# Monochromators for XRF in the photon energy range of 900-1800 eV

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## Introduction

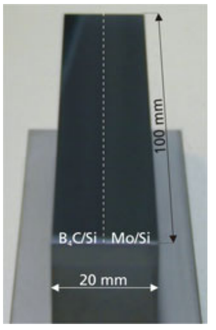
### Problem

Wavelength dispersive X-ray fluorescence analysis requires X-ray monochromators with

- **high reflectance => decrease of detection limits**
- **high resolving power => increase of selectivity**

However: Best values for reflectance and resolving power can not be obtained with the same multilayer

=> Possible solution: Deposition of **two** multilayers onto one mirror!




Multilayer mirror for synchrotron applications.

Left hand side:
$B_4C/Si$ multilayer with high resolving power

Right hand side:
Mo/Si multilayer with high reflectance

=> Depending on the application needs, the mirror can be switched between high resolution and high reflectance mode.

## Theoretical and experimental results

### Theory

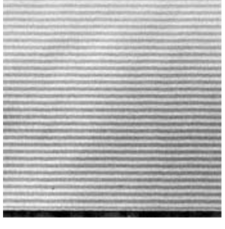
Questions
- Which multilayer combination results in the highest reflectance?
- Which multilayer combination results in the highest resolving power?

Answers
- Si and $B_4C$ have the lowest absorption below E = 1800 eV
- For high reflectance, absorber layer materials with the best compromise between high contrast to the refraction index of the spacer material and lowest possible absorption are needed => several candidates: Mo, W, Ru, …
- For high resolving powers, a high number of periods is necessary, which contribute to the total multilayer reflection

=> decrease of the period thickness and increase of the number of periods N
=> absorber layers with lowest possible absorption

### Experimental results

#### $B_4C/Si$ multilayers with high resolving powers

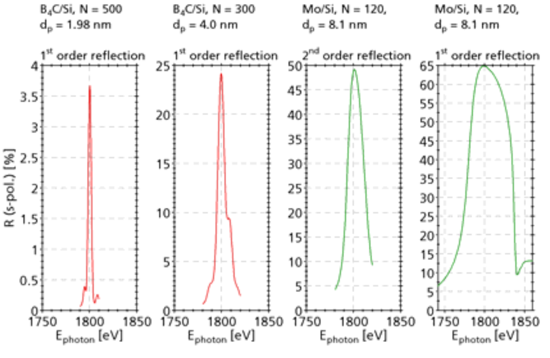


Theory predicts highest resolving powers for $B_4C/Si$ multilayers.

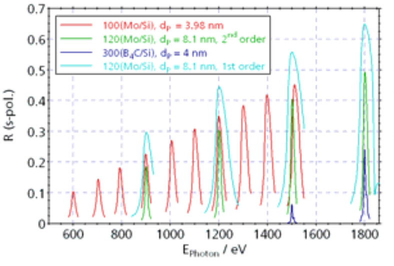
Open question:
Multilayer morphology (interface diffusion and roughness) of real multilayers?

TEM investigation:
- atomically smooth interfaces
- no significant interdiffusion

#### Reflectance versus resolution



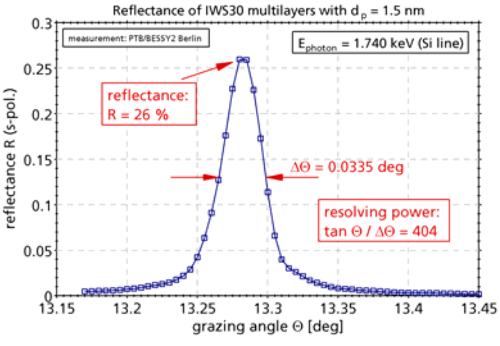

#### Reflectance versus photon energy




Reflectance steadily increases with photon energy up to absorption edges of the multilayer materials.
=> Tungsten based multilayers only useful for photon energies ≤ 1.5 keV (Al emission line).

### Recent developments: TlAP replacement

**IWS30 multilayers** with higher resolving powers and better reflectances than $W/B_4C$ multilayers and TlAP crystals!




Comparison with other multilayer types and the TlAP crystal:

| type | Mo/Si | Mo/Si | $B_4C/Si$ | $B_4C/Si$ | $W/B_4C$ | IWS30 | TlAP |
|---|---|---|---|---|---|---|---|
| $d_P$ [nm] | 8.1 | 8.1 | 4.0 | 2.0 | 1.51 | 1.55 | |
| Order | 1st | 2nd | 1st | 1st | 1st | 1st | 1st |
| E [keV] | 1.8 | 1.8 | 1.8 | 1.8 | 1.74 | 1.74 | 1.74 |
| R [%] | 65 | 49 | 24 | 3.7 | 21 | 26 | ~ 25 |
| E/ΔE | 31 | 89 | 203 | 492 | 309 | 404 | ~ 400 |

**=> Replacement of the TlAP crystal by IWS30 multilayers possible!**
=> High performance of IWS30 for emission lines up to sulfur.

### Acknowledgments

We would like to thank F. Scholze, C. Laubis and B. Beckhoff (PTB/BESSY2 Berlin) for the reflectance measurements.

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