**Proposal Details**
**2050**

Title:

**Variable Thermal Conductivity during Photothermal Renewable theory with Electron-Holes Excitation of Semiconductor Material**

Short Title or Acronym:

**Photothermal Renewable theory with Electron-Holes Excitation**

Keywords:

Photo-thermoelasticity; Thermal Conductivity; Heat conduction; Thermal stress; Renewable energy.

- Funding: 450,000 EGP
- Duration: 12 Months
- Total cost: 450,000 EGP
- Research Theme: Collaborative Research Project (CRP)
- Project field: Basic and fundamental sciences
- Project Subject: Mathematics

## Proposal Summary: English and Arabic (max. one page each)

In this project, a novel mathematical model of photo-thermoelasticity theory will be constructed. The governing equations are taken when the semiconductor material is homogenous, and has isotropic properties. The interaction between the electrons and holes inside the medium during The photo-thermoelasticity theory is taken into account. The microelement processes with the coupling between electrons-holes inside the medium is taken into consideration. The two dimensional deformation for governing equations is taken to discuss the main model in dimensionless. Some mathematical techniques is used to remove one space-time variable in the physical domain. To obtain the main physical quantities in the time domain, the ramp type heating is used at the free surface. Other mechanical-elastic-plasma conditions at the boundary is used with some numerical technique. The numerical results will be represented graphically to discuss the behaviour of the plasma, thermal, elastic and mechanical waves through the semiconductor elastic material.

## Introduction/Background (max. three pages)

The semiconductor materials have many physical and mechanical importance properties. These materials may be insulator in the nature but when apply some external effect such as raising heat they changes to conductors. Therefore, many applications for semiconductors materials are used in industrial especially inexpensive materials. Many scientists studied these materials for example silicon (Si) in the past as elastic materials neglecting the effect of thermal influence of incident light on them. In fact, there is a great contradiction in that, as when the semiconducting material is exposed to light or a beam of laser all surface electrons vibrate, causing elastic collisions which called thermoelastic (TE) deformation. But in reality, the electrons and the holes also move at the same time from one position to another causing electronic deformation (ED). In this case, the photo-excited processes are occurred and the free electrons with carrier density appears. On the other hand weak electrical current is generated with thermoelectric coupling parameter. Therefore, the microelements processes during the photothermal transport processes with microtemperatures influence inside the semiconductor medium are taken into accounted. The importance of the problem under study appears more when the thermal conductivity is variable nd is exposed to a strong external magnetic field. The effect of magnetic as the surrounding the Earth affects on the behavior of physical fields inside the medium. On the other hand, the interaction between electrons and holes must be taken into consideration.

The microelements possess with microtemperatures is studied during the development the second law of thermodynamic in the context of the bodies theory when the inner structure of the medium is taken into account [1]. In the theory of bodies with

microstructure taken the balance laws of continuum media into consideration when the first heat flux moment added to the heat equation [2]. Riha [2] investigated the inner structure of the thermoelastic materials and obtained in studying the silicone rubber material experimentally. In this excrement Riha [2] confirmed that the effect of microelements of the silicone rubber on thermal conductivity. During the study of thermoelasticity theory, many authors introduced various models depend on the microstructure of the elastic medium, in this case microtemperature field should be taken into consideration [3-6]. The elastic bodies are investigated in the context of thermo-mechanical theory when the microelements processes with microtemperature field is taken into account [7]. After that, Many authors investigated different models during the generalized thermoelasticity theory with microtemperature state when the inner structure of the elastic media is considered [8, 9].

Recently, the electronic deformation of the semiconductor materials should be studied when the interaction between electrons and holes taken into account. Therefore, various researchers introduced new models which that are taking up the effect of sunlight or laser beams on the semiconductor materials. The photothermal technique is introduced firstly to study the photoacoustic spectroscopy during a sensitive processes when a laser beams fell on a semiconductor sample [10, 11]. In the physical experiments for nano-composite semiconductor media, the photothermal technique during photo-excited processes is used to obtained the real values of the thermal-elastic and electrical parameters [12-16]. Lofty et al. [17-19] studied many novel models when they studied the semiconductor materials and constricted a novel theory call photo-thermoelasticity theory. Lofty et al. [18] investigated the impact of the thermomagnetic field in the context of microelement transport processes with microtemperature for the

semiconductor sample. On the other hand, Lotfy et al. [18, 19] discussed the Electromagnetic Hall current influence during microtemperature transport process when the thermal conductivity is variable in the context of a photothermal excitation semiconductor media. Many problems with photothermal transport processes are studied in the context of the two temperature theory for semiconducting medium under the impact of Thomson and rotation fields [20, 21].

Thus, In the project, we will study the interaction between electrons and holes in the context of the photo-thermoelasticity theory to improve some solar cells.

## Questions and Objectives (Max. three pages)

1. Constructing a new mathematical models of isotropic thermoelastic materials in the context of the photo-thermoelasticity theory.
2. Studying the impact of the plasma-thermal-mechanical loading on the deformation during electros-elastic deformation.
3. Construct a new techniques which describe the coupling between electrons and holes inside the elastic semiconductor materials.
4. Comparing the behaviors of the plasma-elastic-thermal-mechanical waves in the context of the photo-thermoelasticity theory.
5. Maximizing the partnerships between Arab Academy and Zagazig University and support research collaboration and communication in nano sciences.
6. Determine existing capabilities of the Egyptian in mathematics research capabilities.
7. Publish important articles and very interesting results which can enhance the manufacturing and using the semiconductor materials.

## Project Description (max. six pages)

In this project, a mathematical model of photo-thermoelasticity theory with using semiconductor elastic materials subjected to various types of plasma-elastic-thermal-mechanical loading will be constructed under many frames of the governing equations of photo-thermoelasticity theory when the interactions between electrons and holes are occurred.

By considering different initial and boundary conditions, we will get the solution of the models by using analytic direct method, state-space approach, transform method, normal mode method, finite element method, or other different mathematical methods.

The numerical results will be represented graphically to illustrate the distribution wave propagations of the plasma-thermal and elastic-mechanical waves.

The results will be discussed to stand on the parameters which plays a vital role on the speed wave propagation of the thermal and mechanical waves.

Among this project, some comparisons between are made during the phoyo-thermoelasticity theory with various theorems of thermoelasticity to discuss the effects of many mechanical and thermal parameters on the elastic semiconductor materials.

Through this project, we will get complete information about the behaviors of the semiconductor materials and improve the using in industries as solar cells.

Finally, at least two papers will be published in international journals.

## Research Design and Methods (max. four pages)

We will follow the following steps:

1- Prepare the literature review.

2- Constructing the mathematical models and the governing equations.

3- Determine the suitable types of the plasma-thermal and the elastic-mechanical loading.

4- Setting the governing equations in dimensionless variables.

5- Determine the suitable initial and boundary conditions.

6- Using the suitable methods to get the solution (Laplace and Fourier transformations harmonic wave motion, Normal mode... etc.).

7- Using numerical and algorithmic methods to get the final numerical solution.

8- Present the numerical results in 2D and 3D graphs and figures.

9- Discuss the numerical results according to the graphs and the figures.

10- Write the work and its conclusions in scientific articles and send them to international journals.

## Anticipated Results and Evaluation Criteria (Max. three pages)

1- The numerical results will be represented in 2D and 3D figures with some comparisons.
2- The conclusion about the results will be written to show its added values and connect this result with applications in industries.
3- The project and the results will be written in scientific forms to publish in international journals.

## Expected Project Outcomes and Impact to AASTMT (Max. two pages)

I- Technical output and Impact:

New results and conclusion about the behaviours of the plasma-thermal-elastic-mechanical of semiconductor materials will be published in international journals.

II- Financial feasibility & Socio-economic Impact:

Improve using the elastic semiconductor material in industries.

Maximizing the partnerships between Arab Academy and Zagazig University

III – Publication:

At least two papers will be published in international journals.

## Resources (Max. two pages)

1- High performance computers for the teamwork.
2- Solar cells (semiconductor material)
3- Mathematics Software (Matlab, Mable, FORTRAN).
4- Other software such as (Microsoft office, EndNote, Acrobat).
5- Printers laser color.
6- Some office tools (A4 papers-Pens- Printers Ink-Flash memories-…etc.).
7- The expertise of the team is enough to will help to complete this project.
8- Publication fees and reporting.
9- Teamwork salaries.

## Team Information (Max. of one page per team member)

1- **Prof. Dr. Allam Abdelaziz (Principal Investigator P-I)**

**Affiliation:** Institute of Basic Science, Arab Academy for Science, Technology, and Maritime Transport, Alexandria.

**Specialist on:** Thermoelasticity-Solid Mechanics- Numerical Analysis.

**The Role in Project:** Advisor of all the project stages.

2- **Prof. Dr. Khaled Lotfy Ali El-Azab (Co- Investigator CO-I 1)**

**Affiliation:** Mathematics Department- Faculty of Science- Zagazig University.

**Specialist on:** Applied Mathematics-Solid Mechanics- Numerical Analysis.

**The Role in Project:** Constructing the mathematical models, Discuss the results, write the papers.

3- **Dr. Radwa A.Ossman (Co- Investigator CO-I 2 )**

**Affiliation:** Institute of Basic Science, Arab Academy for Science, Technology, and Maritime Transport, Alexandria.

**Specialist on:** Thermoelasticity-Solid Mechanics- Numerical Analysis.

**The Role in Project:** Get the solutions and the numerical results and write the draft.

4- **Mr. Baraa Adel ( Co- Investigator CO- I 3 )**

**Affiliation:** Institute of Basic Science, Arab Academy for Science, Technology, and Maritime Transport, Alexandria.

**Specialist on:** Mathematics software and Numerical Analysis.

**The Role in Project:** The literature review, and the numerical results and graphs.

## Research Team Information Table

| Name of Res. Team Member in English | Name of Res. Team Member in Arabic | University / Institute In English | Position / Title | % of time spent on project | No. of months | Incentive per month (LE) | Number of other projects and their IDs | Total % of time spent on other projects | Contact No |
|---|---|---|---|---|---|---|---|---|---|
| **Allam Abdelaziz** | علام عبدالعزيز | AASTMT(PI) | Professor | 40% | 12 | 4000 | 0 | 0 | 01001859657 |
| **Khaled Lotfy** | خالد لطفي | Zagazig university | Professor | 40% | 12 | 4000 | 0 | 0 | 01008484056 |
| **Radwa A.Ossman** | رضوى احمد عثمان | AASTMT | | 40% | 12 | 2000 | 0 | 0 | 01001552854 |
| **Baraa Adel** | براء عادل | AASTMT | | 40% | 12 | 2000 | 0 | 0 | 01116733369 |

## Project Management (Max. three pages)

### 1- Collecting papers and literature review

All the teamwork will work on collecting all the required past papers and any data related to the project point to prepare the literature review.

### 2- Constructing the mathematical models

a. The PI and CO-I-1 will construct the mathematical models according to the proposal of the project.

b. The CO-I-2 and CO-I-3 will construct and proposed the geometrical shape of the materials which will be used in the models.

c. The CO-I-2 and CO-I-3,will convert the governing equations of the models to be dimensionless equations.

### 3- Solving the mathematical models

a. The PI and CO-I-1 chose the suitable mathematical method which will be used to solve the models.

b. The CO-I-2 and CO-I-3 will apply the suitable mathematical method to solve the models.

c. The CO-I-2 and CO-I-3 represent the numerical solutions in figures.

d. The PI and CO-I-1 chose the suitable comparisons which will be shown in the figures.

### 4- Discuss and conclude the results

All the teamwork will work on the discussion and the conclusion sections for sure about the quality of the results.

### 5- Write and publish the papers

a. The CO-I-2 and CO-I-3 write the draft of the papers.

b. The PI and CO-I-1 revised the draft and write the final form of the paper.

c. The PI and CO-I-1 submit the papers to international journals.

## A DETAILED PLAN ON PROJECT'S ACTIVITIES (*GANTT CHART*):

| Activity Name | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 | M11 | M12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Main 1: Start the project | | | | | | | | | | | | |
| Sub 1.1: Collecting papers | | | | | | | | | | | | |
| Sub 1.2: Collecting data | | | | | | | | | | | | |
| Sub 1.3: Literature review | | | | | | | | | | | | |
| Main 2: Construct the models | | | | | | | | | | | | |
| Sub 2.1: Set the models | | | | | | | | | | | | |
| Sub 2.2: Set the equations | | | | | | | | | | | | |
| Sub 2.3: Dimensionless | | | | | | | | | | | | |
| Main 3: Solve the models | | | | | | | | | | | | |
| Sub 3.1: Method of solution | | | | | | | | | | | | |
| Sub 3.2: Apply the method | | | | | | | | | | | | |
| Sub 3.3: Get the results | | | | | | | | | | | | |
| Sub 3.4: Figure the results | | | | | | | | | | | | |
| Main 4: Discuss and Conclude the results | | | | | | | | | | | | |
| Sub 4.1: Write discussion | | | | | | | | | | | | |
| Sub 4.2: Write conclusion | | | | | | | | | | | | |
| Main 5: Publishing | | | | | | | | | | | | |
| Sub 5.1: Submit the papers | | | | | | | | | | | | |

## Allowable Project Costs (Max. two pages)

(i) - Personnel costs of the research staff

| | | |
|---|---|---|
| 1- | P-I | 48,000 EGY Pound |
| 2- | Co-I-1 | 48,000 EGY Pound |
| 3- | Co-I-2 | 24,000 EGY Pound |
| 4- | Co-I-3 | 24,000 EGY Pound |
| | **Total** | **144,000 EGY Pound** |

(ii)- Mobility costs (travel and subsistence expenses)
Attending international conference **0.0 EGY Pound**.

(iii)- Costs related to organizing seminars and workshops within the project

Holding one workshop within the project **20,000 EGY Pound**.

(iv)- Acquisition of material and small-scale research equipment

| | | |
|---|---|---|
| 1- | Laptops | **100,000 EGY Pound** |
| 2- | Semiconductor materials (solar cells) | **50,000 EGY Pound** |
| 3- | Software and surfaces | **86,000 EGY Pound** |

(v)- Running costs/Indirect costs

Reports and publication fees **50,000 EGY Pound**

## Breakdown of Costs Other Grant(s) (Max. two pages)

[Table of Eligible Cost]

| Eligible costs | Break downs | | AASTMT support (L.E.) |
|---|---|---|---|
| (A) Staff Cost | PI: Prof. Dr. Allam Abdelaziz | | 48,000 |
| | Co-I-1: Prof. Dr. Khaled Lotfy | | 48,000 |
| | Co-I-2: Dr. Radwa A Osman | | 24,000 |
| | Co-I-3: Mr. Baraa Adel | | 24,000 |
| | | | |
| | **Total** | | **144,000** |
| (B) Equipment | Equipment | | 100,000 |
| | Spare parts | | |
| | **Total Equipment** | | **100,000** |
| (C) Expendable Supplies & Materials | Stationary | | 0.0 |
| | Miscellaneous Laboratory, Field supplies, Materials | | 20,000 |
| | **Total expendable Supplies & Materials** | | **20,000** |
| (D) Travel | Internal Transportation | | 0.0 |
| | Accommodation | | 0.0 |
| | **Total travel** | | 0.0 |
| (E) Other Direct Costs | Services | Manufacture of specimens & prototypes | 0.0 |
| | | Acquiring access to specialized reference sources databases or computer software | 80,000 |
| | | Computer services | 8,000 |
| | Report preparation | | 10,000 |
| | Publications & patent Costs | | 30,000 |
| | Workshops organization or Training | | 20,000 |
| | Others (explain) | | 0.0 |
| | **Total other direct costs** | | **148,000** |
| **(G) Total Costs** | | | **400,000** |

## Plans for Disseminating Research Results / Sustainability of the action (Max. three pages)

The results of the project will be collected and will be written in scientific articles to be submitted and published in international journals.

## Key Publications and references (Max. two pages)

[1] R.A. Grot, Thermodynamics of a continuum with microstructure, Int. J. Eng. Sci., 7, 801-814, (1969).

[2] P. Riha, On the microcontinuum model of heat conduction in materials with inner structure, Int. J. Eng. Sci., 14, 529-535, (1976).

[3] D. Iesan and R. Quintanilla, On a theory of thermoelasticity with microtemperatures, J. Thermal Stresses, 23, 199-215, (2000).

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[5]D. Iesan, Thermoelasticity of bodies with microstructure and microtemperatures, Int. J. Solids Struct., 44, 8648-8662, (2007).

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[10] J.P. Gordon, R.C.C. Leite, R.S. Moore, S.P.S. Porto, J.R. Whinnery, Long-transient effects in lasers with inserted liquid samples, Bull. Am. Phys. Soc. 119, 501, (1964).

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[16] Y.Q. Song, D.M. Todorovic, B. Cretin, P. Vairac, Study on the generalized thermoelastic vibration of the optically excited semiconducting microcantilevers, Int. J. Solids Struct. 47, 1871, (2010).

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[18] Kh. Lotfy, , W. Hassan and M. H. Ahmed, Hall current influence of microtemperature magneto-elastic semiconductor material, Superlattices and Microstructures, 139, 106428 (2020).

[19] Alaa. K. Khamis , A. A. El-Bary & Kh. Lotfy, Electromagnetic Hall current and variable thermal conductivity influence for microtemperature photothermal excitation process of semiconductor material, Waves in Random and Complex Media, DOI: 10.1080/17455030.2020.1775912, (2020).

[20] Kh. Lotfy, A. Khamis, A. El-Bary and M. Ahmed, Thomson and rotation effects during photothermal excitation process in magnetic semiconductor medium using variable thermal conductivity, Appl. Math. Mech.-Engl. Ed. 41, 909–926 (2020).

## Declaration of original submission and Other Grant(s) (Max. one page)

We declare that their proposal did not and will not be submitted in whole or part for funding; twice within the same cycle, or to other funding programs within AASTM, or other funding agencies. This is to avoid any possible double funding.

PI

Prof. Dr. Allam Abdelaziz

*Allam Abdelaziz Allam Abdelnaeem*

**Acknowledgment Form:** ***Please copy this section, sign and scan it as a part of your proposal***

By signing below, I acknowledge that I have read, understand and accept to comply with all the terms of the foregoing application, mentioned in AASTMT general conditions and guidelines for submitting a research proposal, including, but not limited to:

- The total number of the application pages should not exceed **30 pages** excluding a cover page, as well as all sections of the proposal (as mentioned in AASTMT General Conditions and Guidelines for Submitting Research Proposal).
- At any time, a contracted AASTMT project team member should only be participating in a maximum of one project.
- Allowable budget maximum limit should be strictly adhered to in the project proposal. In all cases, requested budget has to be justified in detail.
- AASTMT guidelines, IPR rules, code of ethics, etc. (www.aast.edu), should be read carefully and adhered to. These are integral parts of the contract.
- All proposals – in addition to PI and other data - must be uploaded to the AASTMT website by the designated deadline. Uploaded PI data should conform to the corresponding data in the application form.

**Applications will not be considered eligible and will be discarded in the following cases**:

- Proposals submitted by e-mail or sent as hard copies or uploaded to the AASTMT website after the deadline.
- Proposals not conforming to the designated format.
- Proposals whose uploaded PI data does not conform to PI data in the proposal file.
- Proposals in which the allowable budget maximum limit has been exceeded.
- Proposals in which maximum allowable contracted AASTMT project participation limit has been exceeded.
- Proposal letter does not include a scanned copy of the signed and stamped PI institution endorsement letter in case of team member work outside AASTMT.
- Proposal does not include a scanned copy of the signed acknowledgment form.

Date & Signature:

*10/03/2021*

*Allam Abdelaziz Allam Abdelnaeem*