Journées Nationales en Nanosciences et en Nanotechnologies

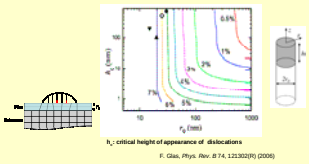
BONAFO
BOîtes dans NAnoFils pour l'Optique

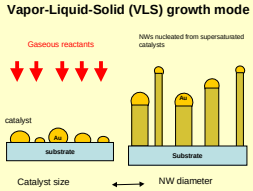
Target:

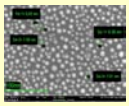
- **to acquire the growth control of heterostructures in nanowires (NWs) for three different materials systems : InAsP, CdZnSe and AlGaN (MBE, MOCVD)**
- **to get a deep understanding of their optical fundamental properties and to evaluate the advantages of their optical properties for opto-electronic applications.**
  - → Extensive optical studies (IR to UV), at the single nano-object level.
  - → Evaluation of the advantages of this type of QDs in comparison to epitaxially grown Stranski Krastanow QDs two following applications : single photon emission and photo-detection (interband and intraband)

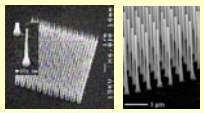
Advantages of nanowire geometry

- No too restricting lattice-matching condition
  - low cost substrate (Si)
  - high quality heterostructure
- NW quantum dot
  - − No need of SK mode
  - − No constriction for the QD height
  - − No wetting layer (thermionic escape of carrier)






Dewetting of 1 nm Au on Si substrate (d~ 5-13 nm, h~3 nm)


InP NW, *Nanotechnol.* 14, 1255 (2003)

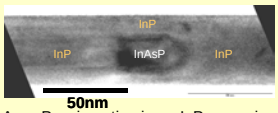
Nanowire growth and structural analyses

- **To establish the know-how to achieve high quality QDs based on NW heterostructures.**

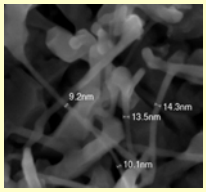
  -> control of radius and length of the QD.
- **To demonstrate that such QDs could transcend several limitations of QDs formed by SK growth**

  -> require to establish the know-how to master nanowire growth: morphology, heterostructures, spatial ordering (density)

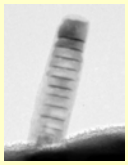
Large surface/volume → High structural quality for high optical properties



$InAs_{0.24}P_{0.76}$ insertion in an InP nanowire. D=22 nm, h=40 nm. 20 nm thick InP shell surrounding the axial heterostructure



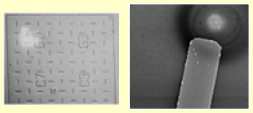
MBE grown ZnSe nanowires on GaAs substrate

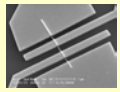

MBE grown GaN insertions in an AlN NW grown on a GaN columnar nucleus. h=2.5 nm , D=30 nm


MOCVD grown radial (lateral overgrowth) and longitudinal (multiple quantum well: 5 x (5 nm $In_{0.2}GaN_{0.8}$/10 nm GaN)) heterostructure on top of a GaN NW.

Handling and electrical contact

- To isolate and locate single NW for performing micro-PL, intraband absorption and TEM measurements
- To contact single nanowire for photoconduction spectroscopy

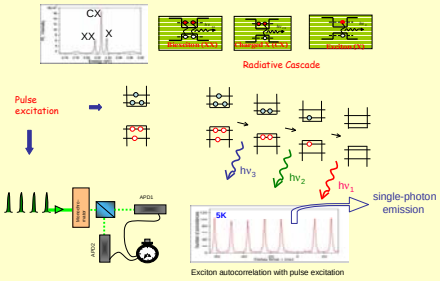


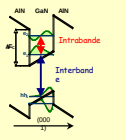


Optical properties

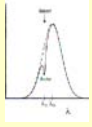
- **To get a deep understanding of the generic optical properties of NW and NW heterostructures**
- **To demonstrate that the grown QD can emit single photon on demand**

  → single photon emission at temperature higher than the state of the art temperature reached by SK QDs (absence of wetting)
- **To initiate photo-conduction studies on the NW based (hetero)structures.**
- **To initiate intraband spectroscopy study of a single QD** (very challenging task).
  - photoconduction spectroscopy for the 3 material systems (InAsP/InP, GaN/AlN, and CdSe/ZnSe)
  - differential transmission optical spectroscopy at near-IR wavelengths for GaN/AlN QD (possibility of intraband transitions at the telecommunication wavelength 1.55 µm, very original and challenging task).





Spectral hole-burning



CONSORTIUM:

- **CEA/ INAC: Institut Nanosciences et Cryogénie (coordination)**
- **CNRS/Institut Néel**
- **CNRS/LPN: Laboratoire de Photonique et de Nanostructures**
- **UPS-CNRS/ IEF: Institut d'Électronique Fondamentale**
- **ENS/ LPA: Laboratoire Pierre Aigrain**

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