UNIVERSITE PIERRE & MARIE CURIE
LA SCIENCE A PARIS

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

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Miroirs multicouches gravés pour l'analyse spectrométrique X des éléments légers

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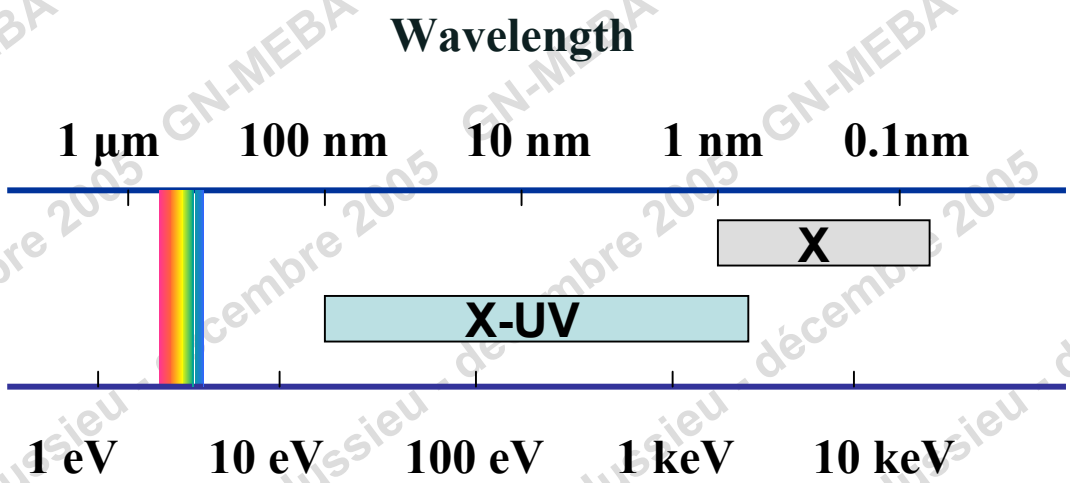
Réunion GN-MEBA Paris 8 et 9 Décembre 2005

X-UV multilayer interferential mirrors (MIM)

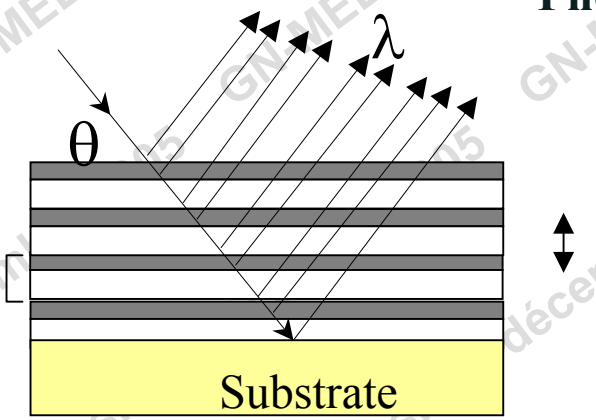
Optical components in the X-UV range

Consist in periodic stacks of ultrathin layers with nanometer thickness



Absorbing material (Mo, W…)

Light material (Si, C, B4C…)



$d = d_{absorbing} + d_{light}$

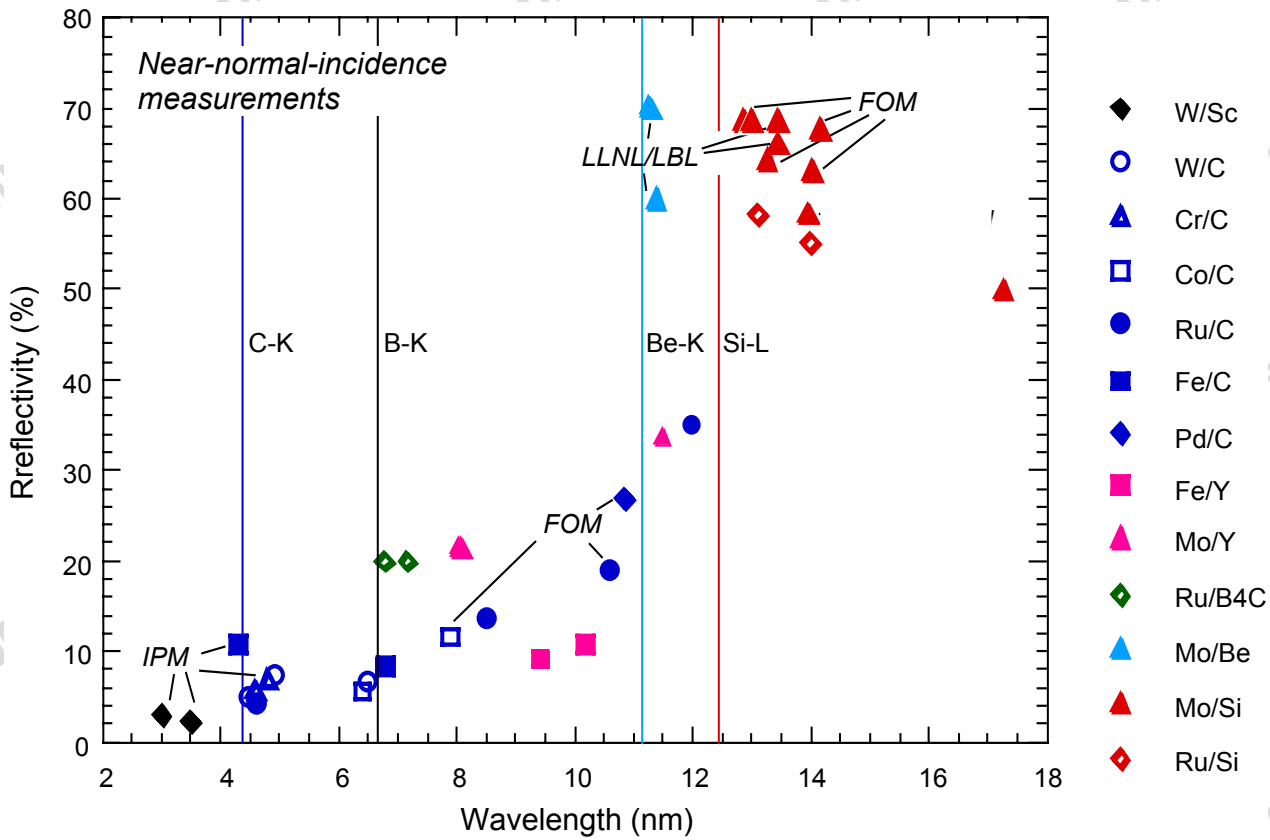
$\gamma = d_{absorbing} / d$

$$2d\sin\theta\sqrt{1-\frac{2\delta}{\sin^2\theta}} = k\lambda$$

Bragg's law corrected by the effects of refraction

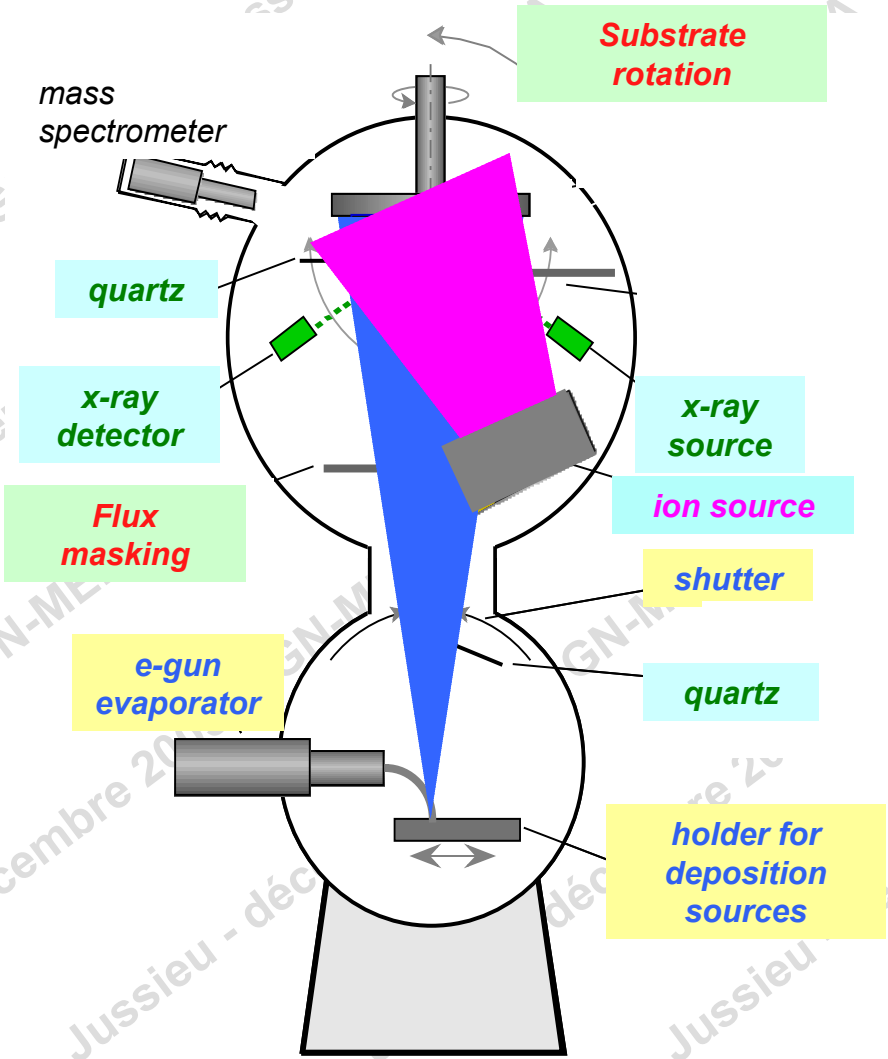
δ is the unit decrement of real part of the refractive index

Choice of material components



Materials choice based on high optical contrast, low absorption :

MIM fabrication



UHV system:

Upper vessel :

- X-ray monitoring
- Quartz

Thickness control

- Smoothening
- Substrate rotation
- Flux masking

Thickness uniformity

Lower vessel :

- E-beam deposition
- Quartz

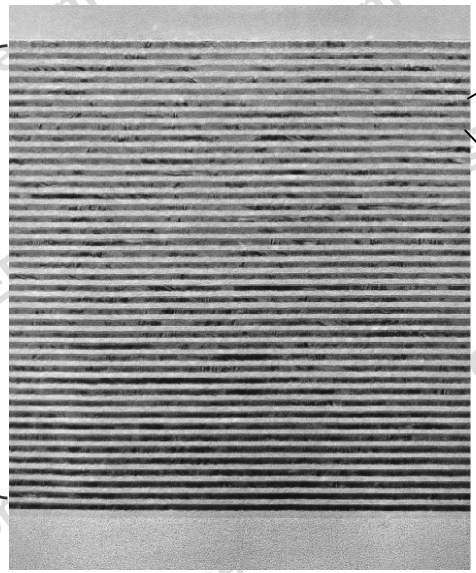
Example of MIM: Mo/Si

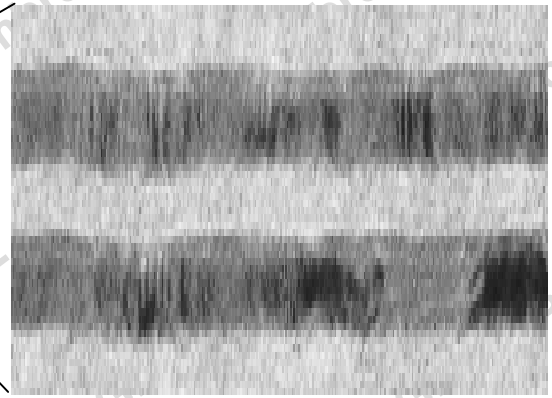
HRTEM

50 periods

d = 69 Å,

$\gamma \approx 0.4$





Si amorphous;
Crystallization of Mo and Mo/Si interfaces.

Use of MIM as Bragg monochromators for the X-UV & soft x-ray range

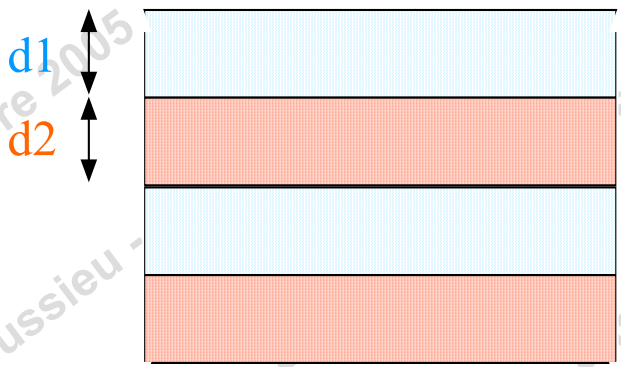
Study of the 100 - 500 eV (12 - 2.5 nm) range is difficult :

no natural crystals available as Bragg monochromator

use of Multilayer Interferential Mirrors (MIM)

but MIM have a moderate resolution

(typically 20-30 eV around 280 eV / C K emission)



The period (d1+d2) can be adjusted to study a particular photon energy range

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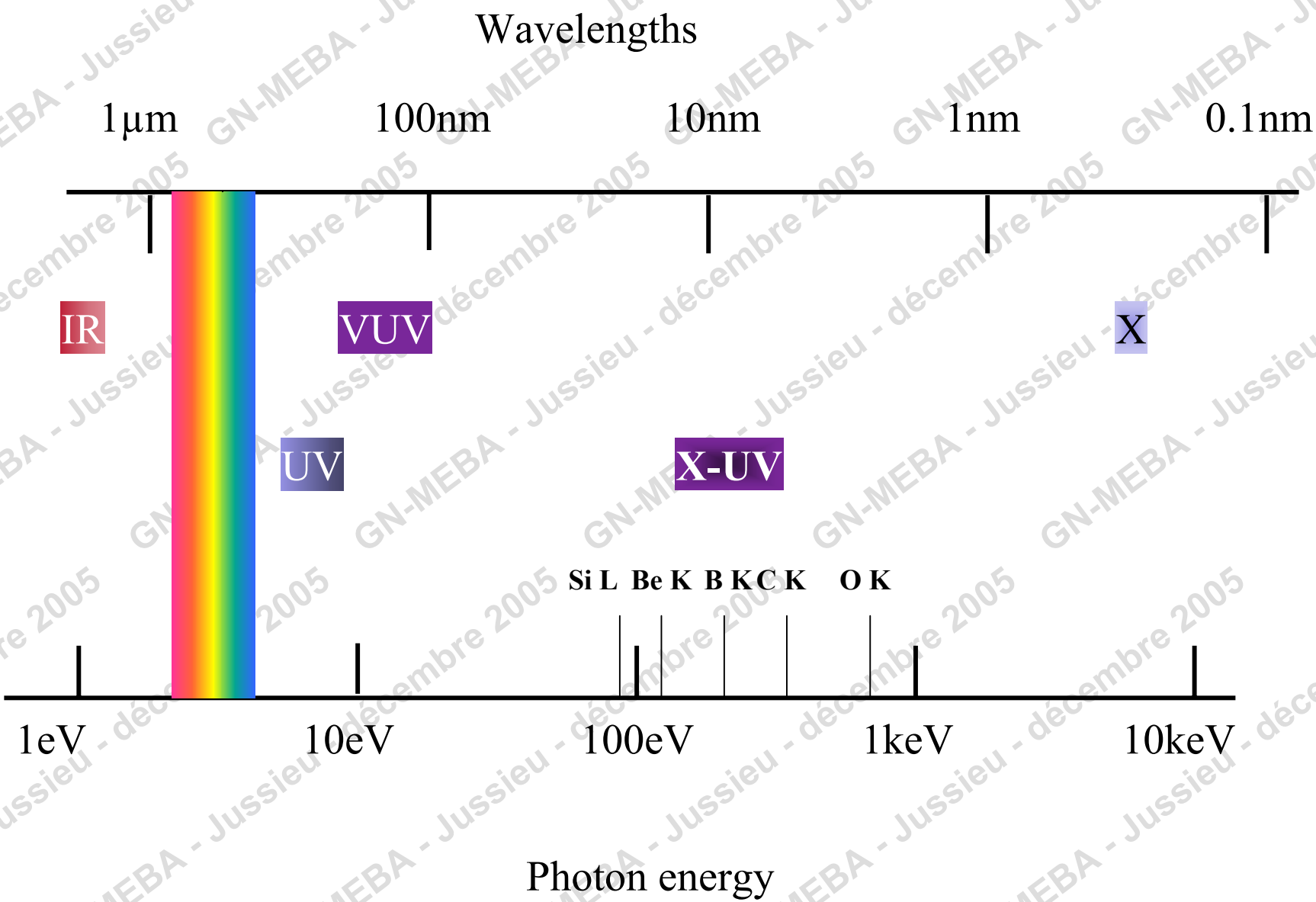
K emissions of light elements



Improvement of the MIM bandwidth

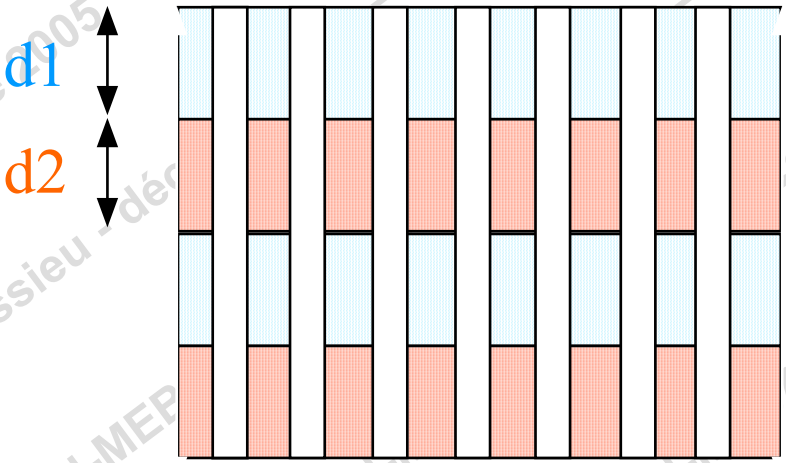
* Problem :the resolution of the MIMs is limited by their large bandwidth (BW) due to a limited number of effectives bilayers involved in the Bragg diffraction

* Objective: reduction of the BW

•Solution: increase of the number of effective bilayers through an increase of the x-beam penetration

Multilayer gratings (MG)

Etching of the MIM → « high-resolution » monochromator multilayer grating (MG)

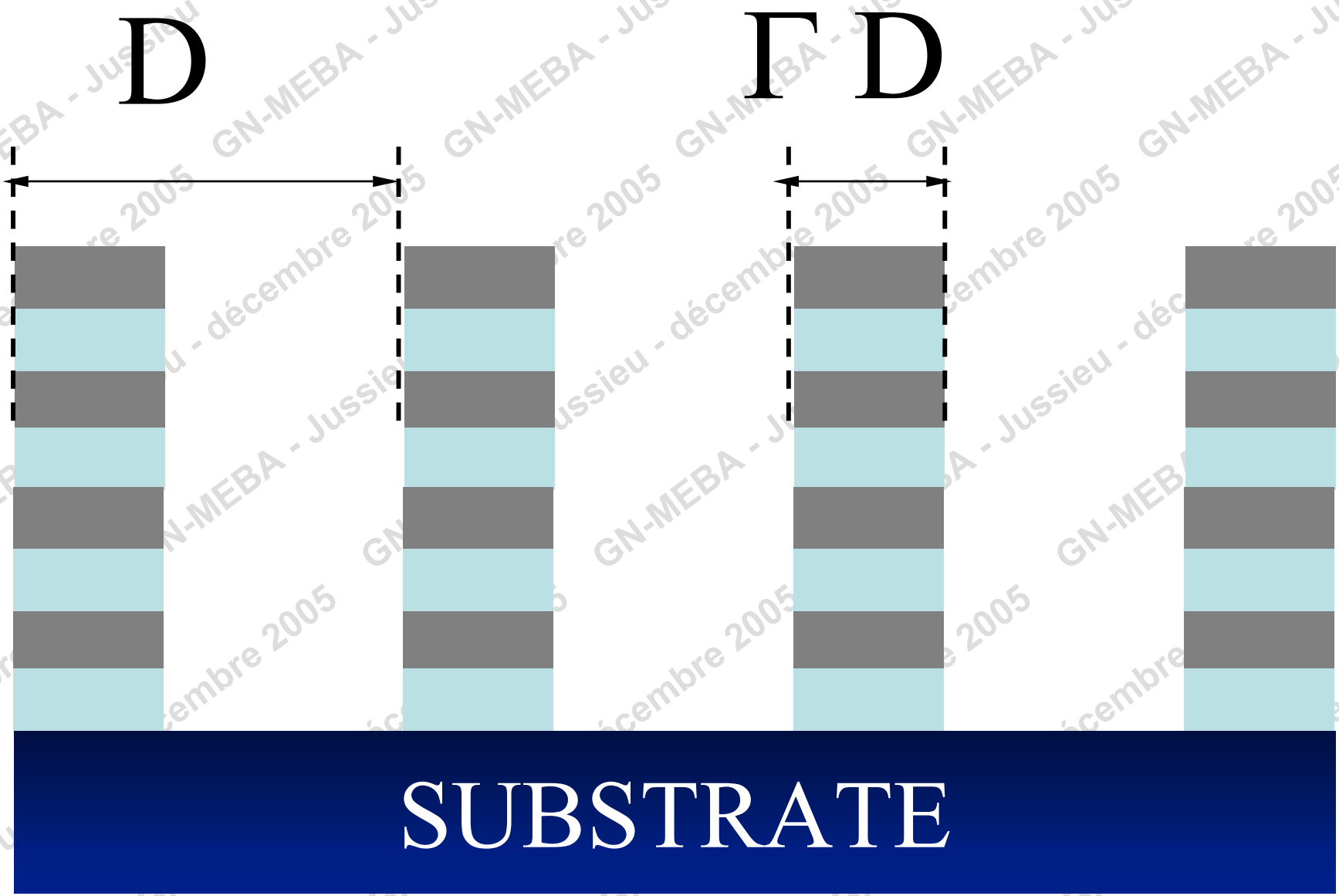


etching by using processes from the microelectronics

The resolution improves because more bi-layers can participate to the diffraction

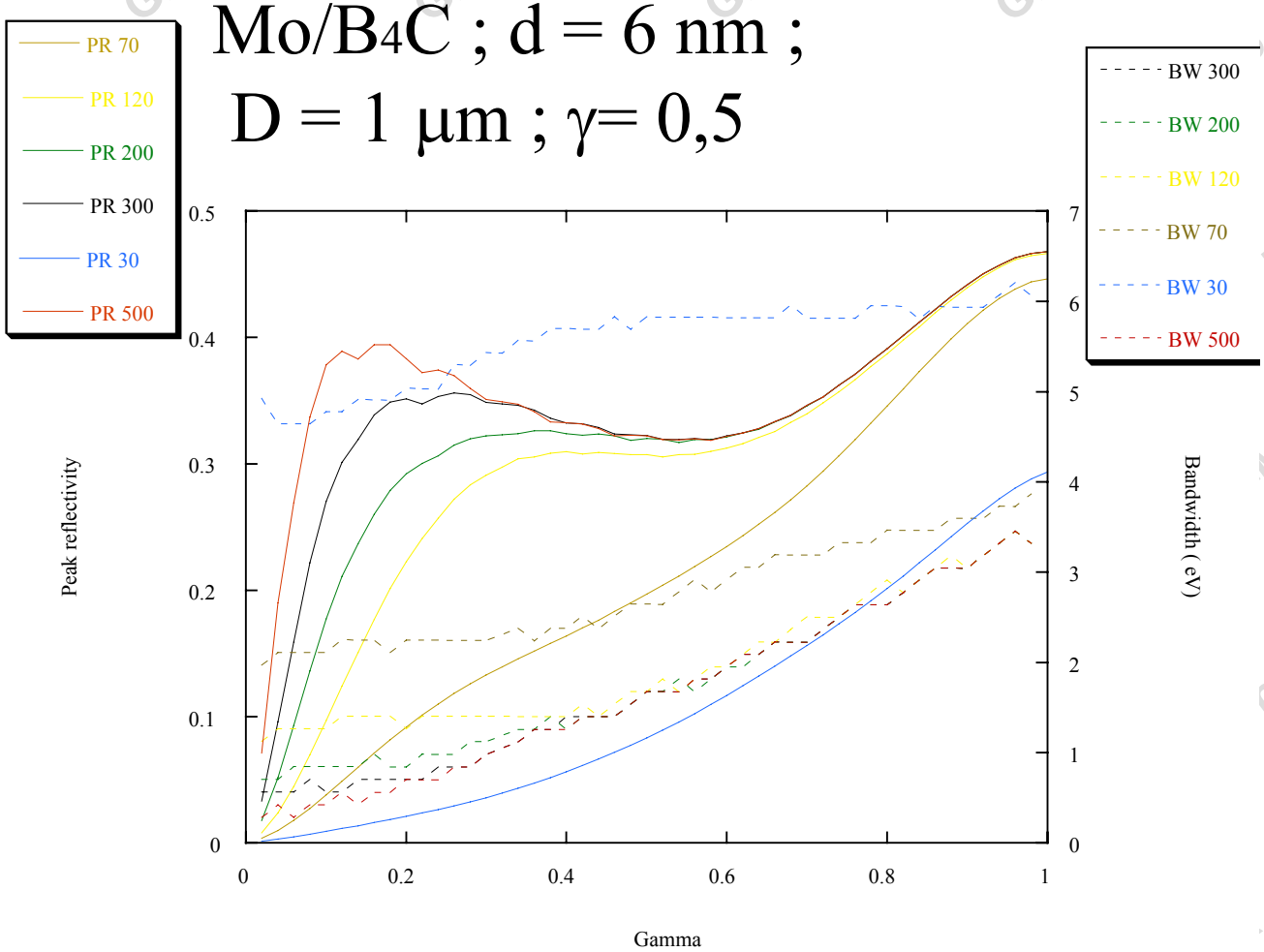
A factor ≈3 can be gained in resolution
at the expense of a reflectivity loss of several %

MG parameters



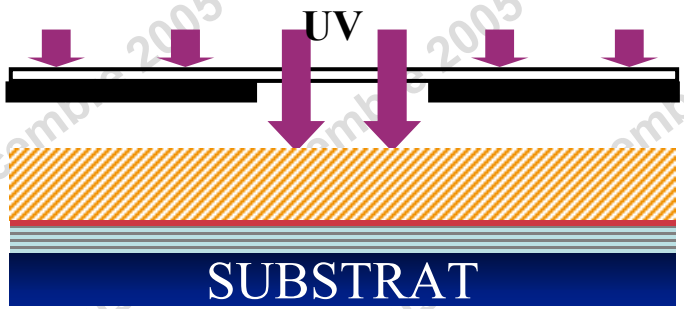
Optimization of the MG parameters

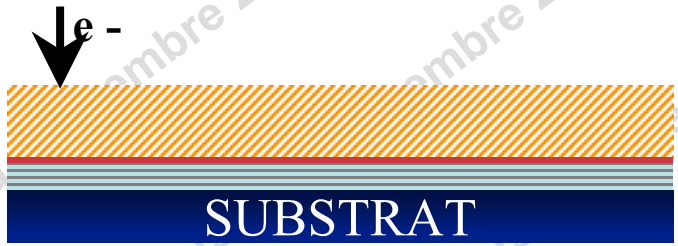
Mo/B_4C ; d = 6 nm ;
D = 1 µm ; γ= 0,5



Fabrication des MG

Dépôt du promoteur d'adhérence
Dépôt de la résine
1er recuit de séchage



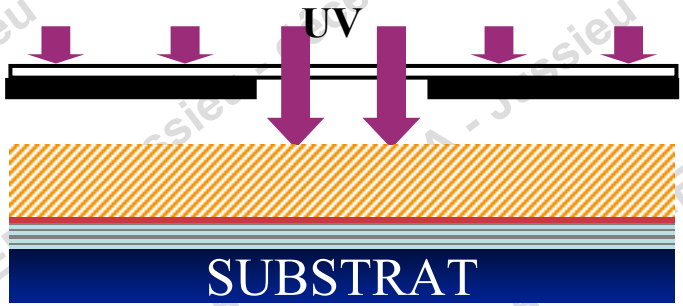


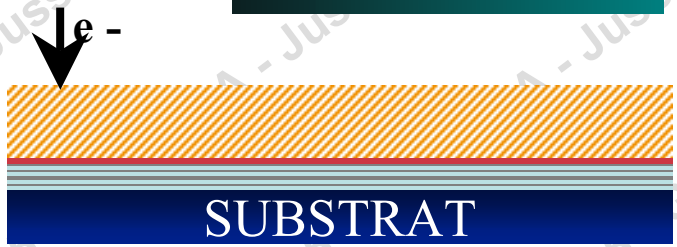
Exposition UV ou par faisceau d'électrons
Recuit après exposition (PEB)

Révélation des motifs
Recuit de durcissement

Étape de gravure
Enlévement de la résine

LIFT-OFF





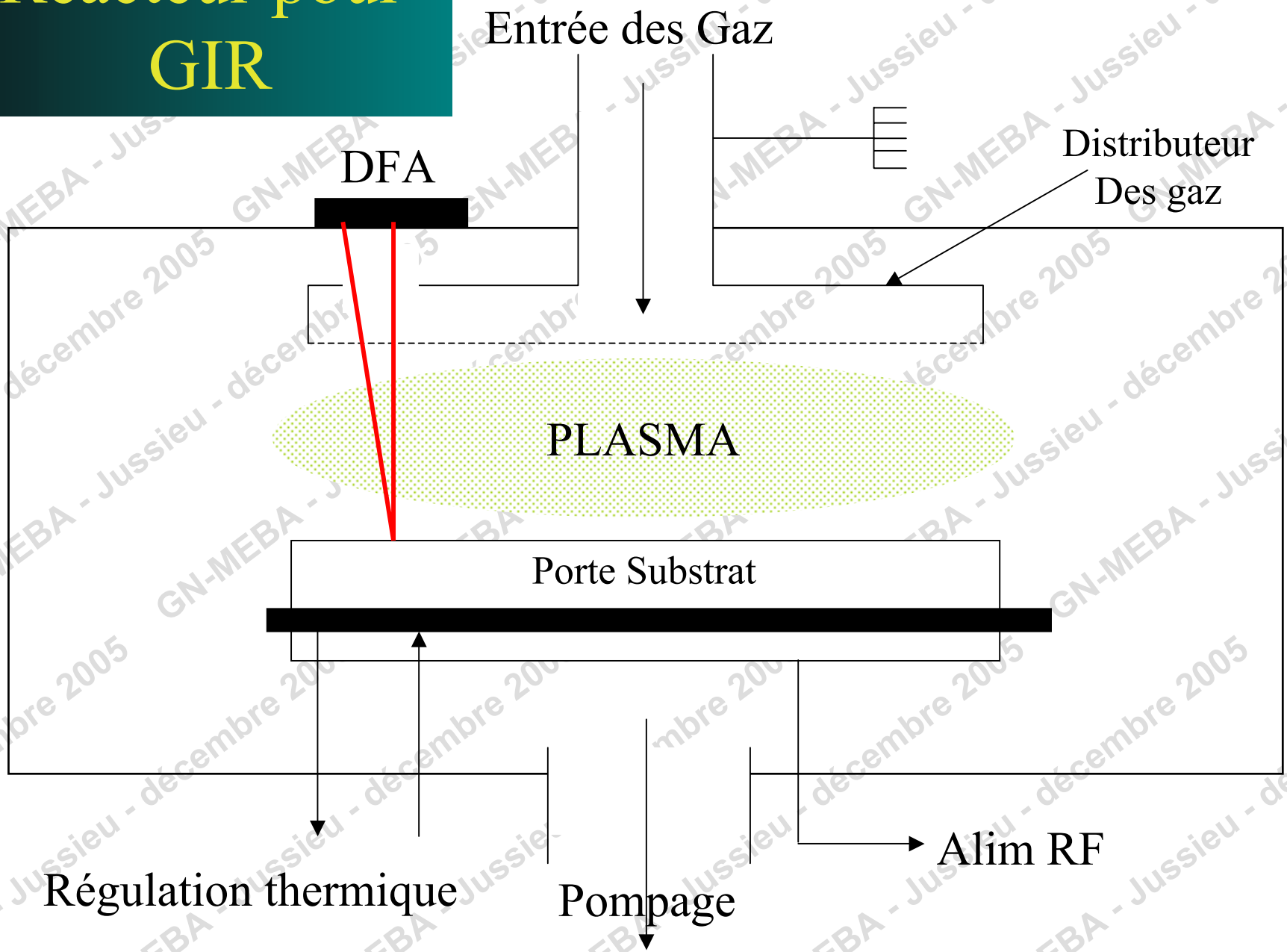
Exposition UV ou par faisceau d'électrons
Recuit après exposition (PEB)

Révélation des motifs
Recuit de durcissement

Dépôt de la couche mince

LIFT OFF

Réacteur pour GIR



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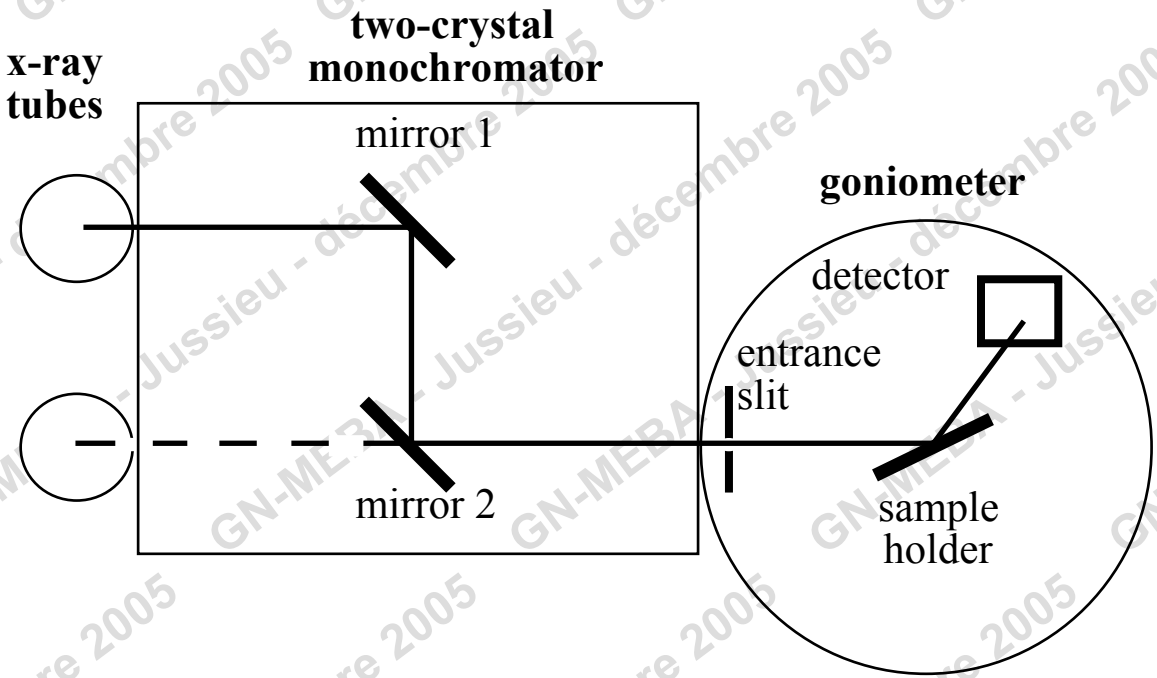
MONOX apparatus



soft x-ray reflectometer

or

plane x-ray spectrometer

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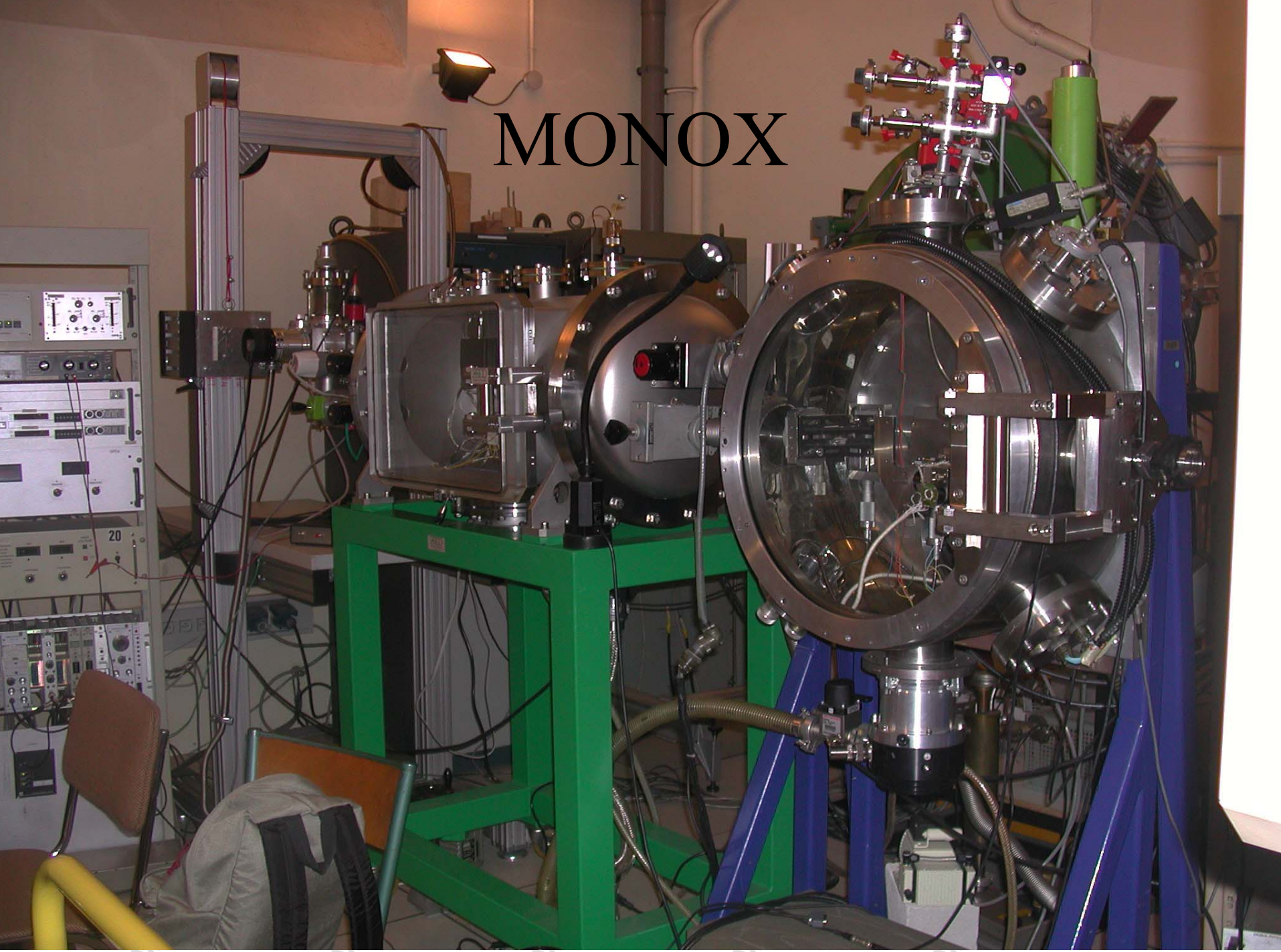

MONOX

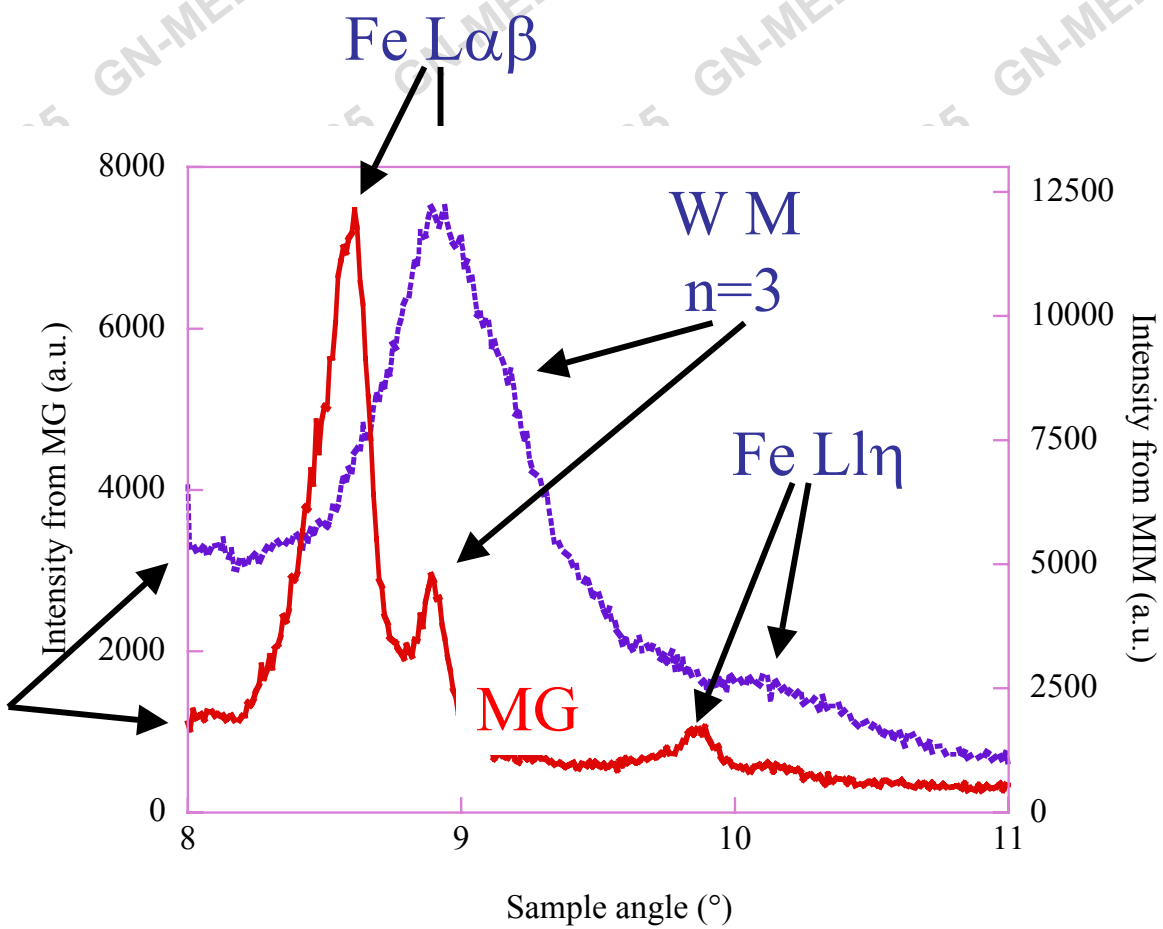
Analysis of a Fe target

Comparison between MIM and MG
Mo/B_4C, period 6 nm, 150 bi-layers

better resolution

W contamination
other lines

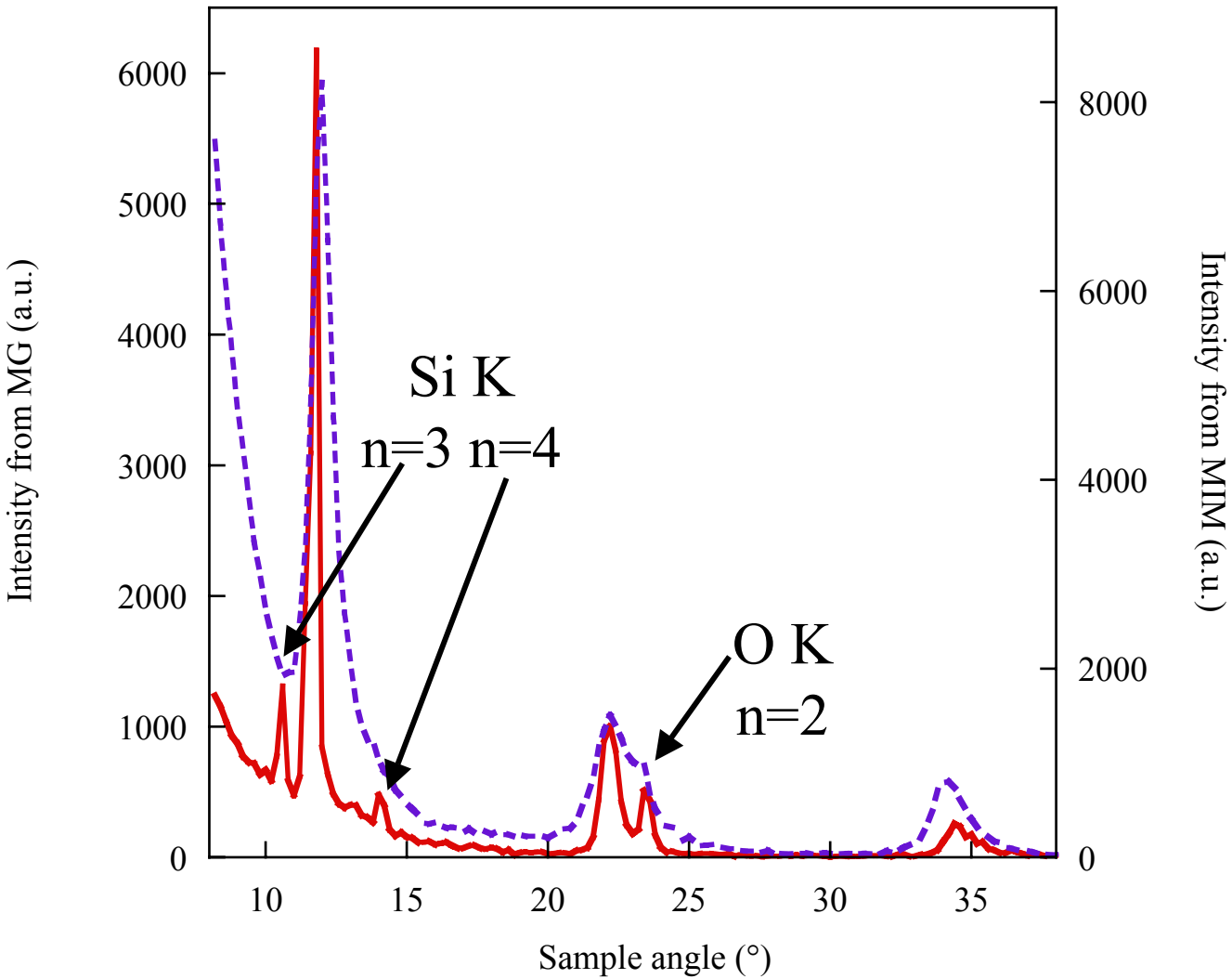
lower background
toward low Bragg
angles



better quantification

Analysis of B4C target

Comparison between MIM and MG
Mo/B_4C, period 6 nm, 150 bi-layers



Acknowledgments

- R. Barchewitz (LCP-MR)
- B. Pardo (IOTA)
- R. Benbalagh (LCP-MR & CAMECA)
-P. Jonnard (LCP-MR)
- H. Maury (LCP-MR)
-A. Sammar (LCP-MR)

-G. Julié (IEF)
-L'équipe lithographie électronique de CEA/LETI