NEXT PV kick-off meeting, ENSCP december 17th, 2012

LGEP presentation
Laboratoire de Génie Électrique de Paris, UMR CNRS 8507
(Electrical Engineering Lab.)

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100 people: 34 Researchers (CNRS, Universities)
16 Engineers/Technicians
50 PhD students and post-docs
STAFF (June 2012):

- 9 permanent researchers
- 11 PhD students/post-doc researcher
- 5 engineers and technicians from MADELEC Department

Objectives:

- to study semiconductors and devices that can be useful for photovoltaics and optoelectronics
- to develop electronic characterization techniques from the macroscopic level down to the nanoscale and related modeling
Development of characterization techniques
« CAMADISC Platform »

TOPICS:
Thin Film Semiconductors for Photovoltaics

- Silicon thin films and interfaces with c-Si : a-Si:H, µc-Si:H, pm-Si:H and SiNMWs.
- CIGS thin films.
- Organic Semiconductors.

TOPICS:
Wide bandgap semiconductors for Optoelectronics

- CVD Diamond (polycrystalline, homoepitaxial).
- III-V Nitrides
**« CAMADISC Platform » :**

**Electrical and photo-electrical characterization**

- Conductivity in the dark (3)
- Conductivity under dc light (3)
- Constant Photocurrent (CPM) ac and dc,
- Modulated Photocurrent (MPC) (4)
- Steady-state Photocarrier Grating, SSPG (2)
- Solar simulator (up to 10 suns)
- Time-of-Flight (TOF)
- Admittance Spectroscopy: capacitance and conductance vs T, f, V (2)
- DLTS
- Thermally Stimulated Current (TSC)
- Spectral Photoresponse incl. mapping

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**Solar cell under test**

**Accelerated light-soaking**

**Modulated Photocurrent**
Optical characterization

- Transmission/reflection measurements from 200 nm to 3 µm
- FTIR measurements
- Confocal µ-Raman/µ-PL and AFM/SNOM

Topography and Electrical nanocharacterization

- 5 Atomic Force Microscope (AFM) (2 Veeco, 1 Mol. Imaging, Witec, Nanosurf) with the home made electrical extension “Resiscope”
Numerical Modeling

THIN FILMS:
DEOST (Density Of States)

Calculation of the photocurrent in different regimes (steady-state, ac small signal, transient) to simulate many experimental techniques (SSPC, SSPG, MPG, MPC, TPC…):
- Evaluation of some material parameters (capture cross sections, mobilities…),
- influence of some parameters on measurements,
- validation of theoretical development of new characterization techniques.

PV DEVICES:
- 1D modeling:
  - AFORS-HET (Automat FOR Simulation of HETerostructures)
  - Logiciel Samah
  Simulation of photoluminescence and electroluminescence techniques
- 2D modeling:
  - SILVACO-TCAD
  Modeling of specific structures (IBC Si HJ, Silicon nanowires)
National Projects:

- **ANR (National Research Agency)**
  - SiFLEX (Jan 2009-Dec 2011), Silicon nanowires on flexible substrates
  - ULTRACIS (Jan 2009-Dec 2011), Very thin CIS films for PV
  - NewPVonGlass (Jan 2009-Dec 2011), New PV devices based on III-V materials (InGaN) on glass
  - SHARCC (Jan 2010-Dec 2012), Interdigitated Back Contacts Si Heterojunctions
  - CANASTA (Jan 2011-Dec 2013), Novel plasma processes for Carbon Alloyed NANocrystalline Silicon Tandem thin film solar cells
  - MULTISOLSi (Jan 2012-Dec 2015), Multispectral solar cells on Si

- **OSEO Project**: SolarNanoCrystal (End: May 2013, interrupted: end of 2011)
  Partners: PV ALLIANCE -PHOTOWATT, CEA, EDF Energies Nouvelles, EMIX, PHOTOSIL, APOLLON SOLAR, 6 CNRS laboratories.

- **ADEME project**: Polysil (Jan 2010-Dec 2014)
  Partners: SOLSIA, Solems, Air Liquide, CEA, LPICM, LGEP. Silicon Thin films

- **SOLSIA Contract** (start in 2011). Silicon Thin films

- **NANORGASOL network** (organic materials for PV applications)

- **CNRS PV Federation of Ile-de-France region**: LPICM, LGEP, IRDEP, ILV, LPN
Recent international Projects

• **NIMS-CNRS joint project** (2006/2008), Y. Koide – J.P. Kleider, **CVD diamond, UV detectors**

• **PICS**: (2008/2010), LGEP-SCM/ Ioffe Institute/ Physics and Technology Centre for Research and Education of the Russian Academy of Sciences. **IV, III-V Heterojunctions for PV.**

• **CEFIPRA**: (End: Dec 2010), LGEP-SCM/ LPICM/ SOLEMS/ Energy Research Unit of the Indian Association for the Cultivation of Science (Kolkata, Inde). **Deposition process shared with an industrial PV partner.**

• **European project FP7 HETSI**: (End: Feb 2011), CEA/ LGEP-SCM/ LPICM/ ECN/ IMEC/ ENEA/ Helmholtz-Zentrum Berlin/ IMT Neuchâtel/ Utrecht University/ Photowatt/ Solon AG/ Q-Cells). **Silicon Heterojunctions.**

• **ECOS-Sud**: (End: Dec 2011LGEP-SCM/ INTEC (Santa Fe, Argentina). **Photocurrent techniques for Si thin films.**

• **France-Canada project**: (June 2010- June 2012LGEP-SCM/ "Advanced Photovoltaics and Devices" of Toronto University. **Si thin films deposited by new adjustable plasma process and application to heterojunctions for PV.**

+ **3 international joint PhDs**:
Olga Maslova (LGEP/ Ioffe Institute (Russia)); Jennifer Luckas (LGEP/ Aachen University (Germany)); Renaud Varache (LGEP/ Helmholtz Zentrum Berlin (Germany))
Topography and Electrical nanocharacterization

- 5 Atomic Force Microscope (AFM) (2 Veeco, 1 Mol. Imaging, Witec, Nanosurf) with the homemade electrical extension "Resiscope"

AFM under vacuum and high temperatures

In-plane lateral Silicon NanoWires

AFM electrical characterization of the c-Si/a-Si:H interface

A->B Cross section
- Monitoring GaAs and GaInAs growth on silicon with negligible strain relaxation defects
- CBE ELO (Epitaxial Lateral Overgrowth) through nano-holes into an ultrathin SiO2 layer
- Goal: GaInP/Si/ GaInAs triple junction multispectral solar cell (efficiency potential of 45.5% under AM1.5G)
- Growth: IEF lab (Orsay)
- Advanced structural characterization: CEMES lab (Toulouse)

Epitaxial coherence with the Si (100) substrate
Acknowledgements

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- Nikolay Cherkasin, CEMES