Mastered Techniques

1. Characterization of Semiconductor Materials and Nanostructures:

   - ***Optical:*** NSOM[1], micro-Raman Scattering Spectroscopy, Spectral Ellipsometry, Specular and Diffuse Reflectances, FTIR[2]
   - ***Nanoscale material mechanical properties:*** Nanoindentation, load controlled nano-scratch, surface stiffness by AFM,
   - ***micro and nano-Topography***: AFM, NSOM
   - ***Structural:*** Synchrotron x-ray nanoProbe, TEM and HRTEM[3], XRT[4], anisotropic etching/Nomarski microscopy, OPP[5], and nano-topography by AFM.
   - ***Chemical:*** STEM Z-Contrast, EELS[6], micro-FTIR[7] Synchrotron Source, SIMS[8] et μ-SIMS imaging,
   - ***Optoelctronic:*** CL,[9] EBIC[10]/SEM, MOS-EBIC, Spectrale Response, LBIC[11]/CSLM[12].
   - ***Electrical properties:*** I-V[13], CV[14], Recombination Lifetime by μPCD[15], Generation Lifetime by Zerbst Analysis, High Resolution Spreading Resistance,
   - ***Energy Level Spectroscopy:*** electrically active impurities: by DLTS,[16] PICTS,[17] μPCD Injection Level Spectroscopy.

2. Sample preparation:

   - Sample preparation for TEM.
   - Chemical Etchings (Secco, Sirtl, Wright, Schimmel) for defect delineation in semiconductors,
   - Surface electrical passivation for charge carrier lifetime measurement,

3. Device fabrication techniques and sample preparation:

   - Ion Implantation, Neutron Irradiation, Sputtering,
   - Epitaxy of silicon
   - CVD[18] of silicon dioxide and silicon nitride,
   - Oxidation and diffusion of dopants in open tubes furnaces,
   - Diffusion of dopants and Antireflective coating in belt furnaces,
   - Silicon passivation and impurity gettering,
   - Anisotropic dry etching (RIE),
   - Evaporation, Photolithography,…

4. Photovoltaic Cell Fabrication:

   - Solar cell fabrication on crystalline (mono and poly) silicon, and II-VI semiconductors
   - P-N junction based devices + back surface field (BSF) or back surface reflector (BSR)
   - Thin films solar cells fabrication by electro-deposition and by airless spray,
   - Chemical end Electrochemical etching for optical propriety control: textured et porous structures,
   - Screen printing, Spin-On, Airless-Spray, Electrodeposition of thin film.

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[1] **NSOM**: Near Field Optical Microscopy: (beyond diffraction limits, spatial resolution 50 nanometre)
[2] **FTIR**:Fourier Transform Infra Red
[3] **HRTEM**: High Resolution Transmission Electron Microscopy
[4] **XRT**: x-ray topography using Lang camera. Allows defect imaging in transmission and reflection modes as well as cross-section and limited projection topography (LP-XRT)
[5] **OPP**: Optical Precipitate Profiling: i. e. , Infra Red Scanning Differential Interference Contrast Microscope
[6] **EELS**: Electron Energy Loss Spectroscopy
[7] **micro-FTIR**: Fourier Transform Infra Red couplée a une sourece Synchrotron (n*ear*- and *far*-IR)
[8] **SIMS**: Secondary Ion Mass Spectroscopy
[9] **CL:** Cathadoluminescence
[10] **EBIC**: Electron Beam Induced Current: Imaging of carrier recombination current induced in semiconducteurs by electron beam scanning in SEM.
[11] **LBIC**: Light Beam Induced Current, similar to EBIC, but employs a well focused laser beam.
[12] **CSLM**: Confocal Scanning Laser Microscopy
[13] **I-V**: Current Voltage characteristic of devices
[14] **C-V**: Capacitance Voltage characteristic
[15] **μ-PCD**: Laser Microwave Photo-Conductance Decay (micro-PCD).
[16] **DLTS** :Deep Level Transient Spectroscopy
[17] **PICTS**: Photo Induced Current Transient Spectroscopy
[18] **CVD**: Chemical Vapor Deposition

5. Computing and Software(s):

- High Performance Computing for materials modeling:
  - Atomistic (quantum mechanics and molecular dynamics): CERIUS2, UNICHEM, MATERIALS STUDIO,[19] VASP,[20] EDIP,[21] ADESH[22]
  - Simulation d'implantation ionique: SRIM[23]
- Numerical Analysis: Optimization, Simulated Annealing, Newton-Raphson, Non Linear Problems, Linear Algebra, Sparce Matrix, LU factorization, Gauss-Seidel, Finite differences, Implicit and Explicit methods for Resolution of Differential Equations.
- Phenomenological Analysis of thermal, structural, and optical coupled fields by Finite Elements as well as Diffusion and Impurity and Atom and Point Defect Clustering
- Used Finite Element Analysis Software: ANSYS and FEMLAB
- Used Numerical Analysis Packages: Origin/NAG, Numerical Receipies, ISML, LINPACK
- Data Analysis, Statistical Analysis and Experiment Design: ANNOVA, DAAD

6. General Utilities Software(s)

- Numerical and Symbolic Math Tools: MATLAB, MATHCAD, MAPLE.
- Image Processing: Adobe Photoshop, IP image digital processing package, Scion Image[24] (formerly NIH Image), Image Tools, Gimp (under Linux).
- Graphics: AVS, Origin, Gnuplot.

7. Other Software(s)

- Compilers: FORTRAN, Basic, Visual Basic, Pascal, and Assembling language
- Parallel computing: Parallel Fortran and MPI[25]
- Systems: MSDOS, MS Windows, Linux
- Networks: TelNet, FTP, SSH,…
- Macro Languages for automation of Word Processing and Spreadsheets (MS Office)

8. Computer Hardware/Automation:

- LabView software, Test Point software
- Instrument and device interfacing via RS170A, RS232C, IEEE488.
- Transputers INMOS800, INMOS400,
- Micro-controller: Intel 8052.

[19] CERIUS2, UNICHEM, MATERIALS STUDIO developped by Accelrys Inc., San Diego
[20] **VASP**: Vienna Ab-initio Package Simulation
[21] **EDIP:** Environment Dependent Interaction Potential
[22] **ADESH:** "Atomistic DEfect Simulation Handler", Casa Engineering, Hopewell Junction, New York, NY.
[23] **SRIM:** Stopping and Range of Ions in Matter
[24] **Scion Image**: developpé par NIH
[25] **MPI**: Message Passing Interface