NANOPOWER

Nanoscale energy management for powering ICT devices

www.nanopwr.eu

6 partners:
Wurzburg (Ger), ICN (Sp), VTT (Fi), Univ Geneva (Ch), Unicam (It)
2.6 M€, 3 years, lead by NiPS

NANOPOWER is an EC funded project (Objective ICT-2009 8.6 – Call 5, GA no: 256959) under the **FET proactive initiative "Toward Zero-Power ICT" (2zeroP)**

what

The scientific objective of this project is thus to study energy efficiency with the specific aim of identifying new directions for energy-harvesting technologies at the nanometre and molecular scale.

The technological objective of the project is to integrate such technologies into autonomous nanoscale systems to allow new, low-power ICT architectures to find their way into devices.

In a joint effort, the NANOPOWER consortium composed by word leading experts in the fabrication of Si and III-V semiconductor nanodevices, fundamental and applied modelling as well as design and integration of ICT architectures will fabricate, test and evaluate new challenging prototype devices:

- ✓*Nanomechanical nonlinear oscillators*
- ✓*Phonon rectifiers*
- ✓*quantum harvesters*

addressing applied prototypes and non-equilibrium processes down to the quantum level.

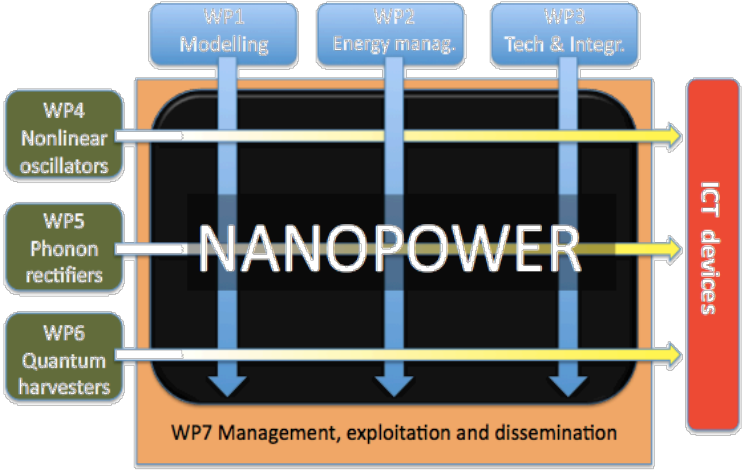
who

- Luca Gammaitoni
- Lukas Worschech
- Jouni Ahopelto
- Clivia Sotomayor Torres
- Markus Buttiker
- Fabio Marchesoni

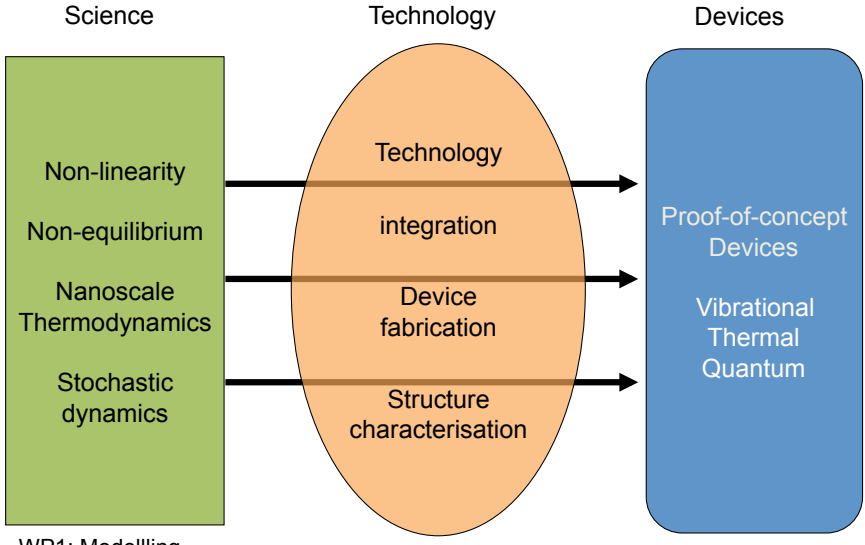
where

- NiPS Laboratory, Università di Perugia (IT)
- Julius-Maximilians Universitaet Wuerzburg (Ger)
- Valtion TeknillinenTutkimuskeskus (FI)
- Catalan Institute of Nanotechnology (SP)
- Universite de Geneve (CH)
- Università di Camerino (IT)

how

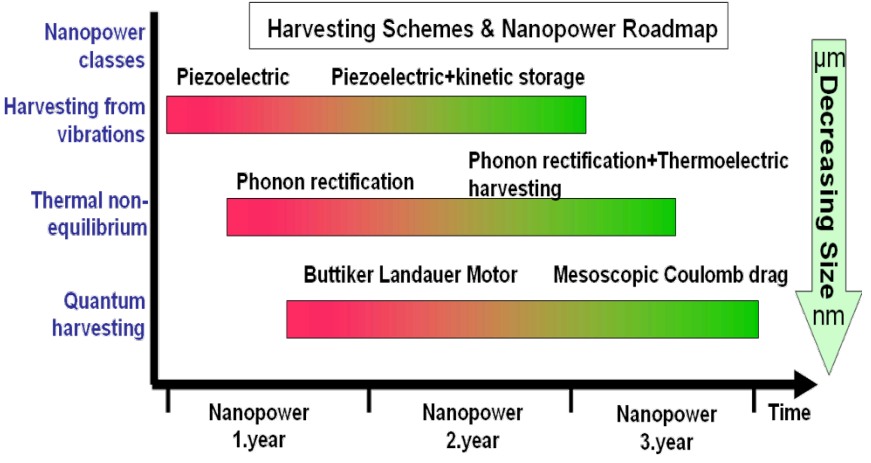

WP1
Modelling
WP2
Energy manag.
WP3
Tech & Integr.
WP4
Nonlinear
oscillators
WP5
Phonon
rectifiers
WP6
Quantum
harvesters
NANOPOWER
ICT devices
WP7 Management, exploitation and dissemination

FET: bringing science into technology



when

2010 - 2013

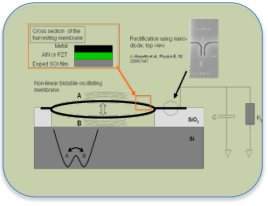


Major achievements First Period

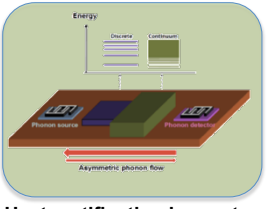
Aug 1st 2010 – Jul 31st 2011

- We developed our studies on energy management at nanoscale in the framework of "Stochastic energetics". In this framework we addressed the problem of energy efficiency in fluctuations rectification.
- We elaborated an operative procedure in order to optimize the operating efficiency of a nanodevice.

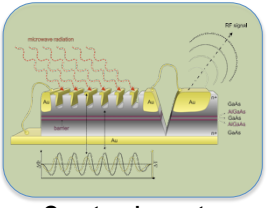
Three classes of potential nanoscale energy harvester devices have been studied.



Nonlinear nano oscillators



Heat rectification harvester

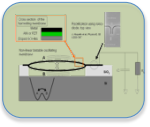


Quantum harvester

We have made significant progresses in all the three classes as detailed in the following.

Major achievements First Period

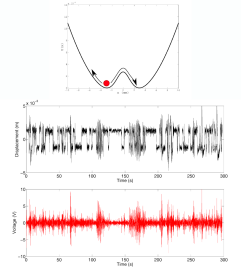
Aug 1st 2010 – Jul 31st 2011



Nonlinear oscillators for vibration energy harvesting

Comprehensive description of the theory of non-linear energy harvesting.

More details on D2.2: *Report on nonlinear oscillators for energy harvesting*.

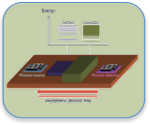


Novel concept device of a vibration energy storage system

More details on
D4.2: *Report on design of a prototype vibration energy storage*.

Major achievements First Period

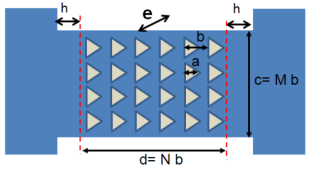
Aug 1st 2010 – Jul 31st 2011



Heat rectification harvester

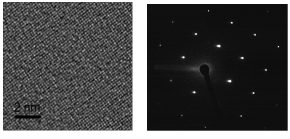
Phonon rectification through a spatially asymmetric medium:
First design of a phononic Cristal

More details on
D5.1: *Report on principle of operation of the device class*.
M5.1: *Design of a phonon rectifier with rectification potential larger than 20%*



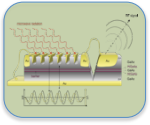
b = 2a
N = 1, N=2
N=10, N=25
h = b
c = 25
e = b
a = 800 nm

HRTEM image of freestanding Si membrane, thickness 6 nm



Major achievements First Period

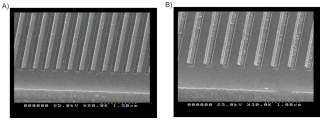
Aug 1st 2010 – Jul 31st 2011



Quantum harvester

Buttiker-Landauer Motor: Theory and test toward first design

The device consists of a Büttiker-Landauer motor and an integrated RTD. Herby, the BLm generates an electrical current by a periodic and spatially symmetric electronic potential subject to an out of phase heating of the electron gas (or more general nonlinear noise). The harvesting principle is based on em radiation absorption at nanoscale.



Heat-charge-current conversion

A novel concept device where a quantum dot is coupled to two heat reservoirs via tunnel contacts which permit carrier exchange and is coupled capacitively to a gate such that there is only energy exchange between the conductor and the gate but remarkably no particle exchange.

More details on D6.1: *Report on principle of operation of the device class*

Summary

✓ **Foundations of Energy Harvesting at the nanoscale**. We aim at the demonstration of radically new strategies for energy harvesting and local storage below the micrometer scale based on our studies on thermal ratchets and nonlinear noise induced transport in non-equilibrium thermodynamic systems.

✓ Exploration and harnessing of potential energy sources at nanoscale with specific reference **to non-equilibrium thermal fluctuations** (phonon rectification and quantum harvesting) and **wide-band random vibrations** (nonlinear energy harvesting)

✓ Introduction of **new-concept nanoscale power generators**: phonon rectifiers, nonlinear oscillators for vibration energy harvesting and quantum harvesters.

✓ The **integration** of the three componets of nanoscale power generators (the energy conversion, the voltage rectification, the storage) into a single self-powered autonomous electronic ICT device.