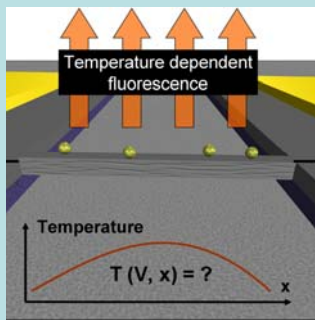


Principe et Objectifs



Il s'agit de caractériser thermiquement des nanofils métalliques et semi-conducteurs en utilisant des nanosondes fluorescentes dont les propriétés d'émission sont dépendantes de la température. Les nanofils sont obtenus en utilisant plusieurs procédés de fabrication : lithographie électronique, croissance électrolytique sur membranes poreuses et croissance par épitaxie. Plusieurs types de sondes sont comparées (nanoparticules, nanocristaux, molécules organiques et inorganiques, etc.) afin d'accroître les résolutions spatiales et temporelles en milieux sec et liquide.

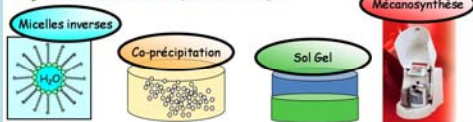
Outre la compréhension des phénomènes de transfert thermique dans des structures de faible dimensionnalité, ce projet vise à développer des capteurs chimiques et biologiques dont les propriétés de surface sont modulées thermiquement.

Fabrication of fluorescent particles

Choix des techniques expérimentales

- Critères à respecter :
- Taille nanométrique intermédiaire (40 nm - 500 nm)
 - Distribution monodisperse (taille)
 - Morphologie sphérique
 - Pureté chimique

Différentes voies de synthèse envisagées :

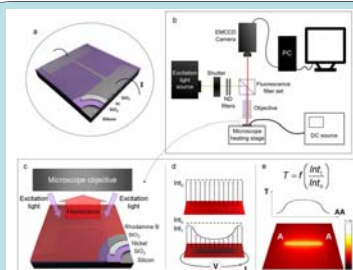


Techniques d'analyses utilisées :

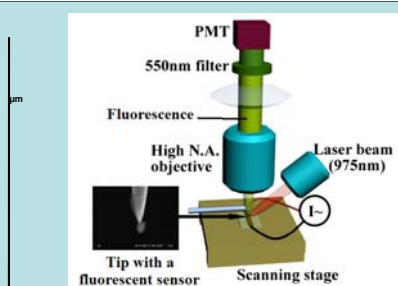
- FTIR
- DRX
- MET

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Fluorescence Thermometry : Two experimental configurations

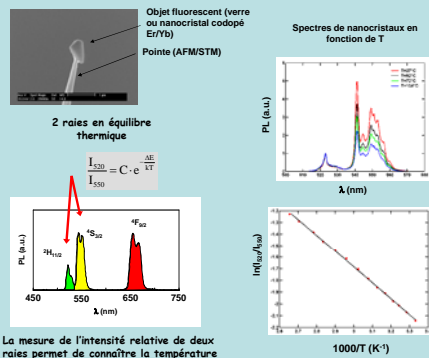


a) Resistive heating in a metal micro- or nanowire is used in our case to achieve locally confined temperature changes. b) Setup for fluorescence thermometry using an EMCCD camera to capture fluorescent images. c) The sample is covered by a thin and dense layer of Rhodamine B molecules. d) Local heating occurs when a current is applied to the sample. Depending on the local temperature change, the local emitted fluorescence intensity changes. e) With precise knowledge of the relation between intensity change and temperature change, a given change in intensity can be converted to temperature.

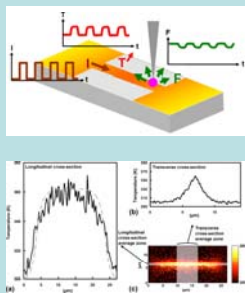


Description of the experimental set-up for Scanning Thermal Imaging. A small fluorescent particle (diameter < 500nm) is glued at the extremity of an atomic force microscope tip. The particle is excited with a laser beam. When it 'touches' a hot zone, the fluorescence is modified. The set-up works in a dc or ac mode. In the ac mode (see images below), the device is heated with an alternating current ($f \sim 1$ kHz) which modulates the fluorescence emission of the particle.

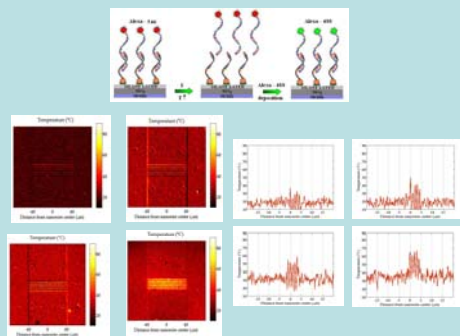
Photoluminescence spectra



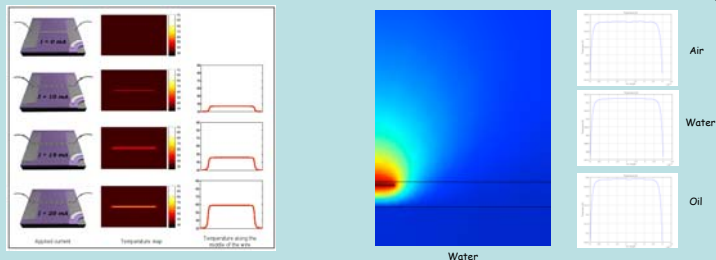
Experimental results obtained for metallic nanowires



Preliminary results on DNA melting with heated nickel nanowires



3D Finite Element Simulations in liquid conditions

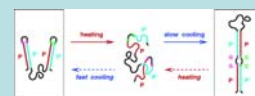
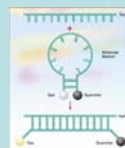


Using the FEM simulation software COMSOL, theoretical predictions, particularly those regarding the temperature distribution, can be made. From the top row to the bottom, simulated temperature maps of the four cases. As the current is increased, the temperature increases while the profile of the temperature distribution remains virtually the same.

2D simulations of the temperature distribution around a heated nickel nanowire in air, water and oil.

Perspectives

Thermodynamic and kinetic characterizations of DNA hybridization using molecular beacons



T. Barilero et al., Anal Chem. 81, 7988, 2009

V. Viasnoff et al., Nanoletters 6, 101, 2006

Collaborations with Ludovic Jullien (ENS Chimie Paris), Charlie Gosse (LPN, Marcoussis) and Virgile Viasnoff (ESPCI, Paris)

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