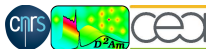


Towards "real materials" *in situ*: future and plans for upgrading

N. Boudet

May, 26th 2009

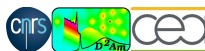
- 1 General presentation of the project
- 2 Scientific case
- 3 Context, Expected improvements, Technological requirements
- 4 Financial aspects
- 5 Conclusion



Project presentation

based on D2AM strong points, expertise

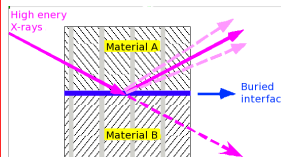
- Beam stability, low background noise
- Designed for anomalous scattering
 - ▶ **Diffraction Anomalous Fine Structure** spectroscopy
 - ▶ Anomalous **GISAXS**
- **Grazing Incidence** studies: in plane and out of plane
- Detector development



Project presentation

based on new needs in Materials Science and context

- Access to **higher energies** (30-40 keV) : more K-edges and thick samples.
- Strains and composition of (buried) nanostructures
- Morphology, arrangement of surface objects
- Increasing nano-activity in Grenoble area
- Complementary to surrounding synchrotron radiation facilities (nano-focusing at ESRF, "tender X-rays" at SOLEIL)



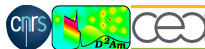
Project presentation

New X-ray scattering tools for multi-scaled materials with the possibility to perform *in situ* studies

Growth quality and evolution in working conditions, thanks to *in situ* experiments at various scales in space (from 0.1 to 100 nm) and time (from min to ms), on **bulk or nano-structured samples**

We need:

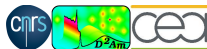
- a new optical quality of the beam (progress made by the source) in the range 6-40 keV
- a gain in photon flux (reduce acquisition time)
- versatile instruments (users sample environments)



Scientific case

Materials of interest

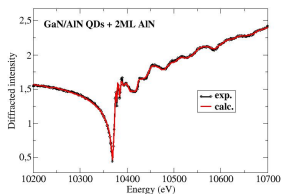
- **Nanostructures**
- **Multi-scaled materials**
- **Soft condensed matter**



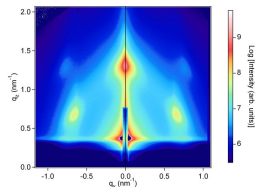
From Nanostructures to Devices

→ devices performances, strain and shape engineering

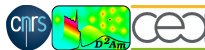
- Strain and composition : XRD, DAFS and MAD
- Morphology and spatial distribution : GISAXS
- Buried interfaces or nanostructures : high energy



DAFS scan: 8 hours !



*towards organized porosity
in ULK materials*

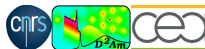


Nanostructured materials

Size and shape dispersity → Quantitative characterization by combining 2 approaches :

- HR-XRD : crystallography and microstructure
- GISAXS : morphology

→ project "Qmax" (French National Research Agency): coupling GISAXS and HR-XRD on a new goniometer + adapting a high temperature furnace for *in situ annealing*.

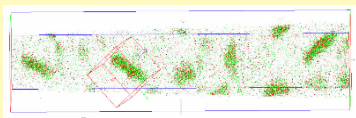


Multi-scaled materials

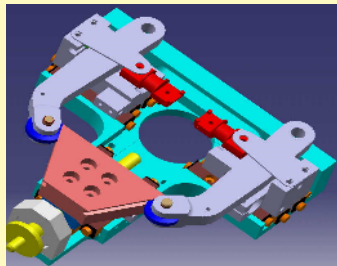
→ phases and defects interactions → macroscopic properties

Metallurgy:

- alloys phase transformations
- microstructure influence on mechanical properties



*Precipitates (1 to 5 nm) in
Al-Zn-Mg-Cu alloys measured by
SAXS.*

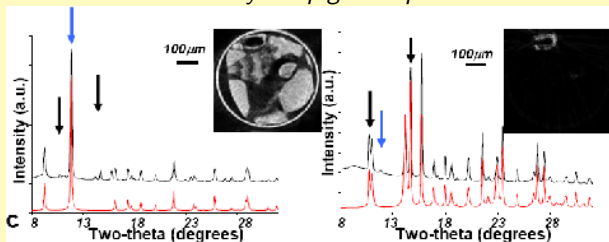


thermo-mechanical test bench

Multi-scaled materials (2)

- **Minerals, environmental samples** : higher sensitivity for minority phases by **tomographic diffraction**

Chalcedony-Fe-pigment powder



Total scattering signal
(red=chalcedony,
majoritary phase)

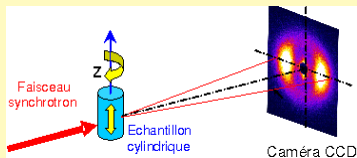
and from a single Fe grain.

Soft condensed matter

→ organization over a wide range of scales

→ role on the macroscopic properties

- Polymers: need for coupling SAXS and WAXS
- Solution and ions : need USAXS
 - ▶ colloids
 - ▶ biological compounds

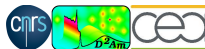


*measuring semi-crystalline
polymer texture*

Context and Expected improvements

- ESRF upgrade of the source
- surface optical quality
- progress in mechanical realisation

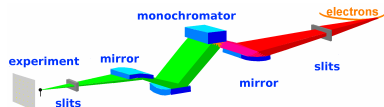
- flux \times 5 to 10
- focus point of $H=20 \rightarrow 100\mu m$ and $V=50\mu m$
- focalized beam up to 40 keV



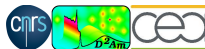
Technological requirements

Optics, instruments were delivered in 94 ...

With the same layout:



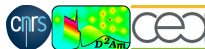
- a new monochromator
 - ▶ designed for spectroscopy
 - ▶ improve sagittal focussing
- mirrors with up-to-date polishing and curvature
- a new goniometer: rapid motorisation, large sample environments
- a new SAXS set-up: simultaneous SAXS-WAXS and longer (4 m) for USAXS



Planned upgrade

Project launched through diverse actions

Monochromator	2009-10	Fondation Nanosciences + CEA/LETI	400k€
Mirrors	2010-12	ANR DIFTOMO	300k€
Goniometer	2010-12	ANR-P3N QMAX	700k€
SAXS	2010-13	Region Rhône Alpes ?	200k€ (hutch) dedicated detector
pixel 2D Detector	2004-09	prototype already financed	400k€



For the next review panel

Hope to present you an up-to-date beam line for Materials Science :

- a stable beam, low background
- flux $\times 5$ to 10
- focus point of $H=20 \rightarrow 100\mu m$ and $V=50\mu m$
- focalized beam from 6 up to 40 keV

With new tools :

- GI-DAFS and GI-MAD
- coupled HR-XRD and GISAXS
- GISAXS
- tomographic diffraction
- combined SAXS-WAXS and USAXS
- versatile instruments for users sample environments
- more data acquisitions with 2D detector

and thanks for your attention !

