaluating them, changing approaches and ways of thinking, as well as drawing correct conclusions. Simply put, by adapting nature to one's own needs, man threatens and damages it. That is why, with the joint efforts of all of us, individuals, organizations and states, it is necessary to take all possible measures to immediately prevent the negative effects that are ahead of us.

The importance of renewable sources of electricity, which this international conference focuses on, is noticeable from two angles: the first - it is certain that fossil fuels as a resource will disappear and it is necessary to find alternative sources, the second - the use of renewable energy sources by its essence implies "clean" technology that significantly contributes to reducing CO_2 emissions and thus mitigating climate change and reducing pollution, while encouraging social and economic development in all spheres of life.

The 11th International Conference on Renewable Electrical Power Sources is organized by the Society for Renewable Electrical Power Sources (DOIEE) at SMEITS, with co-organizers: The Institute of Architecture and Urban & Spatial Planning of Serbia (IAUS) and the Chamber of Commerce and Industry of Serbia, with the support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

The registered participants designed their papers according to the given conference topics:
- Energy sources and energy storage;
- Energy efficiency in the context of use of renewable energy sources (RES);
- Environment, sustainability and policy;
- Applications and services.

Eminent authors - scientists, teachers, experts in this field from fifteen different countries: Algeria, Belgium, Bosnia and Herzegovina, China, Croatia, Greece, Hungary, India, Portugal, Saudi Arabia, Serbia, Slovenia, Spain, the United Arab Emirates, and Ukraine, contributed to the conference through sixty-nine papers that were reviewed by the Scientific Committee of the Conference, and after the review process were accepted for presentation at the conference and for publication in the proceedings.

At the end of this short message and at the beginning of the proceedings I believe that it can be proudly said that scientists, researchers, policy makers and industry experts gathered in one place, in order to exchange experiences and knowledge with the aim of promoting scientific and professional ideas and results of research, technology improvement for the use of RES, promoting the rational use of electricity, affirming and proposing inventive solutions in the field of sustainable sources of electricity.

Belgrade, *Milica Vlahović*
November 2023

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Energetski izvori i skladistenje energije:

<u>Energetska efikasnost u kontekstu primene RES:</u>

<u>Životna sredina, održivost i politika:</u>

Aplikacije:

INTERAKCIJE LASERA OD INTERESA ZA MATERIJALE U SISTEMIMA I KOMPONENTAMA U TRANSFORMACIJI ENERGIJE U LINEARNOM I NELINEARNOM OPSEGU

LASER INTERACTION OF INTEREST FOR MATERIALS IN SYSTEMS AND COMPONENTS IN ENERGY TRANSFORMATION IN LINEAR AND NONLINEAR RANGES

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Apstrakt

Materijali, sistemi i komponente za transformaciju energije su veoma različiti po dimenzijama i principima funkcionisanja. Nekoliko generacija u mnoštvu sistema i transformacija, proširilo se, čak generišući nova imena od nekadašnjih samo pretvarača, do aktuatora, senzora. Među savremenim sistemima i dalje su u upotrebi merni uređaji i komponente, koji se koriste u naučnim institutima, kompanijama, aplikacijama u mass-media primenama, ali i dugogodišnji fotomultiplikatori sa organskim i neorganskim kristalima. Tanki filmovi doživljavaju širenje aplikacija i oblika. Pored rada nekih sistema, u ovom radu se razmatraju vreme života za razmatrane slučajeve, snopne tehnike i različite kombinacije tehnika. Razmatrani su neki režimi rada, kao što su rad u Q-switch režimu, režimu slobodne generacije, i cw, kao i izloženost kratkim impulsima elemenata na bazi Si / solarnih ćelija i drugih savremenih materijala, koji se tiču transformacija energije. Razmatraju se povrede nastale određenim vrstama lasera.

Ključne reči: *Interakcija; transformacija energije; laserska oštećenja; modulacija*

Abstract

Material, systems and components for energy transformation are very different in dimensions and principles of operation. Several generations in a multitude of systems and transformations, have expanded, even generating new names, from former to actuators and sensors. Among contemporary systems, measuring devices and components, used in scientific institutes, companies, mass-media applications etc., but also long-standing photomultipliers with organic and inorganic crystals, are still in use. Thin films are experiencing expansion of applications and forms. Besides operation of some systems, in this paper are considered the time of life for considered cases, beam techniques and various technique combinations. Some operation regimes, as operation in - switch mode, free generation regime, as well as cw, are considered, as well as exposures to short pulses of elements based on Si / solar cells and other contemporary materials, concerning energy transformations. The damages caused with certain types of lasers are considered.

Key words: *Interaction; energy transformation; laser damages; modulation*

1 Introduction

From a historical point of view, it would be difficult to clearly present the state-of-the art of the first acts of energy transformation made by human beings. One could begin with the expression that people have started using solar energy even without being conscious about the closest star to our planet. The next important second way to transform energy was related to the photo effect and its explanation. It could be listed without selection whether it regards to a realized transformation, proposed from the point of view of the theory, experiment and reality. In the part of the paper that puts coherent light in the foreground, we will immediately have to consider non-linear effects in addition to linear ones. This has repercussion that the basic laws which appear in education, from the first years in school to the final university courses, have to be corrected or amended with terms of various intensities and exponents. This means that the basic laws of optics appear along with deviations, that is, relativism must be included somewhere, or quadratic (or even higher exponents) along with linear terms, or a completely different modeling should be used. In some parts, catastrophe theory, chaos modeling, disintegrations and modeling where chaos transforms into coherent states can be included [1-5].

For detailed consideration of such concept, the approach to the interaction and materials should be presumed with chosen principles of final outcome, of process efficiency and the definitions of existing standard transformations, and respective materials, adequate to selected profiles of interactions both with natural and artificial radiation, should be chosen. From this point, the methods for improving the emissivity of solar panels and photo-electric targets could be theoretically and practically established.

2 Experiment

Two solar components were exposed to lasers in the IR and visible range in multiple modes of operation in various dynamical regimes from cw to single- and multi-pulse in the same point (target) (Tabs. 1, 2).

Table 1. Series of experiments with femto second lasers.

Laser type	Coherent Mira 900
Possible parameters depending on the samples	
Min power	1.5 W
Pulse repetition	76 MHz
Wavelength	720 nm, 800 nm, 860 nm
Unfocused beam, linear polarization (horizontally)	
Beam diameter	1 mm
Possible time of exposition in this experiment	1 s, 3 s, 5 s
For conclusion: the highest effects and damage occurred at 720 nm	

Table 2. Series of experiments with Nd^{3+}: YAG laser; the case of solar cell materials with thin layer and ms regime.

Laser of interest for medicine, e.g. Dermatology, Dentistry	
Pulse duration	τ = 20 ms
Energy density:	300 J/cm^2
Pulse repetition:	1 Hz
Time of interaction/exposition:	10 pulses in the same location
The damage is marked by black arrows	

One group of the components that were related to the work of the laboratory ("Vinča") were exposed to: Cr^{3+}:Al_2O_3 and Nd^{3+}:YAG lasers. The macroscopic appearances of other group of the components are given in Figs. 1 and 5, and partial analyses of the resulting damages after the exposure was performed (Figs. 2-4, 6).

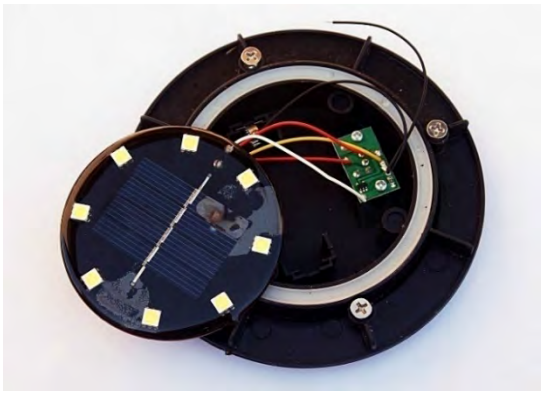

Figure 1. Device with a solar cell, macroscopic view.

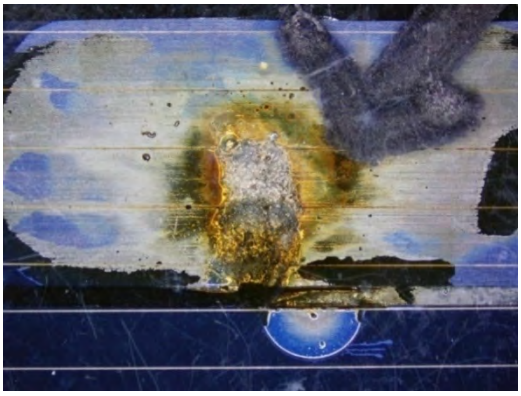

Figure 2. Solar cell, damage appearance, magnification 10x, industrial light microscope.

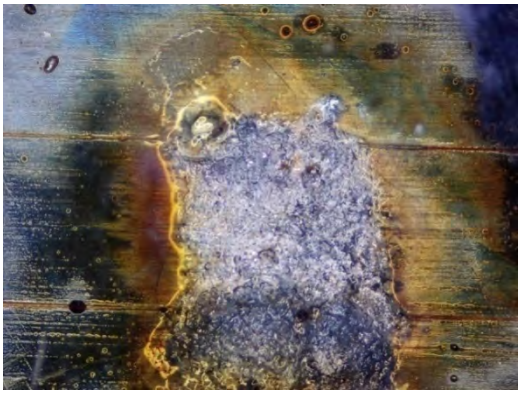

Figure 3. Solar cell, detail of damage appearance, magnification 30x, industrial light microscope.

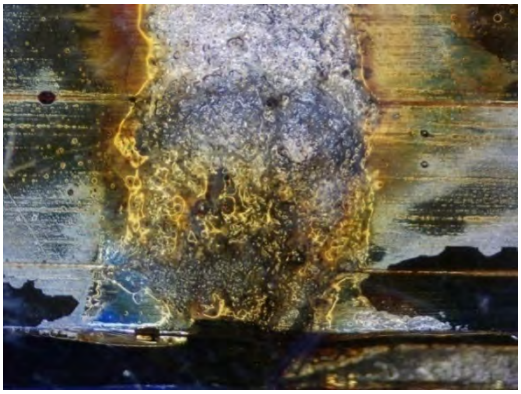

Figure 4. Solar cell, detail of damage appearance, magnification 30x, industrial light microscope.

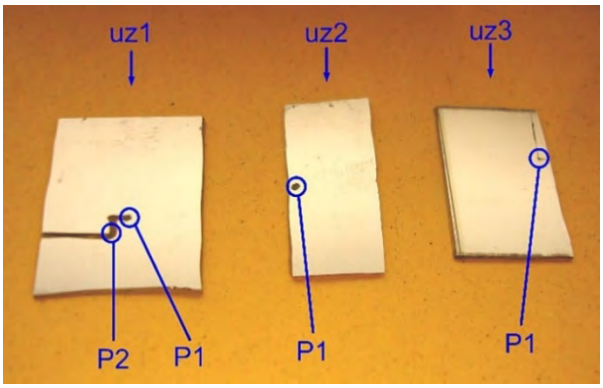

Figure 5. Pure Si, 8066, macroscopic view of samples.

Figure 6. Pure Si, Point P1 (uz3), damage appearance, magnification 10x, light microscope.

3 Lumped circuits

Using program packages, like SPICE and MATLAB is an efficient way for modeling of processes which include said devices (components) represented by their equivalent circuits[6]. In [7] the rate equations for the quantum well laser were modeled by corresponding equivalent circuit satisfying the same equations.

Many basic educationally courses cover the equivalent circuit theory as in [10-14]. A part of basic theory for educational detailed modeling is presented.

Transient analysis was performed in SPICE for the step power supply. Some of the models used for representing PV cell are shown in the Fig.7.

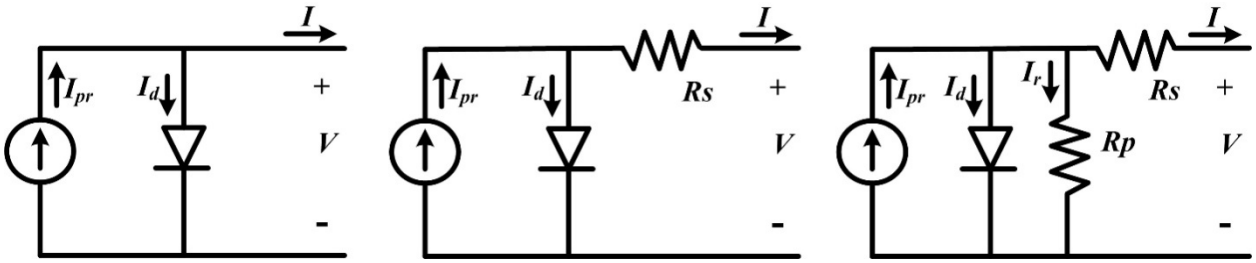

Figure 7. Three variants of PV cell model: a) ideal single diode model; b) practical diode model with serial resistance (R_s); c) practical model with serial and parallel resistance (R_s and R_p) [6]

Before testing the PV cell for power characteristics open circuit voltage and short circuit current need to be established[8, 9],which is a good practice in educative environments.

When measuring short-circuit current PV cell is short-circuited. From the model, it is clear that the diode voltage is 0V so it's current is zero. Thus, current I_L is also a short-circuit current.

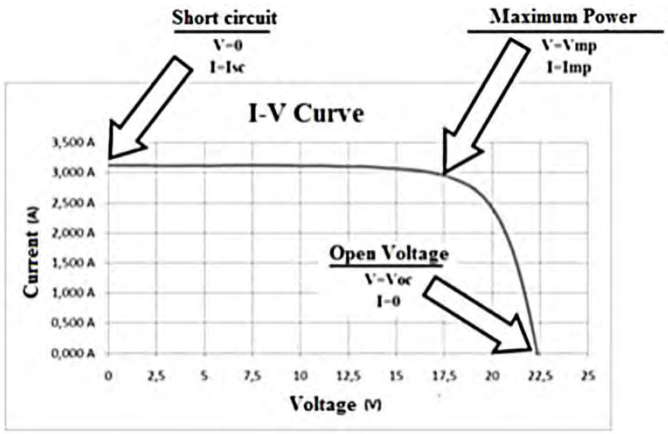

Figure 8. Current-voltage (I-V) curve of a solar cell with specific points (short circuit, maximum power and open voltage)

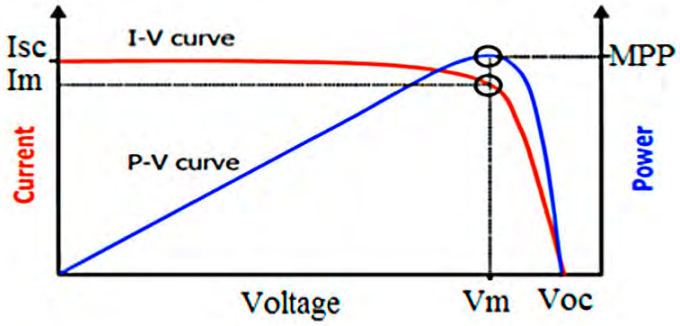

Figure 9.

Open-circuit voltage is measured with the opened circuit (resistance ∞). Then the PV cell is connected to load. Measured current depends on the load value. On small loads, small voltage drop leads to the conclusion that the diode is not operating, but the current equals to short circuit current (or slightly differs). For large loads, the current decreases to zero. On medium loads, the current is less than short-circuit current and the curve in I-V diagram shows a downward slope. In P-V diagram (power vs. voltage), maximum value of P is unambiguously shown.

The short circuit current (i.e. I_L current, *light current*or *photocurrent*) depends on solar irradiance. These values could be representing as a family of curves.

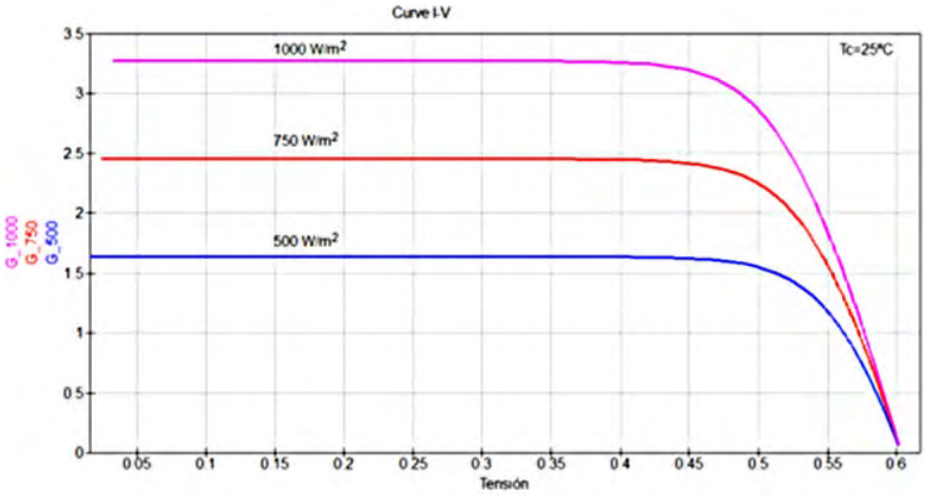

Figure 10. The short circuit current, as a family of curves, depends on solar irradiance.

Determining the characteristics of the PV cell.

a) Measurement of short circuit current I, for different solar irradiance. Determining the dependence of this current from solar irradiance G.
b) Measurement of open circuit voltage
c) Curve fitting for different G – movement of P_{max} point.

Contemporary references cover many tasks in civil engineering, power engineering, sustainable sources of energy i.e. many practical problems are solved where physical or chemical type of processes can be recognized [18-23].

4 Interaction and simulation draft

In the early works, near the end of the last century, there was a search for the relief caused bya certain type of laser and short pulses, which at that time were of the order of a few nanoseconds, created a flat area around the damage, practically without accumulating ejected materials around the edge of the crater.Comparing the same samples of various types of laboratory silicon, for regimes of free generations (on the order of *ms*, with approximately 100 to 150 spikes), typical images with accumulated layers of material around the crater were obtained.It was of interest to look for the profile of the crater, which was neither a circle nor an ellipse.At that time, the relationship between the incident injury and the theoretical spot in various materials was sought, and the ideal position for focusing the coherent beam was sought.It is often suggested that the beam be concentrated at 1/3 of the focal length below the surface.Since the application of lasers in connection with semiconductors and their interaction with resistive components was in its infancy, and along the way trimming of resistors, capacitors (and micro motors) were developed, many specific problems had to be solved for the industrial use of a certain type of quantum generator, related to material with mass production and dimensions prescribed tolerances.At that time, a large group of results appeared which showed the dependence of the lattice and the shape of the laser injury, macroscopically.

Many references show characteristic cases, where we had the influence of beam polarization, differences in material exposure at atmospheric pressure and in vacuum and cases in which there was an accompanying plasma, which depended on the intensity of the beam and on the target material (valence of the main of atoms in the target). Laser damage or materials cleaning are the subject of many experiments as well as modeling (solved by analytics or with computer support). Various principal descriptioninteractions with lasers are principally based on laser damage, laser cleaning processes and the cases of joining or drilling. Interaction with recoil modeling could be connected to corrosion processes. Mechanicalstresses provoked by laser beam transportation are also interesting area of investigation [24-29].

4.1 Life time, luminescence, line shape and application

Several of the listed concepts / processes / areas of application could cover several theoretical and practical activities, including various branches from the field of physics, metrology, different areas of the electromagnetic spectrum, with the motto of our work, energy transformation.Theoretically, one of the most common lines, from which the other two end lines are obtained by limes, with developed formalisms, are Voigt, Lorentz and Gauss lines. They are derived, on the other hand, according to the dynamics of the process in some ensemble of selected micro particles, in the broadest sense.Indicators are also related to the cosmos (astronomy), dynamics of solutions in liquids, with small or macromolecules.Developed formalisms in the field of critical phenomena, where measurements are much more difficult, in the case of magnets or neutrons, with developed theories, along with measurements in the "easier areas" of metrology, enables many practical answers and confirmations, through the rejection of hypotheses in the field of critical phenomena (BL, Stanly). The main mathematical formula for the description of the line is related to different areas of the electromagnetic spectrum, which extend from the order of kHz, MHz, to widths that are practically expressed in Kaisers.Detailed study of changes in the shape and main

characteristics of the line, for various fields, in spectroscopes of different types (atomic, molecular, etc.), has been practically mastered, with modern packages of programs and apparatus, with direct constants of certain types of materials and used for many temperature sensors, dirtiness, coagulation process, etc.On the other hand, according to the type of micro particlesthat participates in luminescent phenomena, Fig. 11, in the broadest sense, through PSD techniques (Pulse Shape Discrimination)[5, 15-17, 29].

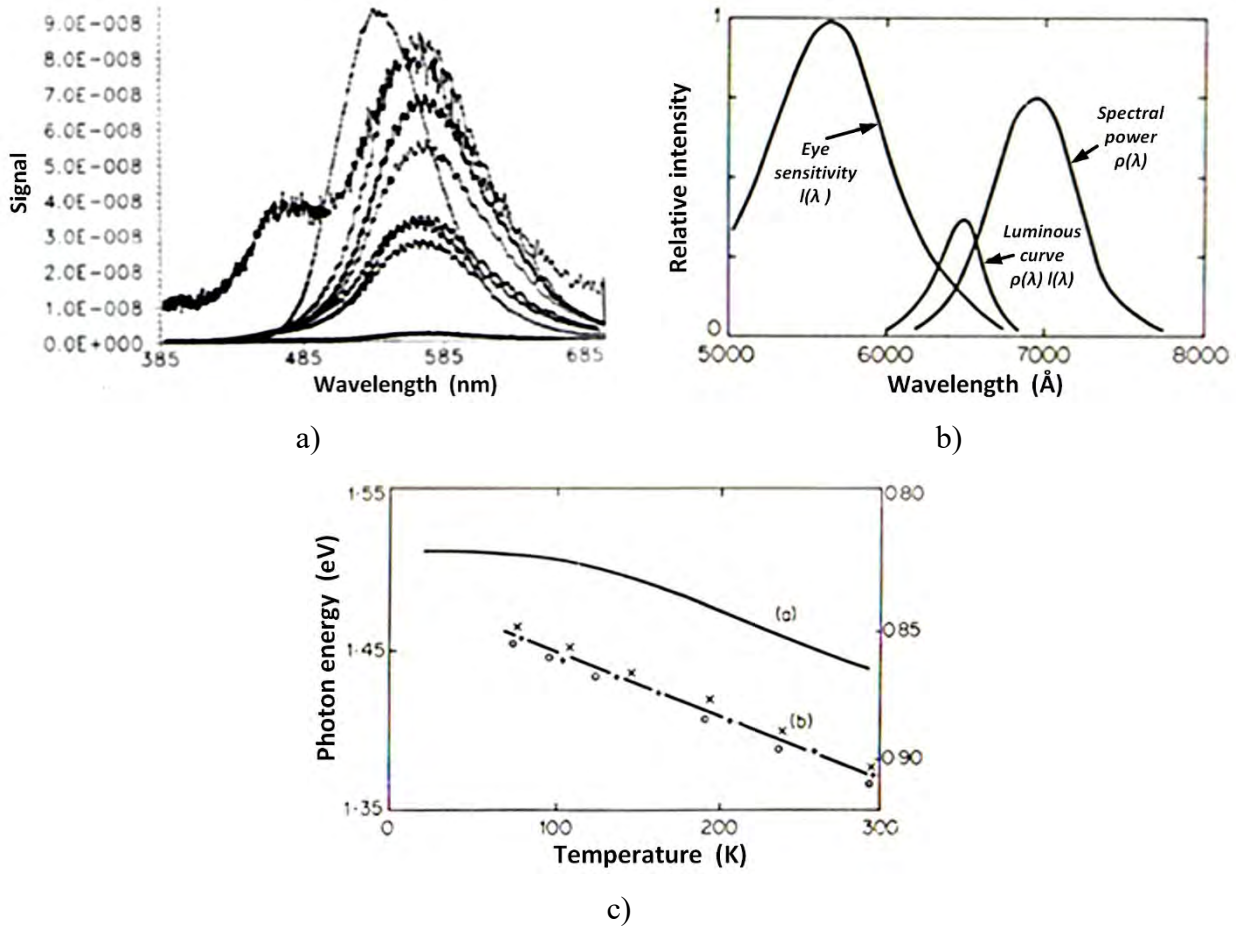

Figure11 a) Luminescence spectra, relative intensity after irradiation with various gamma radiations intensity b) Luminous equivalent of radiation for GaP-red range. c) Emission λ and photon energy of GaAs lasers and laser emission with λ-variation among devices [15-17].

5 Conclusion

In the last few decades, a great deal of activity has been invested regarding the search for new energy/power sources, as well as the transformation of energy, aiming to preserve the existing civilization standard/benefits. For each type of energy and its transformation, purely for *energy purposes*, sensor roles or mass media applications, there are many different aspects of approaching, modeling, and experimental solutions, but it seems that the issues of efficiency, ecology and impact on the biosphere are fundamental. The educational aspect, in search for established paths and the selection orientation of the necessary foundations, includes many requirements for an optimal understanding of the problem. The role of coherent energy, according to the degree of quality in the broad sense and density, along with power density and dynamic mode of operation, has slowly found and continues to establish its place.

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