

NANOTECHNOLOGIES AT SCHOOL: A NEW APPROACH COMBINING SCIENTIFIC KNOWLEDGES AND ETHICAL ISSUES

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Training in Nanotechnologies at Toulouse University

PANAMA- schools (Master)

First PANAMA School - 4-15
July 2005



Second PANAMA School - 3-13
July 2006



NANOs au Lycée

Les nanotechnologies s'invitent au lycée

A l'heure où les Nanotechnologies représentent un enjeu stratégique majeur*, trente-quatre élèves de Terminales du Lycée St Sernin de Toulouse vont être des privilégiés. En effet, ils vont recevoir tout au long de l'année, une formation spécifique en Nanotechnologies. C'est une synergie de plusieurs facteurs qui a permis que cette classe expérimentale voie le jour. « Tout d'abord, c'est une rencontre entre les enseignants du Lycée St Sernin et des chercheurs du Laas (Laboratoire d'Architecture et d'Analyse des Systèmes) », raconte Christophe Vieu, chercheur au Laas et responsable de l'équipe « Nano ». Ensuite, une coopération avec les chercheurs en didactique du Gradif de Toulouse (Groupe de Recherche sur les Interactions Didactiques et la Formation des Enseignants) afin d'adapter les cours « nanos » au programme des lycéens. Les nanotechnologies n'étant pas (encore !) une épreuve au bac, les

cours « nanos » s'inscrivent dans les heures des enseignements de Mathématiques, Physique-Chimie et Biologie. Enfin, cette collaboration étroite entre enseignants et chercheurs a été facilitée par le CNRS grâce à la création du Club CNRS Jeunes « Sciences et Citoyens ». Les 34 lycéens, qui ont reçu leur 1er cours jeudi dernier dans les locaux du Laas et ont visité la Salle Blanche** ont eu un premier aperçu des divers domaines couverts par les nanotechnologies, allant des technologies de l'information et de la communication à la santé et l'environnement, en passant par les matériaux.

Vanessa Bordier

* En 2005, près de 4 milliards d'euros ont été alloués à la Recherche et au Développement dans les Nanotechnologies (Europe : 1 milliard, Japon : 1 milliard, États-Unis : 1 milliard, autres : 1 milliard). ** Rénovée et inaugurée en mai 2006, la Salle Blanche est l'une des six plateformes technologiques nationales mises en place par l'État.



Nanovideos



Third PANAMA School - 2-12
July 2007



NANOTECHNOLOGIES

« Definition » :

Techniques and Processes of miniaturization at the nanoscale (1-100 nm) for specific applications benefiting from new properties arising from the nano-size.

Application fields:

- InfoTechnologies (Nano-electronics)
- Materials (Nano-materials (nanotubes, nanowires, nanoparticles...))
- Biology, Medicine (NanoBioTechnologies)

WHY NANOTECHNOLOGIES FOR AN EDUCATIONAL EXPERIMENTATION ?

« Hot topics », TechnoScience, Multidisciplinary, « NanoEthics »

Forecasts for the world market for nanotechnologies span between **€750 billion and €2,000 billion until the year 2015, and it is estimated that up to ten million nano-related jobs could be created by 2014.**

The manpower issue:

350 000 new Nano specialists by 2010 in Europe*

* Workshop on Nano-Training Bruxelles 14-15 April 2005

The Challenge of NanoTraining :

- Interdisciplinary
- High level prerequisites (quantum physics...)
- High cost equipments (clean room, microscopes, UHV...)

Our approach : Open the minds for multidisciplinary before University

Demonstrate the possible Nanotraining at secondary schools

MAIN OBJECTIVES

- « Modern » science at school
- Lower the barriers between disciplines
- Develop students' understanding of the interdependence between science and society

Partners of the project

- Secondary school : pluridisciplinary team
 - Biology
 - Mathematics
 - Physics chemistry
 - Philosophy
 - English
 - Education in citizenship
- Laboratory LAAS-CNRS : Nanotech researchers
- Laboratory ERT 64 - GRIDIFE : human sciences, didactics, psychology researchers

New educational strategy : didactic plan

- 1.** lectures (Doc and Post-Doc) on Nanotechnologies : based on knowledges listed in official curricula of Terminale S
- 2.** Practical Work (at Research Lab 1 day) : Pupils = Researcher, Fabrication and test of a Nanodevice for high sensitivity biodetection
- 3.** Debate on Socially Acute Question (SAQ) rooted in nanotechnologies (at School)

1- LECTURES

Knowledges

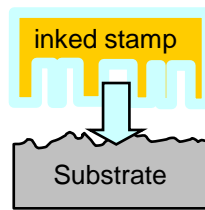
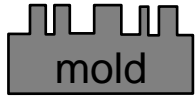
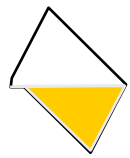
- Physics : light diffraction
- Chemistry: polymers and organic chemistry
- Mathematics : $\sin x / x$ and $(\sin x / x)^2$ functions
- Biology : Immunoassays

2- PRACTICAL APPLICATION

- Fabricate and test a Nanodevice for high sensitivity biodetection
- Fabrication by nanoscale soft lithography
- Label free optical detection based on diffraction
- Applications to DNA and protein biochips

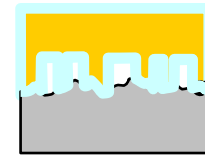
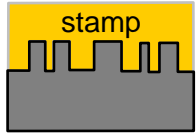
Soft Lithography

Xia Y. and Whitesides G. M. (1998), "Soft Lithography," *Angew. Chem. Int. Ed.* 37, 550-575.



4 . Stamp approach

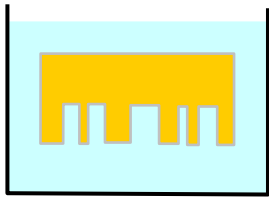
1. Elastomer is poured on the mold



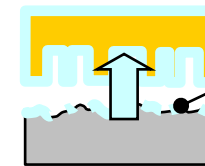
Localised Interaction

5 . Contact

2. Elastomer cross-linking



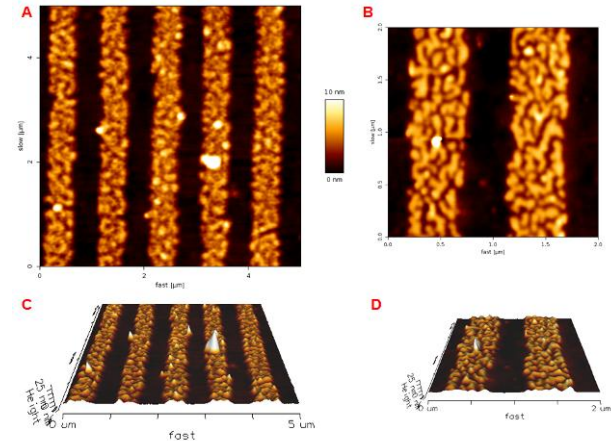
3 . Stamp inking



Deposited ink

6 . Stamp removal

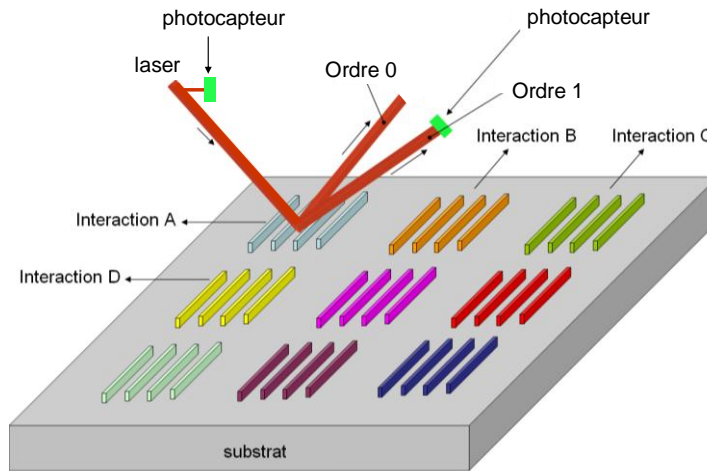
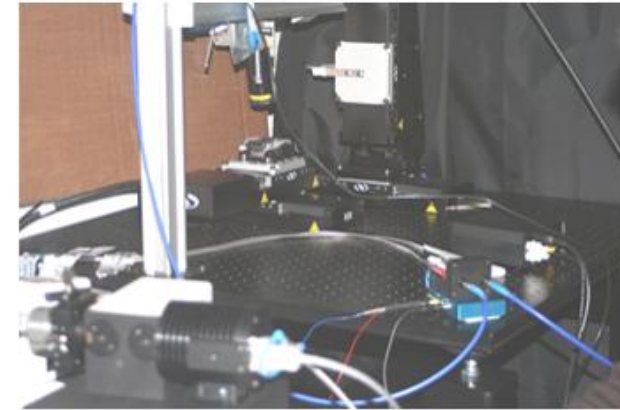
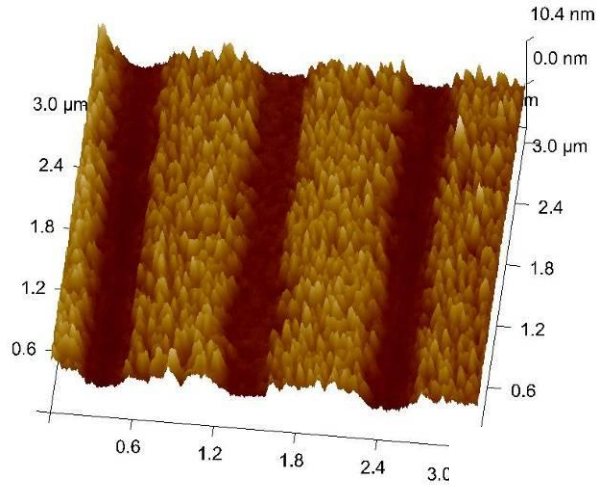
Print of proteins achieved by students
and characterized by AFM



How to use nanoscale patterning capabilities for label-free detection ?

The Diffrachip® concept

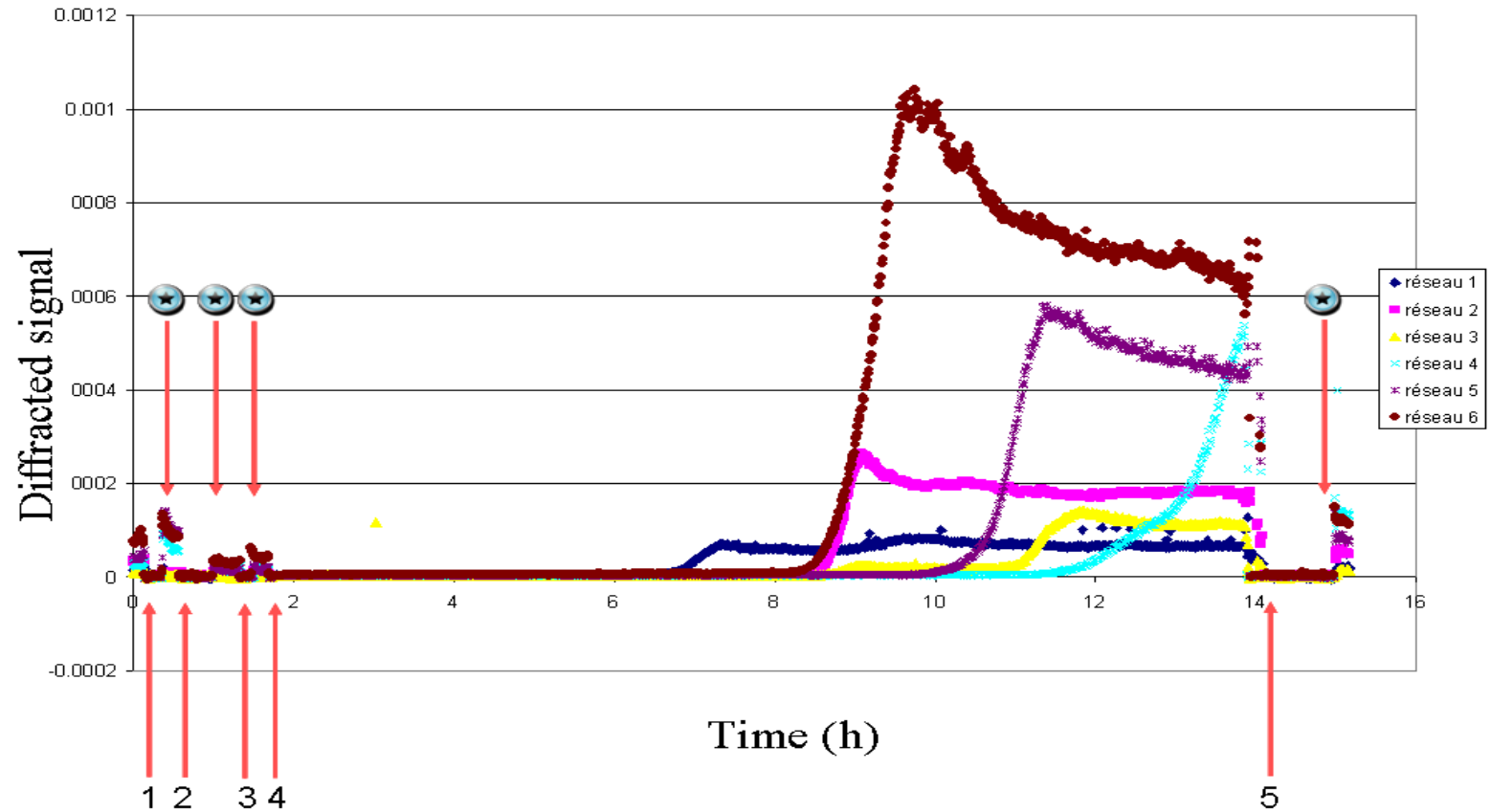
JC Cau, H. Lalo, JP Peyrade, C Vieu, C Thibaut, C Séverac, Patent pending



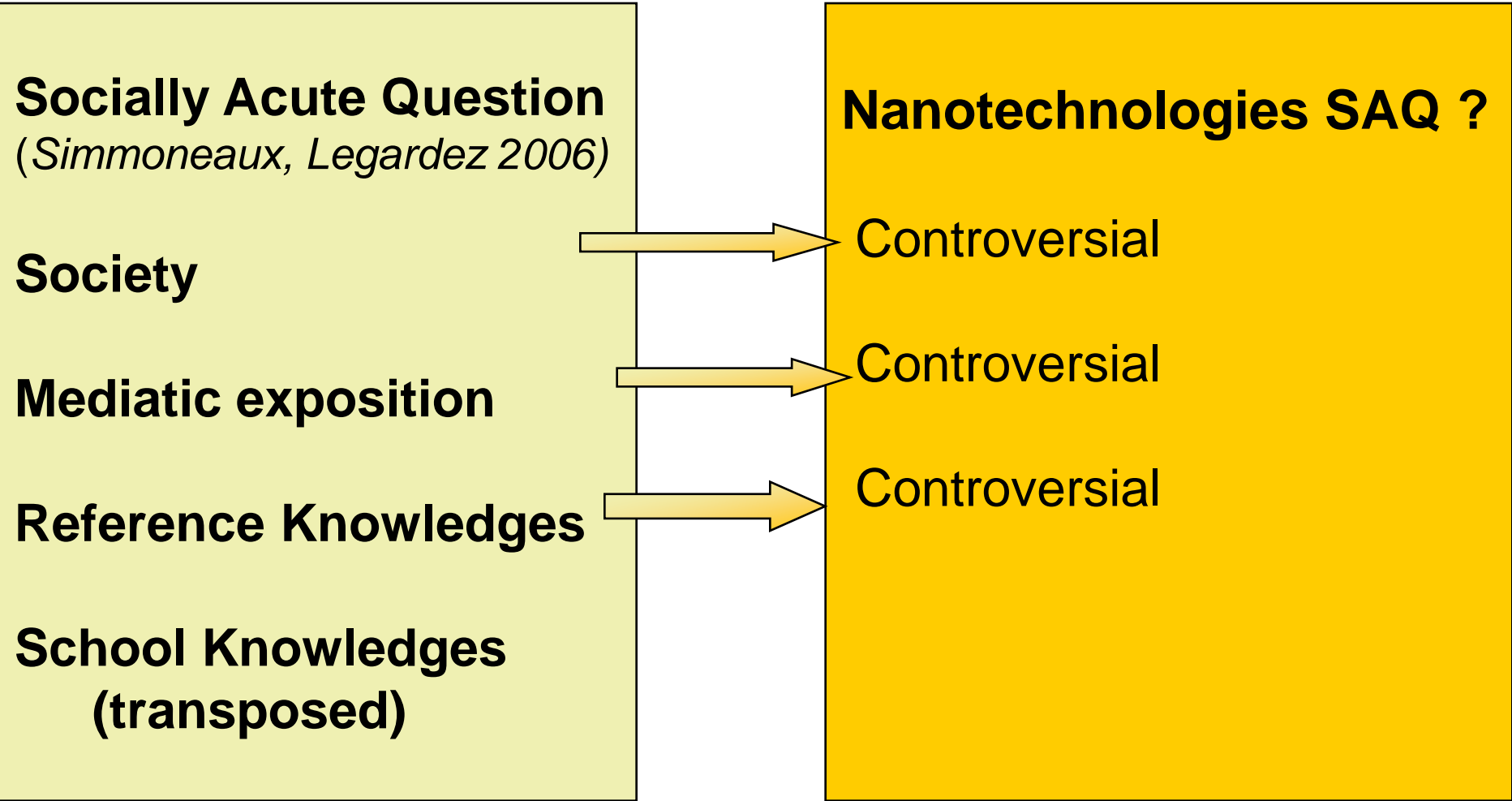
Make use of diffractive arrays of probe molecules : Targeted sensitivity 100 pM

Example of diffraction signals acquired by students during a Protein/Antibody interaction

🌀 : air drying



3. Debate on a Socially Acute Question : SAQ



Debate on Socially Acute Question (SAQ)

Debate protocol

- Documents (press, articles, web...)
- Conference and preparation of a set of questions for experts
- Meeting with experts and definition of the SAQ for the debate
- Debates between students

Two SAQs chosen by the two groups

- D1 : Have we sufficient control over Nanotechnologies to modify human beings and **have we the right to do so** ?
- D2 : **Can we allow** the creation of a superman ?
 - ➔ *Ethical considerations present from formulation of SAQs*

Debate Analysis : modal semantics items

	Certainty	Uncertainty
Adjective	sure, certain, clear, evident...	Doubtful, uncertain, probable, possible...
Adverb	certainly, necessarily, really, undeniably, obviously ...	Likely, maybe, probably
Expressions <i>Expressions toutes faites</i>	For sure, doubtless ...	As I heard , I don't know which, as they siad...
Verb	To claim, to assert, to certify, to admit	To think, to believe, to suppose, to wish, to hope,
Impersonal forms	It is sure that, Its is clear that	It is possible that, it seems that

D1 Have we sufficient control over Nanotechnologies to modify human beings and have we the right to do so?

- **51 % interventions of high school students**
 1. Human scientific experiment (13)
 2. Risks and dangerous effects of Nanotechnologies (11)
 3. Benefit for all progress of Nano and science (7)
 4. Representation of human body and integrity of the body (6)
 5. Legislation, control (5)
 6. Useful/useless (4)
 7. Full power over science and its dangers (3)

One example of student argumentation

4. Representation of human body and integrity of the body

85 Joseph : There is a thing which *bothers* me in the question (...) There is *something which does not sound right* it is the word being (...) Modify the human being, that is in the word being there is also the psyche, psychology, thus *maybe we should* change or we should replace the word being by human "organism"



Critics of reductionism

Thesis opposes Human Being and Human Organism

Personality, values

Functions, technical

When students meet ethicicians

2. Risks and toxicity
4. Integrity of the body



5. Legislation
and control



3. Benefit for all
6. Useful/Useless
1. Scientific Human exper
7. Full power of science



Commission of ethics of science
and technology June 2006, Quebec
« **Commission recommends**
[...] an evaluation of toxicity of
processes and products
stemming from
nanotechnologies before
authorizing marketing».

Jean-Pierre Dupuy :
« **Nanotechnologies open a
vast continent where human
being is going to construct
norms if he wants to give
them signification and aim** »

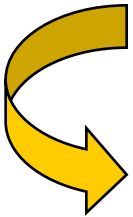
Jean-Pierre Dupuy :
**Consequences of scientific
progress on the individual
and society : statute of
human beings**

‘Who says ethics,
consciencousness, will, tells
of the triumph of the
subject »

Conclusions

« Hot » Science in action

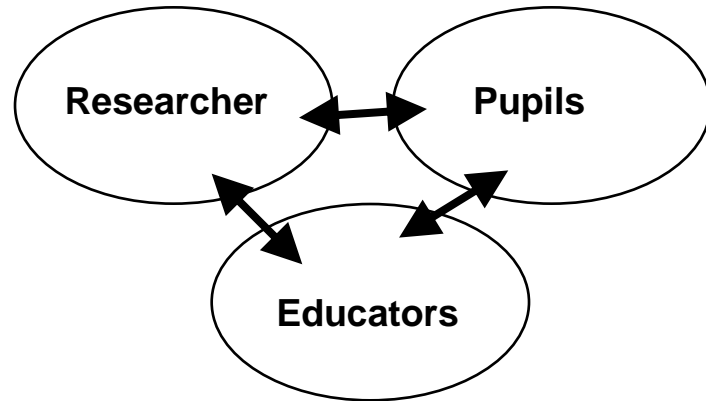
- Nanotechnologies can be introduced in secondary schools
- Multidisciplinary presentation of sciences (P,C,B, Maths, Philo,HG, Eng)
- Fertilization through the coupling with SAQ and debate



- Choice of the SAQ is crucial
- Debate quality depends on the protocol (Long preparation is required)
- Debate : a project which requires the involvement of all

Recommendations

- Boost, structure, officialize the contact



- Nanobiotechnologies a good vehicle
- Combination of Lectures + Practical work and SAQ

Open questions

- Impact on curricula
- Educate the educators