



Materials for Energy Efficiency and Solar Energy Applications

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1. Historical background (Solar Energy Group)

2. Issues to be addressed

3. Objectives and

4. Expected outputs

6. Resources

- Staff**
- Students**
- Equipment**



7. Projects

- Research activities**
- Training activities**
- Workshops/colleges**
- Regional co-operation/network**

8. Monitoring and evaluation

9. Constraints

PHYSICS DEPARTMENT BUILDING



Staff and Postgraduate Students

	PhD	Masters		Total
Academic Staff	9	4		14
Technical Staff	2			2
Students	4	8		12



1. Historical Background



2. Issues to be addressed



2.1 M.Sc. programme

the number of applicants into the M.Sc. programmes has been quite high but due lack of sponsorship and adequate research facilities it has not been possible to accommodate on the average, more than four applicants.



2. Issues – cont.

2.2 PhD Programme

The number of PhD students has been quite low and lack of sponsorship.



2. Issues cont.

2.3 Research

Lack of adequate research resources necessary to build up a critical mass in the area of materials science for solar energy application



2. Issues cont.

2.4 Dissemination

Lack or insufficient knowledge and awareness among young scientists in Eastern and Southern Africa about research on materials science and their applications to solar energy conversion



2.Issues- cont.

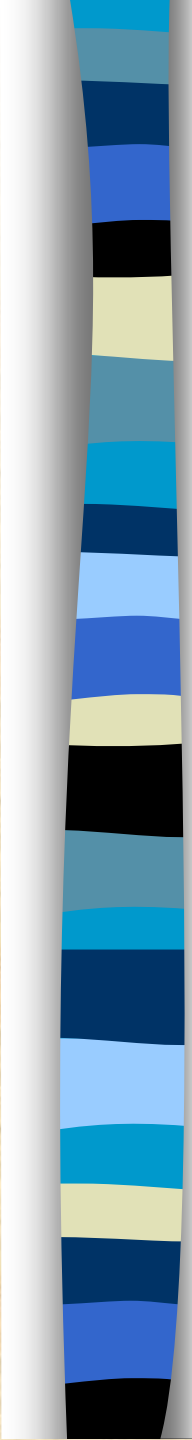
2.5 Technical Training

Lack of sufficient technical skills in thin films among technicians has to some degree limited the optimum and efficient utilisation of resources for research in many laboratories in the sub-region



3. Capacity objective

- **To develop human and infrastructure capacity in advanced research in materials science for solar energy applications**



3.1 to enhance and modernise the existing research facilities at the Solar Energy Laboratory through provision of modern equipment or through collaboration with Kookmin University

3.2 to strengthen postgraduate programmes at the department of physics, University of Dar es Salaam, Tanzania, in order to provide the required high-level skilled manpower for technological development

3.3 To assist Ph.D and MSc students and researchers carry out part of their studies in universities abroad.

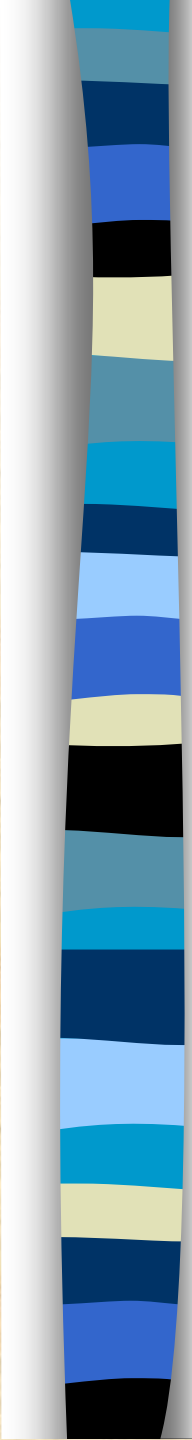
Objectives cont.

3.4 to maintain and strengthen the existing research co-operation between the department of physics, University of Dar es Salaam, and some departments of physics of Universities of Eastern and Southern Africa in the fields of solar energy and materials science.

3.5 to develop communication, experience exchange, cooperation network and awareness among scientists and stakeholders in the field of solar energy through provision of biennial courses covering a wide spectrum of topics in solar energy materials



4. Expected Outputs

- 
- 4.1 Improved research facilities at the Solar Energy Laboratory**
 - 4.2 Post graduate programme strengthened**
 - 4.3 Research quality enhanced**
 - 4.4 Improvement in Regional research collaboration**
 - 4.5 Improvement in student/researcher exchange with other universities in the region and outside;**
 - 4.6 Enhanced awareness in the field of solar energy and materials science**



5.

Resources



Academic staff

Dr. M.E. Samiji (Ms) Senior Lecturer leader

Dr. N.R. Mlyuka Senior Lecturer

Dr. Eqidius Rwenyagila Lecturer

Dr. Anayesu Malisa Lecturer

Technical Staff

Eng. H. Mtelela

5. Resources – cont.

Graduate Students

- **Mr. L. Lwitiko - (PhD. student)**
- **Mr. H. F. Haji. - (PhD. Student)**
- **Mr.M. Mohamed- (PhD. Student**
- **Mr. J. Justine -(PhD. Student)**
- **Ms Eva T. Shana -(MSc student)**
- **Mr. Sungi Gilya -MSc Student**
- **Mr. Sawa H. Buay -(MSc student)**



6. Equipment

Thin Film Coating Techniques



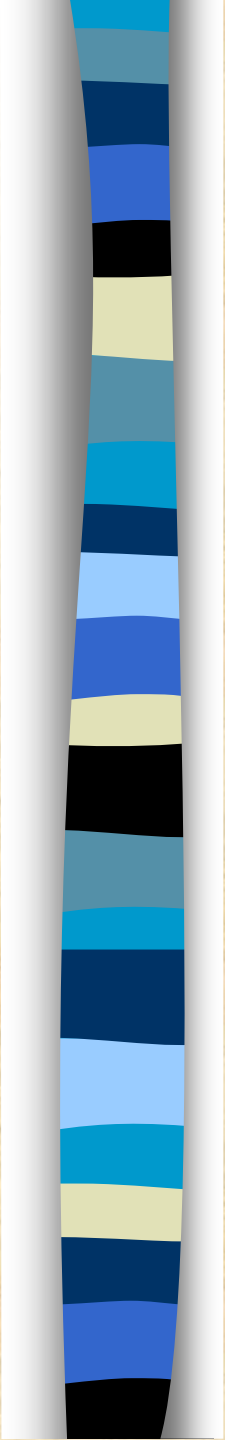
- **High vacuum evaporation unit with resistive heating, electron beam, substrate heating and thickness monitoring facilities**

Thin Film Coating Techniques



- **Sputtering unit with two magnetron sources (for simultaneous deposition), thickness monitoring and reactive sputtering facilities, RF and DC power sources**

Spin Coater



Optical Characterisation



Infrared Characterization



- **FTIR Perkin Elmer spectrophotometer wavelength range 2000 - ~30000 nm**
- **Independent accessories for Diffuse Reflectance and Fixed Angle Reflectance**
- **Horizontal ATR Accessory (ATR \equiv Attenuated Total Reflectance)**

Ellipsometry



- **Home made ellipsometer equipped with a variable QWP**
- **capable of measuring optical constants, n and k , for a bulk material or thin film**

Thickness measurements



- Alpha-step surface profiler – Thickness measurement

Rapid thermal processing (RTP) furnace





- ***Electrical Characterisation***

- **There exist facilities for Hall effect measurement and Four-point probe set-up**

Hall Effect Measurement System



Electrical Characterisation



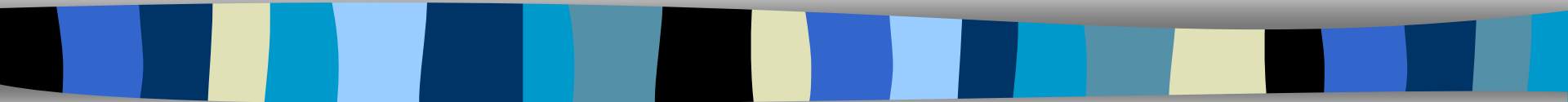
• Four-point probe set-up

Structural Characterisation

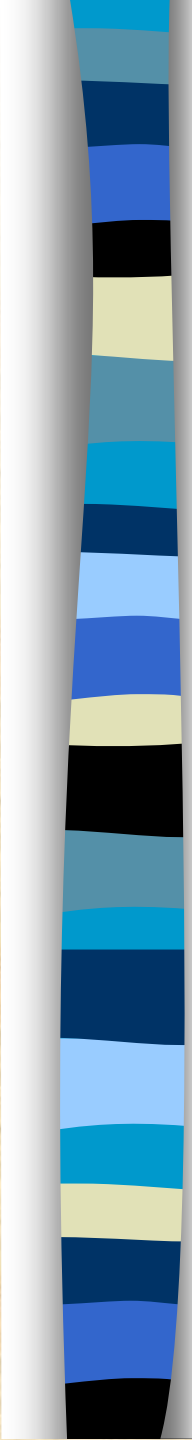


- **Atomic Force Microscope (AFM) Not working**

7. Planned Activities



- 
- **Research development**
 - **Postgraduate training**
 - **Seminars/ Colleges and technical training**



Research Projects

- ***Optical window coatings***
 - **Preparation and characterisation of obliquely deposited films;**
 - **Preparation and characterisation of thermochromic coatings;**
- ***Photovoltaic***
 - Kesterite ($\text{Cu}_2\text{ZnSnS}_4$) thin films**
 - Doped oxide semiconductor based films (ITO, ZnO:Al, ZnO:B, SnO:F) for **PV windows;****
 - **Performance of Photovoltaic Systems.**
- **Design of Photovoltaic systems for rural areas**



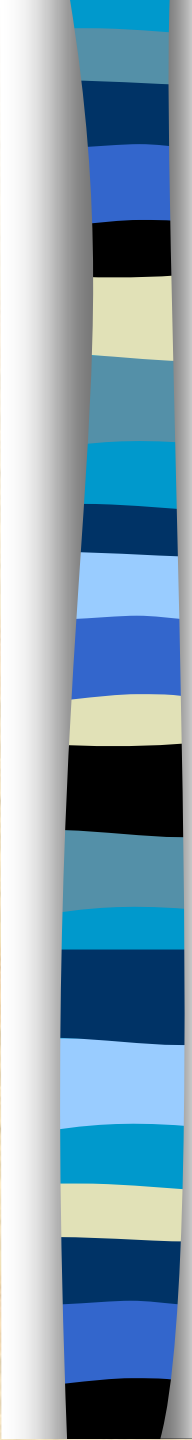
Materials options for photo-thermal conversion:

Selectively absorbing thin film materials

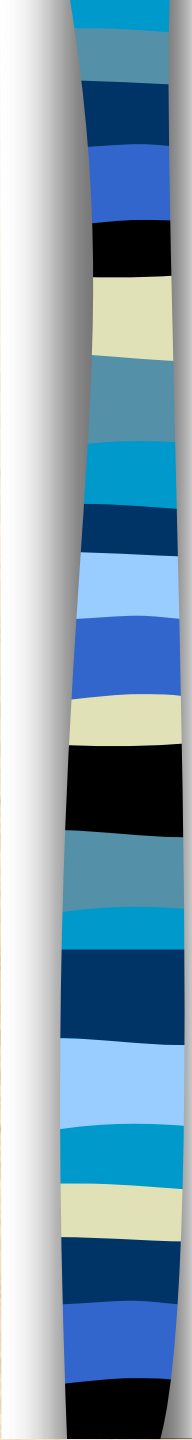
Multilayer stacks

Compound Parabolic Concentrator

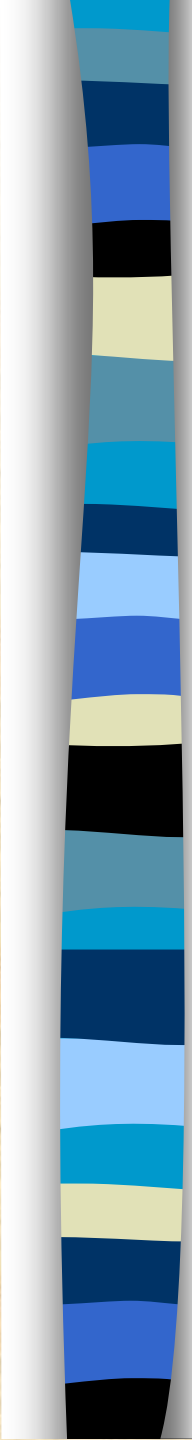
Reflective materials



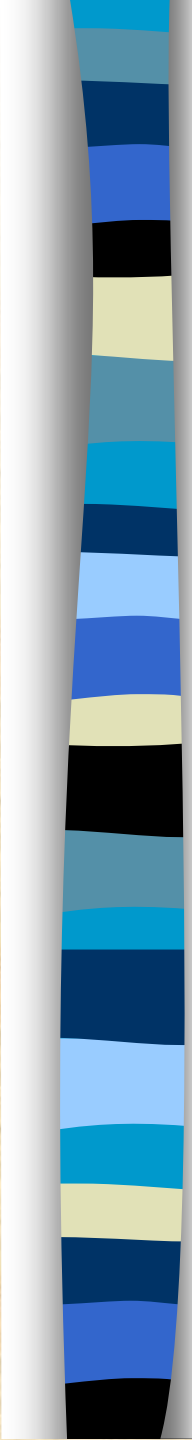
7.1 Research on obliquely coatings involve the study of the effect of substrate temperature on angular selectivity in films of chromium and other materials.



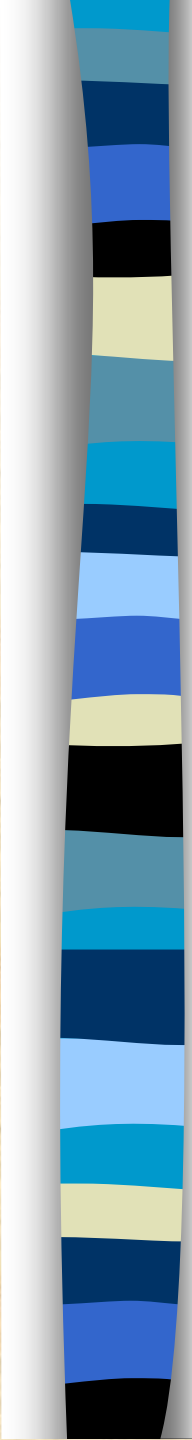
7.2 In the area of energy efficient windows. These films have interesting characteristics in that the optical properties vary with temperature. The objective is to study and understand the physics behind these materials and to develop a technique for lowering the transition temperature to room temperature as well as increasing the level of visible transmittance by using appropriate antireflection coating.



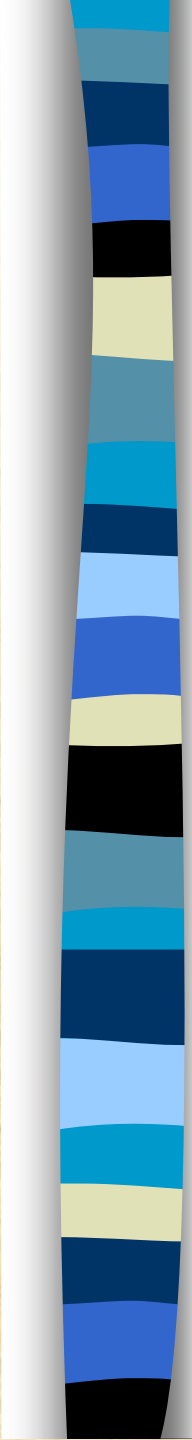
7.3 Regarding PV windows, the study involve optimisation of deposition parameters for zinc oxide doped with impurity atoms like Al and B and so that optimum films with best optical and electrical properties can be obtained. Deposition parameters to be studied include, rate of deposition, oxygen partial pressure, rf power, substrate temperature, sputtering gas pressure, etc.



**7.4 On PV materials, the study involve
characterization of semiconductor
materials of copper indium diselenide
(Cu(InGa)Se) and Kesterite (Cu₂ZnSnS₄)
thin films**



7.6 In order to keep in touch with the outside world collaboration will be sought from other university for financial support for PhD students



7.7 We plan to train more young scientists in the area of materials science. Since physics is seen to be weak in the region, training of postgraduate students as well as technicians will be our primary short-term objective.

Outreach activities



Contributing towards removing barriers/obstacles to wide dissemination of photovoltaic systems, in the rural areas of Tanzania



- **Outreach activities**

The goal is to develop local technical capacity to support the private sector in the field of solar PV Technology in Tanzania.

Science Camp for A- level female students taking Mathematics and Physics



Students doing physics practical during science camp.

Training of Technicians and Artisans- Rukwa Tanzania



Technicians and Artisans writing examination – Rukwa, Tanzania



Technicians and Artisans receiving certificates- Tabora, Tanzania





The outcome of the PV training programmes showed that:

- There has been an increase in number of PV system installations in the local schools, health facilities, domestic houses, etc;
- Improved quality of PV sizing, installation and maintenance (decrease rate of PV system failures);
- Increased customer satisfaction (no complaints);
- Increased volume of imported PV modules
- Increased number of PV companies (job creation)
- Regional PV technician/artisans network formed.



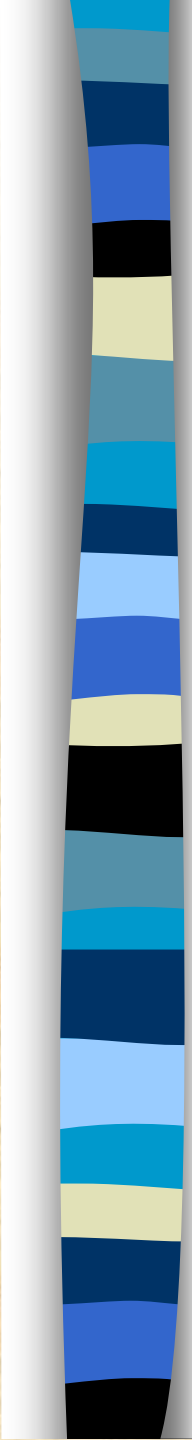
8. Workshops/Colleges organised

Organised and Participated in 9 Colleges on Thin film Technology, 1990 -2006, Dar es Salaam, Tanzania.

Trained about 230 young scientists from the Eastern and Southern Africa region intending to take-up a project in materials science or solar energy

Organised and hosted an International Conference on Solar Energy Materials Research October 13-14, 2009, Dar es Salaam, Tanzania.

More than 50 participants from Ethiopia, Kenya, Malawi, Zambia, Uganda, Lesotho and the host country, Tanzania presented papers

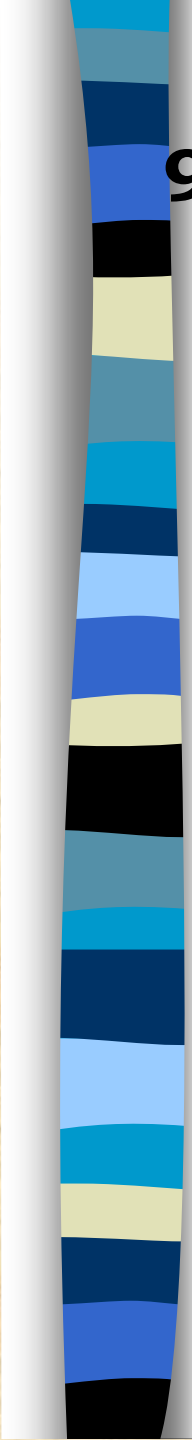


8.1 Given the experience in organising sub-regional courses on solar energy materials, the group would like to continue hosting and conducting the college on thin film technology after every two years.

Financial support will be requested to run these training

9. Monitoring and Evaluation

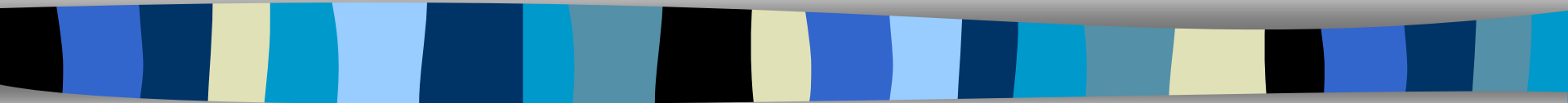


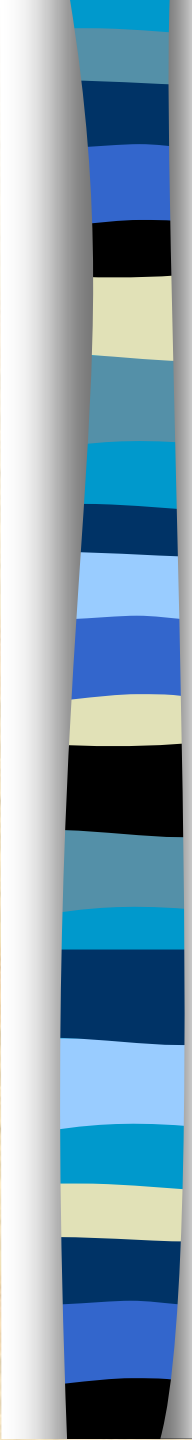


9.1 Group meetings once in two weeks and monthly seminars are normally organised by the group to internally track and evaluate the performance of each research and training activity of the group

9.

Constraints





**9.1 Lack of up to date literature -
mainly periodicals;**

9.2 Inadequate Laboratory space;

**9.3 Inadequate fellowships for local
M.Sc. and Ph.D. students**



Concluding remarks

- Human resource capacity building in the area of materials science research
- Steady spread of research culture in the country.
- Product developed from this research project may be contribute to poverty alleviation in rural areas



**Thank you for
listening**