# 1st ANSOLE-ICTP Fellows´Workshop

# (AIFW 2013)

## 5. Jan. 2013, Mohammedia, Morocco

***Venue***: *Laboratoire de Physique des Matériaux et Applicatios des Energies Renouvelables (LPMAER) département de Physique, Faculté des Sciences et Techniques , Université Hassan II de Mohammédia, Mohammédia Maroc (directeur du laboratoire: Prof. Bouchaib Hartiti, tel: 00212667147535, Email: b.hartiti@univh2m.ac.ma)*

## Chairmen and Evaluators Panel

PD Dr. Daniel Ayuk Mbi Egbe (Linz, Austria)

Prof. Dr. Bouchaib Hartiti (Mohammedia, Morocco)

Prof. Dr. El Mahdi Assaid (El Jadida, Morocco)

Prof. Dr. Abderraouf Ridah (Casablanca, Morocco)

# Programme

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|---|---|
| 10.00-10.10 | Welcome addresses by the host Prof. Bouchaib HARTITI and by ANSOLE coordinator Daniel A. M. EGBE |
| 1st session | *Chairman*: **Prof. Bouchaib HARTITI** |
| 10.10-10.30 | **Dr. Allé DIOUM**: *Transient Decay of the Excess Minority of Electrons Density of a Bulk Heterojunction Organic Solar Cell Based on Blend of P3HT: PCBM: Dependence of Electrons Recombination at the Interfaces* |
| 10.30-10.50 | **Safae AAZOU**: *Bulk Heterojunction Solar Cells Based on Anthracene-Containing PPE-PPV: Fabrication and Modeling* |
| 10.50-11.10 | **Sameh BOUDIBA**: *Les Polymères Conjugués Contenant de l´Anthracène pour les Applications Optoélectroniques* |
| 11.10-11.30 | **Armel Duvalier PENE:** *Influence de l'angle d'incidence sur les paramètres électriques d'une photopile bifaciale sous éclairement multispectral constant* |
| 11.30-11.40 | **Coffee Break** |
| 2nd session | *Chairman:* **Prof. El Mahdi ASSAID** |
| 11.40-12.00 | **Youssef AMMAIH:** *Using the TAGUCHI methodology for the preparation of ZnO thin films by the sol-gel technique associated to spin coating* |
| 12.00-12.20 | **Abou GAYE:** *Phase diagrams of spin-3/2 materials with random crystal field by renormalization group theory* |
| 12.20-12.40 | **Hervé J. N. TCHOGNIA:** *Numerical Simulation of CZTS solar cell by AMPS-1D* |
| 12.40-13.00 | **Samira ELFARRASS:** *Élaboration et caractérisation des couches minces de sulfure d'indium $In_2S_3$ par spray pyrolysis pour application photovoltaïque* |
| 13.00-13.30 | **Closing Ceremony:** Award of attestations of participation, group photos, etc. |
| 13.30-14.30 | **Lunch and Departure** |

# Transient Decay of the Excess Minority of Electrons Density of a Bulk Heterojunction Organic Solar Cell based on blend of P3HT: PCBM: Dependence of Electrons Recombination at the Interfaces

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## Abstract:

The thin film multilayer stacking theory with the optical matrix of the Abeles theory[1] is used to study the Transient Decay (TD) occurs between two steady states through operating points of Bulk Heterojunction Organic Solar Cell (BHJ-OSC) based on blend of a polymer of poly (3-hexylthiophene-2, 5-diyl) (P3HT) as electron donor and a soluble derivative of fullerene called [6, 6]-phenyl $C_{61}$-butyric acid methyl ester (PCBM) as electron acceptor.[2,3,4] The influence upon the recombination parameters such as electron recombination at the interfaces of the blend layer and the bimolecular recombination inside the bulk on the excess minority of electrons density photogenerated is investigated.[5,6,7] So, attention is also paid to the dependence of the monochromatic light wavelength $\lambda$ of the spectrum visible and the blend (P3HT: PCBM) layer thickness $w_b$ on excess minority of electrons density.[8]

**Keywords**: Organic solar cell, bulk heterojunction, blend, recombination velocity, electron

**Acknowledgment**: A. Dioum is grateful to ICTP (International Centre for Theoretical Physics) and ANSOLE Germany e.V. for financial support in the framework of ANSOLE´s INEX (Intra-African Exchange) programme.

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## Publications of Allé Dioum

1. **Transient Decay of Bulk Heterojunction Organic Solar Cell Based on Blend of P3HT and PCBM: Dependence of the Excess Minority of Holes Density**
   ***A Dioum***, *M B Gaye, A Guèye, E H O Guèye, S Ndiaye, O A Niasse, B D Ngom, B Lo and A C Beye*
   *27th European Photovoltaic Solar Energy Conference and Exhibition*, 24 - 28 September **2012**, Proceeding pp. 2930-2937.

2. **Influence of the exciton dissociation on the photocurrent density of a bilayer heterojunction organic solar cell based on copper phthalocyanine (CuPc) and fullerene ($C_{60}$)**
   *A. Dioum, S. Ndiaye, M. Faye, E. H. O. Guèye, O. A. Niasse, O. Sakho and A. C. Beye*
   *AMSE Journal, Ref: 10 567 (2A)*, **2012**.

3. **3-D modelling of a bilayer heterojunction organic solar cell based on copper phthalocyanine and fullerene (CuPc/$C_{60}$): Evidence of total excitons dissociation at the donor-acceptor interface.**
   *Dioum, A., Ndiaye, S., Guèye, EHO., Gaye, MB., Faye, DN., Sakho, O., Faye, M., and Beye, AC.*
   *Global J. Pure and Applied Sciences, Ref: GJPAS/2012/002*, **2012**.

4. **Investigation of structural properties of layered III-nitride semiconductor materials by high resolution X-rays diffraction**
   *S. Ndiaye, A. Dioum, P. D. Tall, K. Bejtka, M. Laugt, H. P. D. Schenk and A. C. Beye*
   *International Journal of Physical Sciences*, Vol. 7(10), pp. 1653 - 1660, 2 March, **2012**

5. **The influence of plasma dynamics on the growth of Sm0.55Nd0.45NiO3 solid solution during pulsed laser deposition.**
   *B. D. Ngom, S. Lafane, A. Dioum, N. Manyala, S. Abdelli-Messaci, R. T. Kerdja, R. Madjoe, R. Nemutudi, M. Maaza, A. C. Beye*
   *Journal of Physics and Chemistry of Solids*, 72 (**2011**), PP: 1218 – 1224.

6. **Nyquist and Bode diagrams technique used for electrical parameters determination on a silicon solar cell under incidence angle illumination.**
   *A. Dioum, A. Thiam, L. Ould Habiboulahy, A. Wereme, A. Diao, G. Sissoko*
   *J.Sci.* Vol. 7, N°3 (**2007**), P. 33-39.

7. **Equivalent Electric Circuit of a Bifacial Solar Cell in Transient State under Constant Magnetic Field.**

*S. Mbodji, H. Ly Diallo, I. Ly, A. Dioum, I. F. Barro & G. Sissoko*

*21st European Photovoltaic Solar Energy Conference*, 4-8 Sep. **2006**, Dresden, Germany, Proceeding pp. 447-450

**8. 3D study of bifacial silicon solar cell under intense light concentration and under external constant magnetic field: Recombination and electric parameters determination**
*M. Zoungrana, M. Thiame, A. Dioum, S. Raguilnaba, G. Sissoko*
*22nd European Photovoltaic Solar Energy Conference*, 3-7 Sep. **2007**, Milan, Italy, Proceeding: pp. 447-453

**9. Incidence angle illumination effect on electrical parameters of a bifacial silicon solar cell in frequency modulation**
*A. Dioum, A. Thiam, A. Wereme, M. M. Deme, A. Diao, G. Sissoko*
*22nd European Photovoltaic Solar Energy Conference*, 3-7 Sep. **2007**, Milan, Italy, Proceeding: pp. 441-446

**10. Bifacial silicon solar cell parameters determination by impedance spectroscopy**
*A. Dieng, A. Diao, A. S Maiga, A. Dioum, I. Ly, G. Sissoko,*
*22nd European Photovoltaic Solar Energy Conference*, 3-7 Sep. **2007**, Milan, Italy, pp.4

# Bulk Heterojunction Solar Cells Based on Anthracene-Containing PPE-PPV: Fabrication and Modeling

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**Abstract:**
Study of organic bulk heterojunction solar cells (OBHJ-SCs) is presented. The OBHJ-SC are based on a recently synthesized anthracene-containing poly(phenylene-ethynylene)-*alt*-poly(phenylene-vinylene) (PPE-PPV)[1] bearing randomly distributed segments of octyloxy and segments of 2-ethylhexyloxy side chains and denoted **AnE-PV*stat***.[2] In the first part, the devices fabrication method is presented. Then, the solar cells are characterized in dark and under AM 1.5 illumination. The incident photon conversion efficiency (IPCE) and the external quantum efficiency (EQE) of the best cell are measured. In the second part, an electronic circuit, containing photocurrent generator, non-ideal diode with its reverse saturation current and its ideality factor, parasitic series and shunt resistances, is adopted to model the fabricated solar cells[3]. Afterwards, different methods[4,5] are used to determine the

physical parameters of **AnE-PV*stat*** based OBHJ-SC, which is done for the first time, an efficiency of around 4% is evidenced.

**Keywords***:* Organic solar cells, PPE-PPV, physical parameters, extraction methods.

**Acknowledgements**: S. Aazou is grateful to ANSOLE for enabling her to carry out the practical part of her Ph.D thesis at LIOS, JKU Linz, Austria in the framework of ANSOLE´s ANEX (Africa-North Exchange) programme. D. A.M. Egbe acknowledges the financial support of the Deutsche Forschungsgemeinschaft (DFG) in the framework of the priority program SPP1355.

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## Anthracene-Containing Polymers for Optoelectronic Applications

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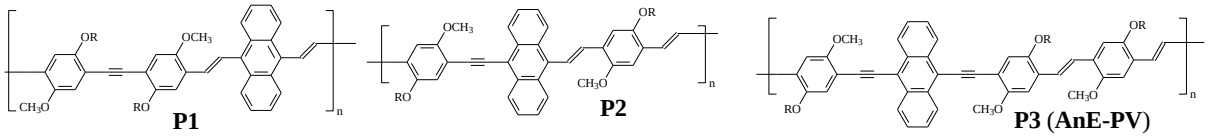
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In recent years many industrial and academic research laboratories have focused on the study of soluble π-conjugated polymers. [1] Their ease of processability and their tunable electronic and optical proprieties make them attractive candidates for advanced materials in the field of electronics and photonics.[2-4] The introduction of triple bond within the backbone of poly(arylene-vinylene) (PAV) has led to a new class of semiconducting polymers, known as poly (arylene-ethynylene)-*alt*-poly (arylene-vinylene) (PAE-PAV) exhibiting outstanding optoelectronic properties.[5] The energy levels and band gaps of PAE-PAV can be tuned either

by the number, position and nature (linear or branched) of grafted solubilising alkoxy side chains[6] or by the nature and location of the arylene units.[7] Latter possibility is readily demonstrated using an arylene unit such as anthracenylene (conjugated at the 9 and 10 positions), whose coplanarity is easily tuned by the location thereby affecting the band gap of a polymer. For instance, placing this unit between two double bonds leads to a backbone torsion of 80° as it was demonstrated by Müllen *et al.*.[8] This is due principally by steric hindrances between the vinylene hydrogen atoms and the anthracenylene hydrogen atoms. These steric hindrances are removed upon replacement of vinylene units by ethynylene units. This explains the gradual red shift of ~50 nm of the absorption maximum going from anthracene-containing polymer of general constitutional unit (-Ph-C≡C-Ph-CH=CH-Anthr-CH=CH-)$_n$ (**P1**) , in which the anthracene unit is located between two double bonds, to the polymer of general constitutional unit (-Ph-C≡C-Anthr-CH=CH-Ph-CH=CH-)$_n$ (**P2**), in which the anthracene unit is placed at the bridge between double bond and triple bond, and a further 50 nm bathochromic shift going from P**2** to the compound of general constitutional unit (-Ph-C≡C-Anthr-C≡C -Ph-CH=CH-Ph- CH =CH-) $_n$ (**P3**: also denoted **AnE-PV**), in which the anthracene unit is inserted between two triple bonds. [9-10]




In this work we describe the synthesis and characterization of a new type of anthracene-containing PPE-PPV whose general constitutional unit (-Ph-C≡C-Anthr-C≡C-Ph-CH=CH-Anthr-CH=CH-) $_n$ contains an anthracene unit between two triple bonds as well as between two double bonds. The grafting of two 2-ethylhexyloxy side chains on each phenylene unit guarantees solubility of this material in usual organic solvent. The repeating unit of this polymer, poly{1.4-[2,5-bis-(2´-ethyl) hexyloxy] phenylene-ethynylene- 9,10-anthracenylene -ethynylene-1,4-[2,5-bis-(2´-ethyl) hexyloxy] phenylene-ethene-1,2-diyl-9,10-anthracenylene-ethene-1,2-diyl}) (denoted **AnE-AnV*bb***) has a 2:2 triple bond/double bond ratio just like polymers of type **P3**, while **P1** and **P2** have a 1:2 triple bond/double bond ratio. The chemical structure of the new material was confirmed by NMR and FTIR. reversible oxidation and reduction of the polymer was observed during electrochemical studies. Photoconductivity in undoped and doped states was investigated. Comparison of the photophysical properties of **AnE-AnV*bb*** with those of **P1**, **P2** and **P3** has been carried out. Solution concentration-dependent emissive behavior was observed.

**Keywords:** π-conjugated polymer, anthracene, photoconductivity, photophysical properties.

**Acknowledgements**: Sameh Boudiba is grateful to ICTP (International Centre for Theoretical Physics) for financial support in the framework of ANSOLE´s ANEX (Africa-North Exchange) programme. Daniel. A. M. Egbe acknowledges the financial support of the Deutsche Forschungsgemeinschaft (DFG) in the framework of the priority programme SPP1355.

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# Influence of incidence angle on the electrical parameter of a bifacial silicon solar cell under multispectral illumination

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**Abstract** :

The importance that have taken the renewable energies in the search for alternative sources of energy to fossil traditional energies because of their rarefaction and harmful impact on the environment, is translated especially for photovoltaic solar energy by many studies on the solar cells. Thus, solar cells structure have been improved from conventional cells to bifacial cells which may be illuminated from both front and back sides simultaneously.[1, 2] The main advantage of these improvements is to obtain better conversion efficiency.[3, 4, 5, 6]

For this purpose, increasingly thorough studies of the photovoltaic cell are currently carried out by taking into account the influences of its environment. We present in this work the influence of incidence angle on the electrical parameters of a bifacial silicon solar cell under steady state and front side illuminated by a multispectral light. The continuity equation has been solved with a one dimensional model in steady state; this lead to the expressions of the excess minority carriers density in the base, the photocurrent and the photovoltage. The recombination velocities[7] inducing respectively the short circuit (Sfsc) and the open circuit (Sfoc) and the shunt and series resistances are deduced.[8, 9]

**Keywords:** Bifacial, incidence angle, recombination velocities, shunt and series resistances.

**Acknowledgement:** A. D. Péné is very grateful to ICTP (International Centre for Theoretical Physics) and ANSOLE (African Network for Solar Energy) for financial support in the framework of ANSOLE INEX (Intra-African Exchange) Programme.

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# Using the TAGUCHI methodology for the preparation of ZnO thin films by the sol-gel technique associated to spin coating

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Photovoltaic solar energy is a reliable energy source that has an energy and environmental balance quite favorable. The major action necessary for the development of this clean energy source is to reduce the price of kwh still too high to qualify for the actual expansion. In recent years, research works are oriented towards new sectors to make thin film solar cells with transparent structure / buffer / absorber / metal.
Zinc oxide (ZnO) is a material of the family of transparent conductive oxides (TCO). The non-toxicity and the abundance on earth of its components make it an ideal candidate as transparent electrical contact for thin film solar cells.
In this work we synthesized ZnO thin films by sol-gel technique associated with "spin coating" on glass substrates for photovoltaic application (optical window and buffer layer). And to quantify the effect of different processing parameters, we used the methodology of Taguchi experimental design to select the significant factors leading to a unique orientation (002) diffracting crystals of ZnO.
The experimental results have verified that the ZnO thin films deposited are relatively uniform substrates. Structural analysis by X-ray diffraction showed that the films deposited on glass substrates are wurtzite structure with a preferential orientation along the direction <002>. This is a very significant item added to the study of the zinc oxide by the sol-gel process. The optical measurements showed that ZnO films deposited exhibit a band gap 'Gap' of 3.28 eV close to that of single crystal ZnO is 3.3 eV.

**Keywords**: ZnO, sol-gel, TCO, methodology of Taguchi.

**Acknowledgements**: The authors wish to thank Mr Francisco KONAN from IREN (Côte d´Ivoire) for initiating the sol gel method. This work has been partially supported by the

HORIZON Project funds (Ref: 59113PS019) of the AUF (Agence Universitaire de la Francophonie). Technical support from LMOPS labs (University of Lorraine) is gratefully acknowledged.

# Phase diagrams of spin-3/2 materials with random crystal field by renormalization group theory

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**Abstract:**

We study the statistical modeling of a material of spin 3/2, under a random crystal field [1,2,3], in the two-dimensional and three-dimensional cases. We use for this purpose the Blume-Capel model [4], on which we apply the Migdal-Kadanoff [5] renormalization group approximation. We give the principal fixed points and phase diagrams found, what allows us to have a better understanding of the critical behavior in these materials. In the two-dimensional case, we observe that the randomness, even in small amounts, removes totally the first order phase transitions present in the pure model [6], replacing them by a smooth continuation; there is only the appearance of second order transitions between the ordered and disordered phases. But in the three-dimensional case, the first order transition resists to small amounts of randomness and the first order transition line finishes inside the ordered phase by an end-point. As the randomness increases, the first order transition line becomes shorter and above a certain threshold, defined by a critical value of probability, it disappears completely and is converted into smooth continuation between the ferromagnetic phases.

**Keywords**: renormalization group, Blume-Capel model, spin-3/2, random crystal field, first and second phase transitions, phase diagrams, end-point.

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# Numerical Simulation of $Cu_2ZnSnS_4$ Solar cells by *Analysis of Microelectronic and Photonic Structures* (AMPS-1D)

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**Abstract:**

Thin film solar cells based on polycrystalline CdTe, CIS, and CIGS have reached the commercialization stage. However, restrictions on heavy metal usage for Cd and limitations because of its scarcity and mainly due to its high cost for In and Te have raised concern about limitations on production capacity of the photovoltaic devices. To solve this issue, it is necessary to develop alternative absorber materials that are both non toxic and easily available.[1]

In this context, $Cu_2ZnSnS_4$ (CZTS) quaternary material has emerged as one of the promising candidates. All the components in CZTS are earth abundant and environment benign.[2] CZTS is a mineral material which shares a similar structure with the chalcopyrite CIS, except that half of the In is replaced with Zn and another half with Sn.[3]

In our work, we performed a numerical simulation of CZTS solar cell properties using the simulator *the Analysis of Microelectronic and Photonic Structures (AMPS-1D)*. We carried out analysis of *thickness*, *carriers* and *defects effects* of CZTS absorber layer on the overall performance of the cell. We also investigated the effect of operating temperature on cell efficiency.

**Keywords:** CZTS, numerical simulation, AMPS-1D, photovoltaic parameters.

**Acknowledgment:** H. J. N. Tchognia is grateful to ICTP (International Centre for Theoretical Physics) and ANSOLE Germany e.V. for financial support in the framework of ANSOLE's INEX (Intra-African Exchange) programme.

**References:**

[1] Wang, H. *International journal of Photoenergy* **2011**, DOI: 10.1155/2011/801292.

[2] Zhao, W.; Zhou, W.; Miao, X. Nano/Micro Engineered and Molecular Systems (NEMS), 7th IEEE, **2012**, Pages 502-505,

[3] Kissin, S. A. *Canadian Mineralogist* **1989**, *27*, 689-697.

# Study of $In_2S_3$ Thin Films Deposited by Spray Pyrolysis

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**Abstract**:

The replacement of harmful heavy metals and even costly elements by non toxic and economically available materials is a major challenge in the field of photovoltaic devices research. In this economical point of view, thin film technology offers a considerable interest due to its versatility and its reduced budget in term of materials consumption and by-products production. Among various semiconductor compounds, Indium Sulphide ($In_2S_3$) has to be considered as a promising candidate for optoelectronic and photovoltaic applications due to its high stability, its wide band gap, its photoconductive properties and its high conversion efficiency.[1,2] In term of applications, it can be considered as a nontoxic substitute for cadmium sulphide (CdS) in copper indium gallium selenide (CIGS) based solar cells.

In this work, we have investigated the deposition of $In_2S_3$ onto the glass substrate by Chemical Spray Pyrolysis (CSP) by varying both the duration time of the deposition and its temperature. The starting precursor is an aqueous solution of indium chloride ($InCl_3$) and thiourea ($CS(NH_2)_2$) technique involves spraying aqueous solution containing indium chloride and thiourea with In/S ratio varying from 1.4/3 to 2.8/3 in the spray solution. The deposits were performed at atmospheric pressure and obtained with a flow rate of 0.8 ml/min onto substrates heated from 300 to 400 ºC.

The $In_2S_3$ films, which are adherent and homogeneous, have been investigated by x-ray diffraction (XRD), scanning electron microscopy (SEM) in order to get information on their structural and morphological properties. The films were also characterized by optical transmission measurements in order to get its absorption properties.

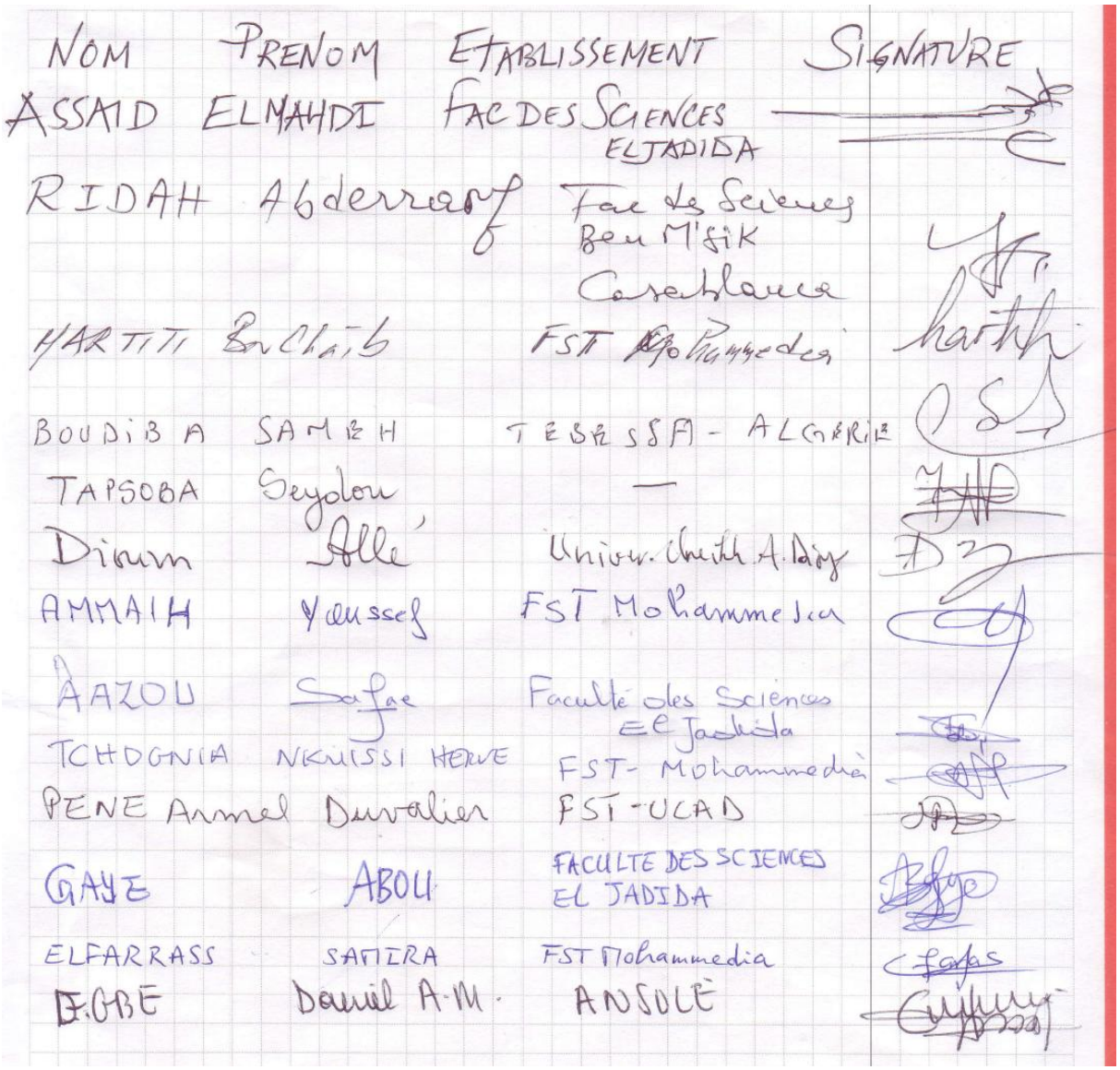
**Keywords:** Thin films, $In_2S_3$, spray pyrolysis.

**References.**

[1] John, T. T.; Bini, S.; Kashiwaba, Y.; Abe, Abe, T.; Yasuhiro, Y.; Kartha, C. S.; Vijayakumar, K. P. *Semicond. Sci. Technol*. **2003**, *18*, 491.

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**List of Participants**



| NOM | PRENOM | ETABLISSEMENT | SIGNATURE |
|---|---|---|---|
| ASSAID | ELMAHDI | FAC DES SCIENCES EL JADIDA | |
| RIDAH | Abderrazak | Fac de Sciences Ben M'Sik Casablanca | |
| HARTITI | Ben Chaib | FST Mohammedia | |
| BOUDIBA | SAMIH | TEBESSA - ALGERIE | |
| TAPSOBA | Seydou | — | |
| Diaw | Alle' | Univ. Cheikh A. Diop | |
| AMMAIH | Youssef | FST Mohammedia | |
| AAZOU | Safae | Faculté des Sciences El Jadida | |
| TCHOGNIA | NKUISSI HERVE | FST- Mohammedia | |
| PENE | Armel Duvalier | FST-UCAD | |
| GAYE | ABOU | FACULTE DES SCIENCES EL JADIDA | |
| ELFARRASS | SAFIRA | FST Mohammedia | |
| E.OBE | Daniel A.M. | ANSOLE | |

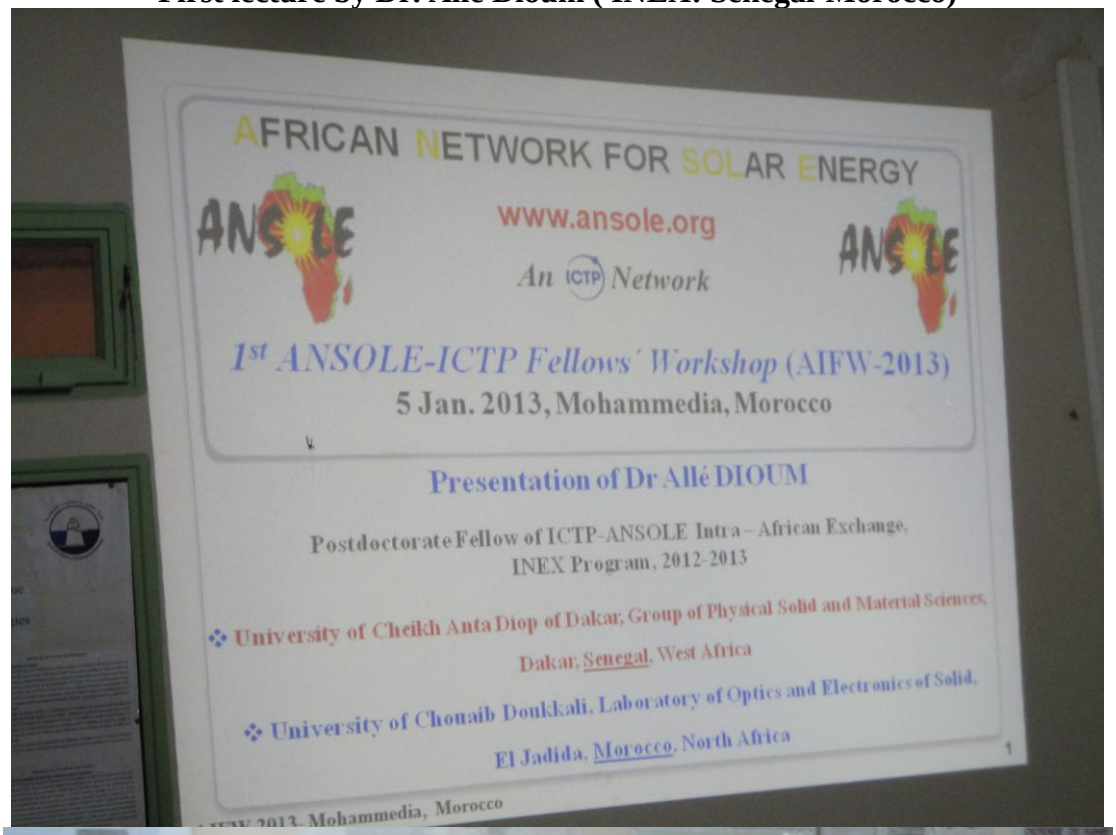
**Welcome Address by Prof. Dr. Bouchaib Hartiti**



**Opening Address by ANSOLE´s Coordinator**



**First lecture by Dr. Allé Dioum ( INEX: Senegal-Morocco)**

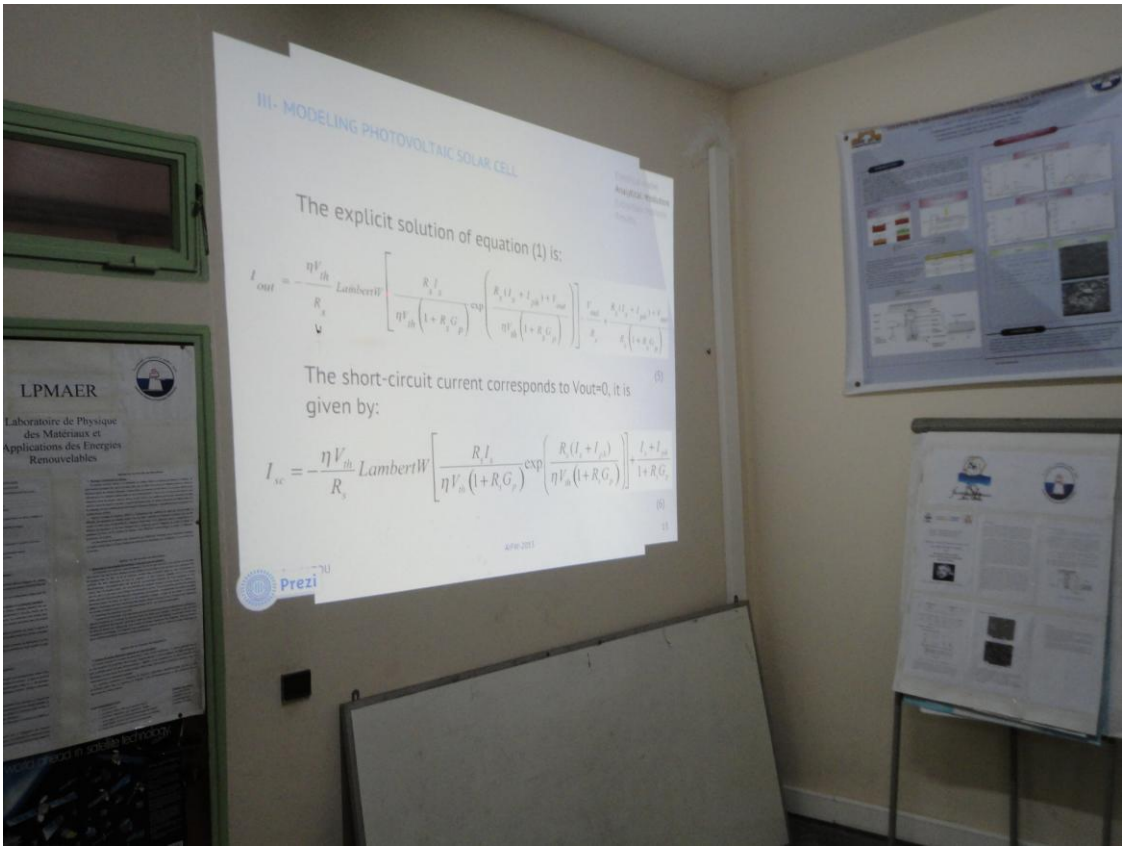





## Second Lecture by Safae Aazou (ANEX: Morocco- Austria)

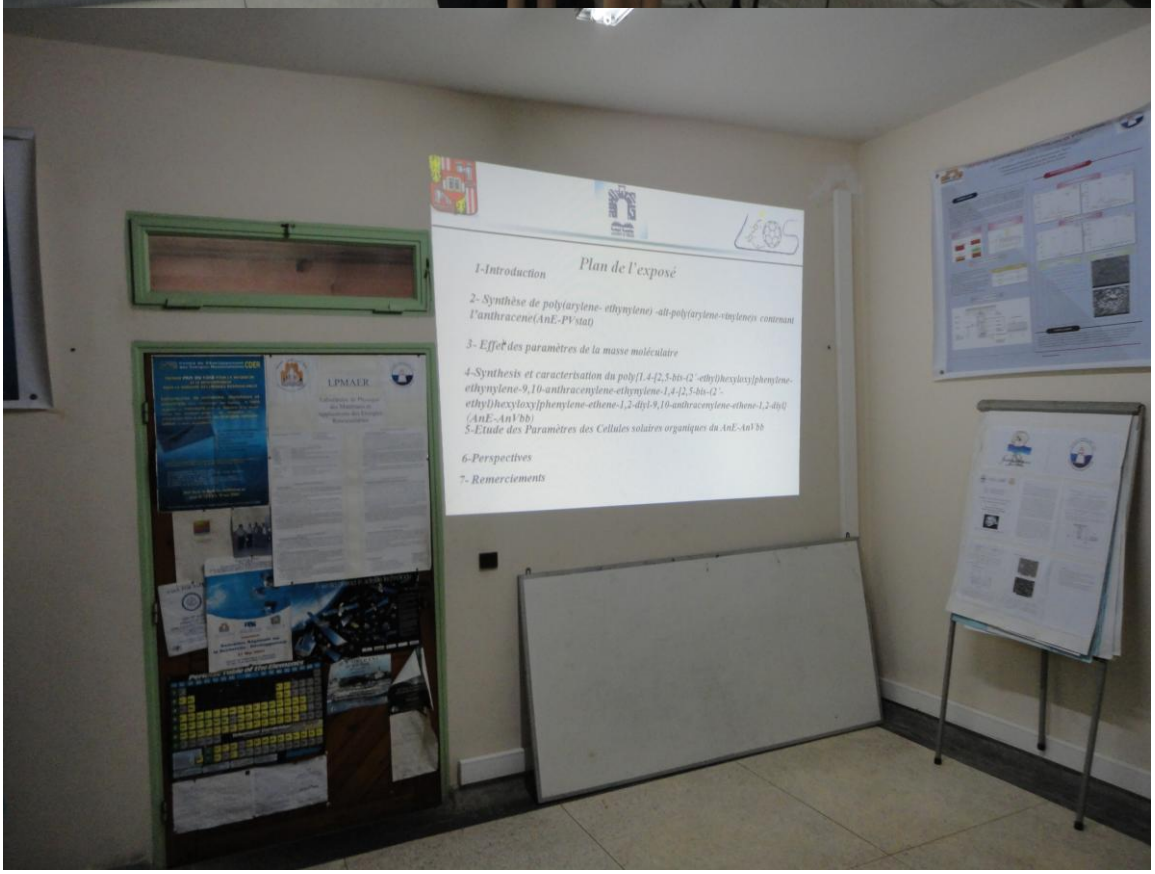


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# The third lecture by Sameh BOUDIBA (ANEX: Algeria-Austria)





# Fourth Lecture by Armel Duvalier PENE (INEX: Cameroon-Senegal)





# Evaluators Panel





# Coffee Break




La Marocaine Délices

**Fifth lecture by Youssef Ammaih (Ph.D student and ANSOLE member in Morocco)**



**Sixth lecture by Abou Gaye (Senegalese Ph.D student and ANSOLE member in Marocco)**





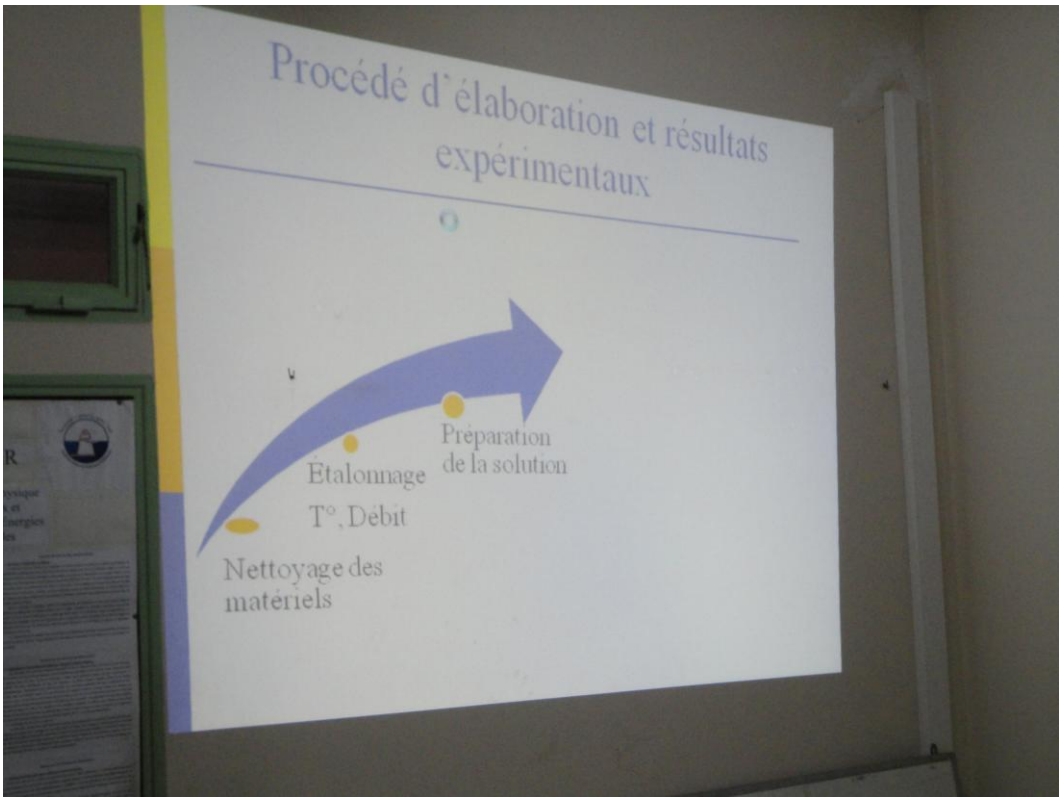
**Seventh lecture by Hervé Joël Nkuissi Tchognia (INEX: Cameroon-Morocco)**






**Last lecture by Samira Elfarrass (Ph.D. student and ANSOLE member in Morocco)**





# Award of attestations of participation

**Prof. Bouchaib Hartiti**



**Abou Gaye**



**Prof. El Mahdi Assaid**



**Armel Duvalier Péné**



**Hervé Joel Nkuissi Tchognia**



**Dr. Allé Dioum**



**Seydou Tapsoba (student from Burkina Faso and ANSOLE member in Morocco)**



**Sameh Boudida**



**Safae Aazou**



**Youssef Ammaih**



**Samira Elfarrass**



**Prof. Abderraouf Ridah**



## Group Photos

### ANSOLE-ICTP Fellows




### Fellows with their hosts



**All participants**





# Lunch in a fish restaurant







**Enjoying Moroccan hospitality through new found friends (eating Moroccan couscous and drinking Moroccan coffee and tea)….**







