Equipe Thermodynamique et Biophysique des Petits Systèmes (TPS)

(Thermodynamics and Biophysics of Small Systems group)

Permanents

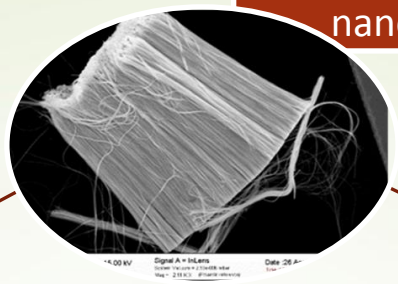
- Cécile Delacour (CNRS section 5)
- Daniel Bourgault (CNRS section 3)
- Hervé Guillou (UJF 28/62)
- Laureline Porcar (CNRS section 8)
- Olivier Bourgeois (CNRS section 3)

Non permanents:

- Guillaume Crouigneau (thèse 2015)
- Mohcine Laarraj (thèse 2015)
- Yanqing Liu (thèse 2015)
- Farida Veliev (thèse 2015)
- Dimitri Tainoff (04/2012-03/2015)
- Meriam Ben-Khedim (thèse 2016)
- Antoine Bourrier (thèse 2017)
- Clothilde Coilhac (thèse 2017)
- Adib Tavakoli (thèse 2017)
- Tuyen Nguyen (LANEF post doc 2015-2017)

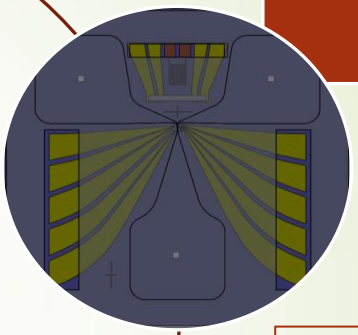
Thermodynamics and Biophysics of Small Systems

Bi_2Te_3 nanowires

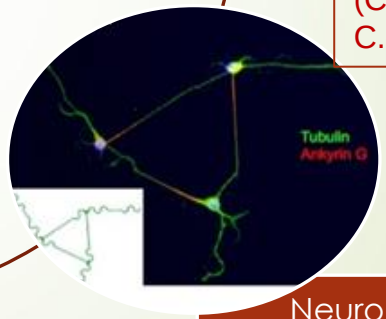


J.-L. Garden (Pole capteur)

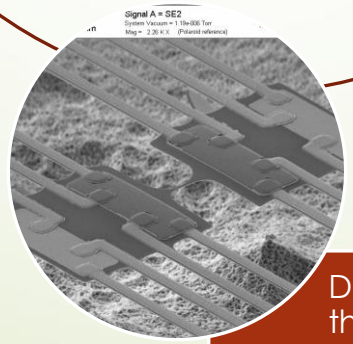
Biothermal detection



Biophysics
(C. Delacour, H. Guillou, C. Villard)



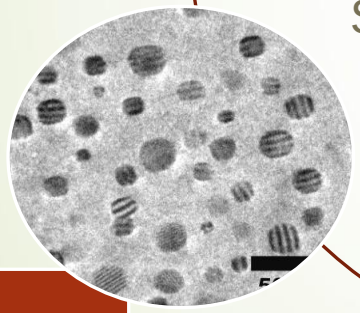
Neurones (Graphene)



Double sensors for thermal transport in Nanowires

Room to low temp. physics
(O. Bourgeois)

GeMn nanostructured materials

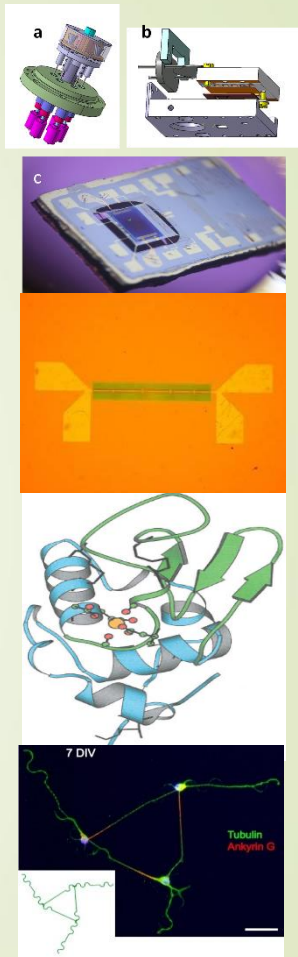


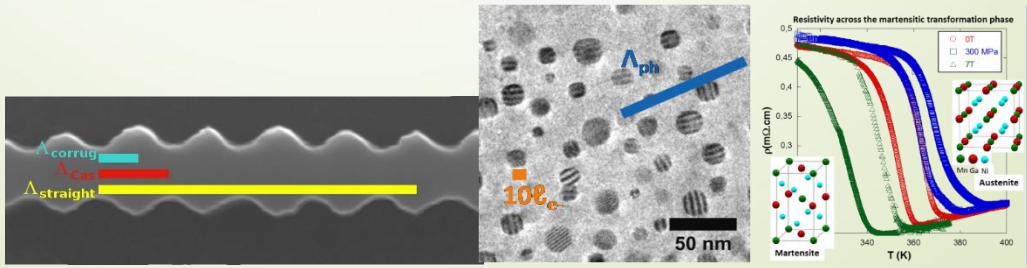
Heusler materials

Materials and energy
(L. Porcar, D. Bourgault)

TPS team: main research topics

- Phase transition in low dimensional systems (quantum phase transition, BKT transition).
- Complex systems and glass transition: out of thermodynamic equilibrium.
- Nanophononics: towards quantum limit of phonon heat flow.
- Thermoelectricity of thin films and nanowires: effect of nanostructuration on the thermal properties and Seebeck coefficient.
- Magnetic Heusler alloys: coupled multifunctional properties for future sensor applications (FSMA)
- Biophysics: neurons, cell micromechanics, biothermics (DNA).





TPS team: scientific and experimental skills

- Principal scientific objectives

• Thermal physics at the nanoscale (Nanophononics, phase transition, TE)	→ Specific thermal event emerging at the nanoscale
• Thermodynamics of macromolecules and living objects	→ Understanding the thermal signatures of DNA denaturation/renat.
• Neurone physics	→ Controlling the information flow in neural connections
• New materials for energy	→ Know-how on material growth and deposition for multiphysics properties

Experimental and Technological Skills:

- Highly sensitive measurements (specific heat and thermal conductance)
- Very low noise measurement chain
- Development of our specific sensor (based on silicon or silicon nitride membranes or polymer membrane)
- Nanotechnological developments (nanofabrication, nanostructuration, cell adhesion, sensor design…)
- Elaboration of new materials
- DSC under H, R(T,H,σ), magneto optical and in situ ρ(T,σ) set up

TPS team: collaborations and fundings

External: UAB, ICN (Spain), Max Planck I., Otto Schott I. (Germ.), LIMMS (Japan), VTT (Finland), IBM Z. (Switz.), Bar Ilan Univ., Technion (Israel)

France or Local: GIN, LNCMI, LPM2C, CEA-INAC, CEA-LITEN, CEA-SPEC, ECP, LPN, CETHIL, Inst. Curie

Internal: E. Collin (MCBT), H. Godfrin, (MCBT), N. Dempsey (Nano), J. Fick (Nano), L. Cagnon (Nano), C. Goujon (MCMF), S. Miraglia (MCMF), V. Bouchiat (Nano)

Industries: Schneider, ST Microelectronics, Nexans, APERAM, SETARAM

- 1 EU FET project MERGING (1 post-doc, 2 thesis)
- 2 EU coordination action projects MicroKelvin (1 post-doc), NANO SC (COST exchange of students)
- 4 ANR projects (Néel coord. for 3 of them)
- Contracts with industry: Schneider, ST Microelectronics, SUPERFACTS (FUI).
- Fundings from CNRS: 1 PIE Energy, 1 « Risque », 1 PEPS.
- Regional fundings: COGEETEN (1 thesis scholarship), Accueil Doc (2 years of thesis scholarship)
- Local contracts: Fondation des Nanosciences, LANEF (2 projects), 2 « UJF thesis scholarship of Excellence »

lanef Laboratoire d'Alliances Nanosciences-Energies du futur

nano SCIENCES FONDATION

Région RhôneAlpes

Agence Nationale de la Recherche ANR

SEPTIEME PROGRAMME-CADRE

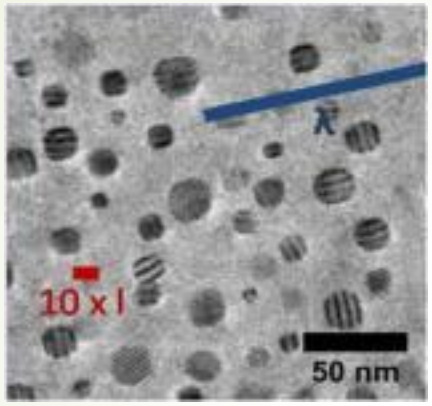
Nano-thermique a 300K :

Etudes des propriétés thermiques d'une couche mince de Ge:Mn nanostructurée pour la thermoélectricité (Thèse de Yanqing LIU)

Thèse de Yanqing Liu (ARC Energie); D. Tainoff (MERGING)

GeMn: verre de phonons, cristal d'électrons

Inclusion diameter:
5 – 50 nm



Thermoélectricité

$$ZT = \frac{S^2 T \sigma}{k}$$

$$\eta_{max} = \eta_c \frac{\sqrt{ZT+1}-1}{\sqrt{ZT+1}+1}$$

Challenges:

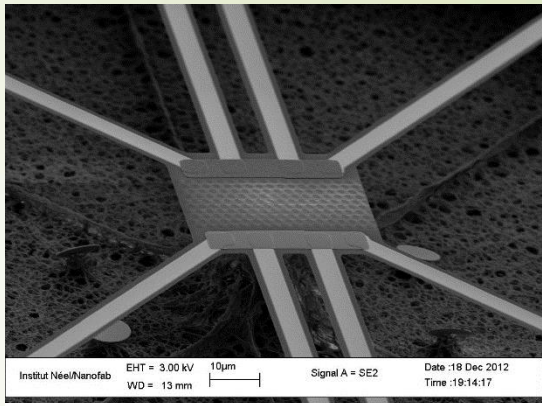
- thin film: ~200 nm
- Electrically conductive

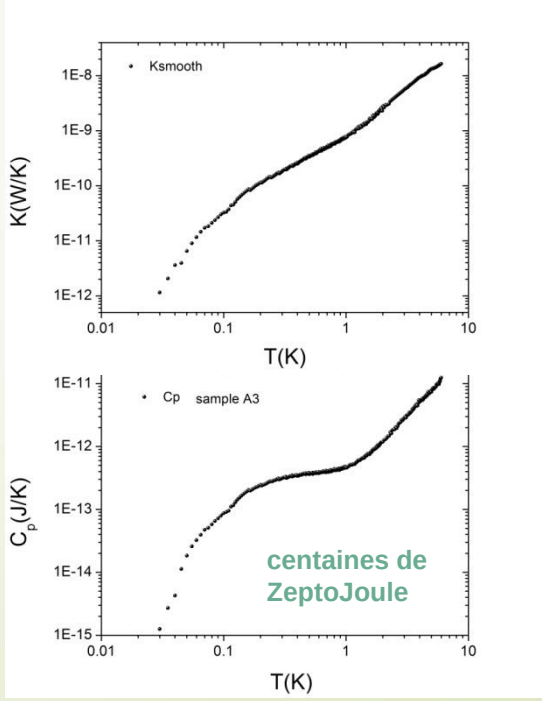
- 3ω method
- Scanning Thermal Microscopy (CETHIL)
- Simulation

Nanophononique sous 100mK:

Développement d'une instrumentation extrême pour les mesures thermiques (Thèse de Adib Tavakoli)

- Membrane: chaleur spécifique de gaz de phonon 2D, transition 3D->2D, TLS et stress couplé aux mesures nanomécaniques (coll. E. Collin)
- Transport de phonon dans le régime quantique: conductance universelle (Landauer), coefficient de transmission, effet de confinement.
- Manipulation à l'échelle du nanomètre des phonons thermiques: cristaux phononiques, diode thermique, rectification.
- Phonon et Nanothermoélectricité: nouvelle approche pour l'équipe (bottom-up) EU MERGING

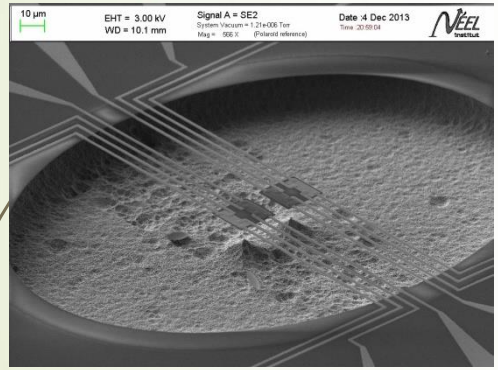


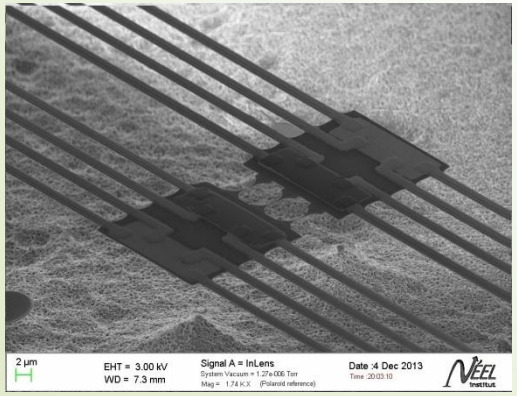


Nanophononique sous 100mK:

Développement d'une instrumentation extrême pour les mesures thermiques (Thèse de Adib Tavakoli)

- Développements de capteurs thermiques uniques ultra-sensibles (Nanofab (Thierry Fournier) et le pole Capteur (Jean-Luc Garden)
- Quelques centaines de ZeptoJoule (10^{-19}/10^{-20} J)
- Univers quantique du transfert de phonon et donc de la chaleur
- Rectification de la chaleur, cristaux phononique, mesure hors équilibre

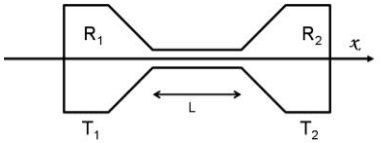


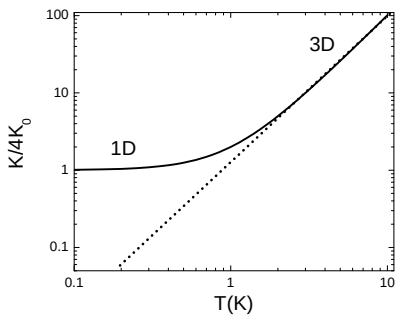


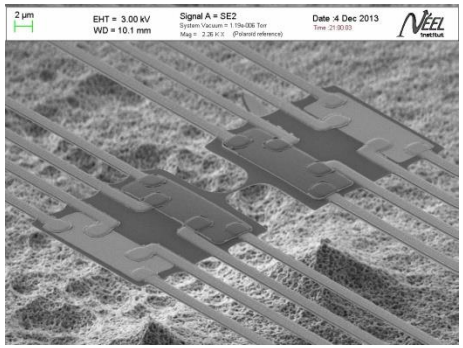
Modèle de Landauer pour les phonons

$$\kappa = \sum_{\alpha} \int_0^{\infty} \Im(\omega) \frac{\hbar\omega}{2\pi} \frac{df_B}{dT} d\omega = \frac{\pi^2 k_B^2 T}{3h} N_{\alpha} \Im$$

$$K_Q = \frac{\pi^2 k_B^2 T}{3h}$$



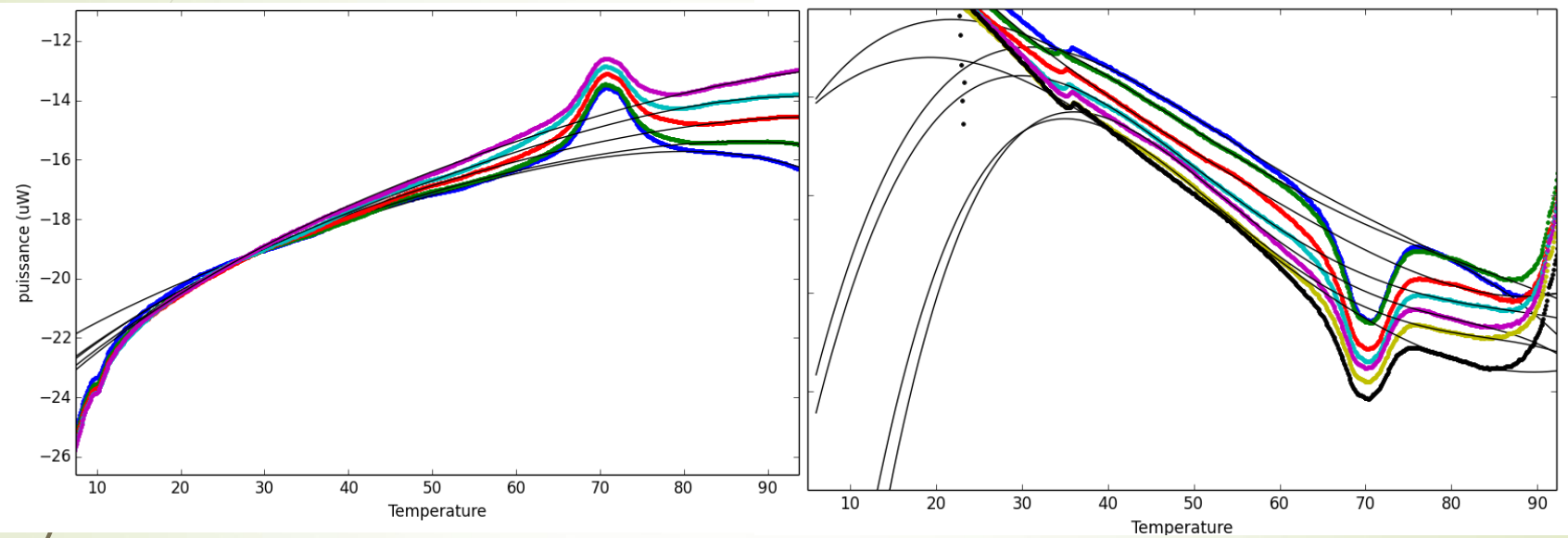




Régime quantique de conductance thermique universelle

Bio-thermique:

Développement d'un capteur microfluidique pour l'étude de repliement de structure d'ADN ou de dénaturation d'ADN (Thèse de Clothilde Coilhac)



DSC (differential scanning calorimetry):

pour mesurer la chaleur libérée/absorbée pendant les réactions d'hybridation ou de dénaturation, pour avoir accès aux paramètres thermodynamique des réaction (ΔH, ΔS, ΔCp, Tm).