Novel narrow filters for imaging in the 50-150 nm VUV range

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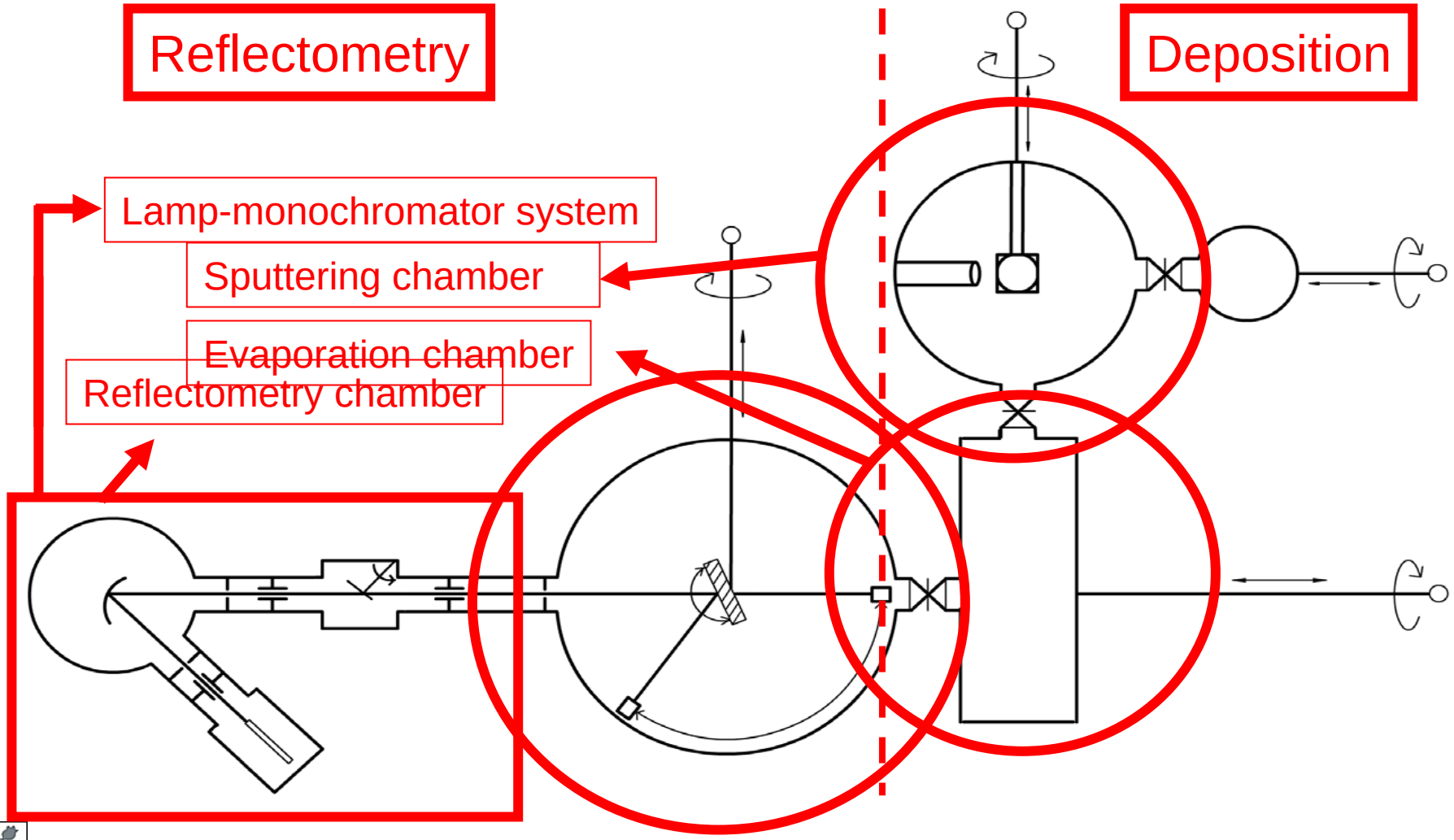
Summary

- Description of the laboratory goals.
- Experimental equipment at GOLD.
- Results:
  - Optical constants
  - Optical coatings
    - Wide band mirrors
    - Narrow filters

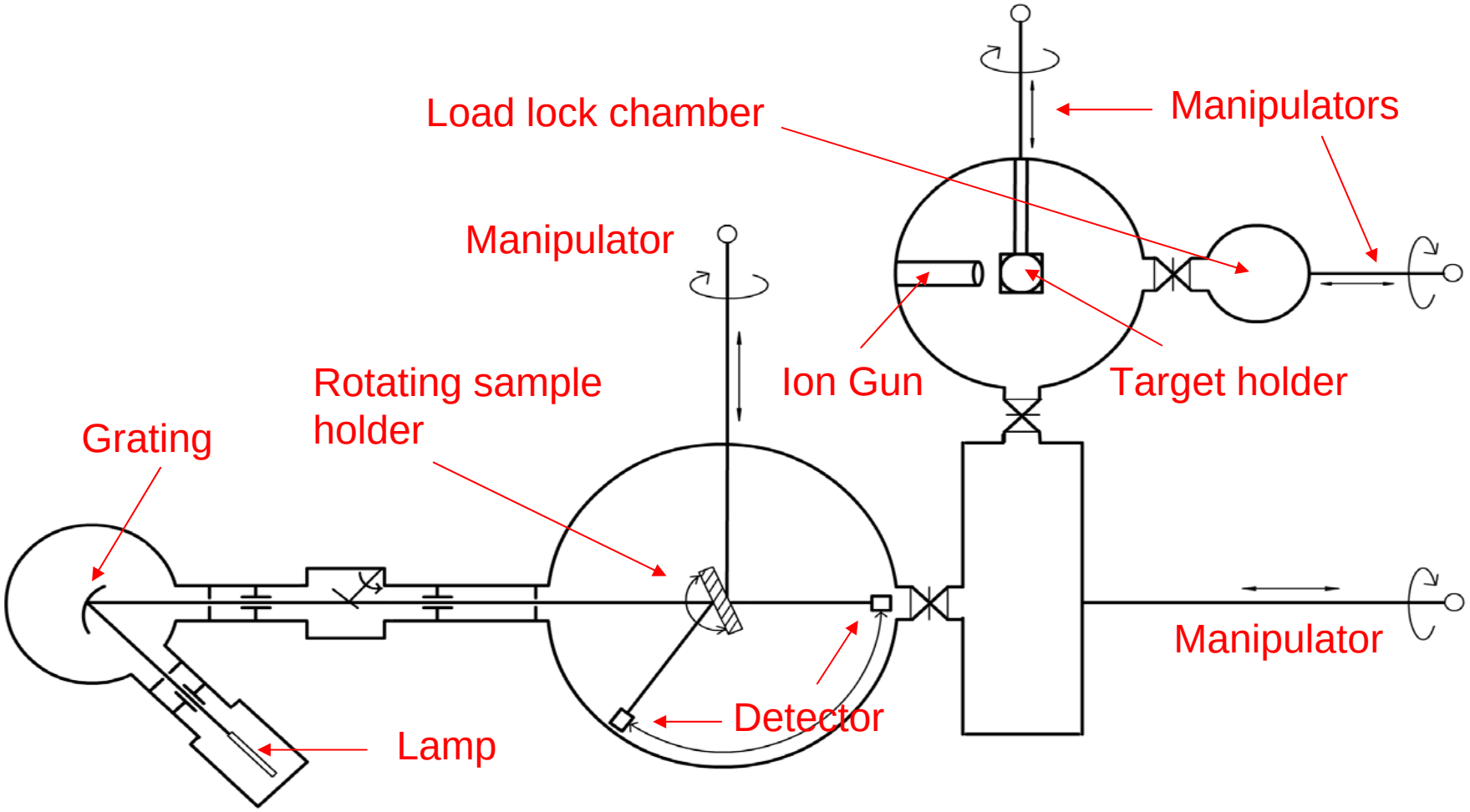
Goals and experimental equipment

- Goal: Preparation of optical coatings of best performance in the VUV.
  - ✓ Search of new materials for the VUV.
  - ✓ Index of refraction (N = n + ik) determination.
  - ✓ Design of multilayer coatings.
  - ✓ Preparation and characterization.
  - ✓ Experimental simulation of work conditions.
- UHV system for single or multilayer thin film deposition.
- *In situ* reflectometry in the 50 – 200 nm spectral range.
- EUV: $\lambda < 105$ nm; FUV: $\lambda > 105$ nm

Description of the UHV system

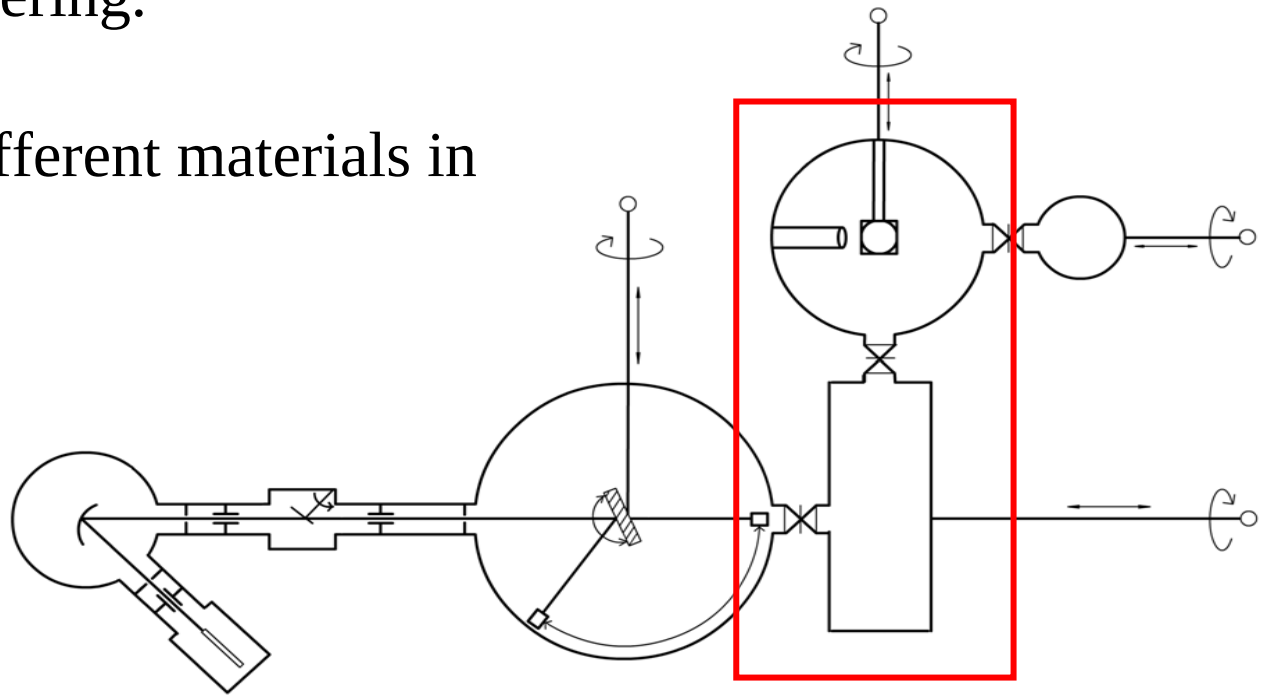


Description of the UHV system



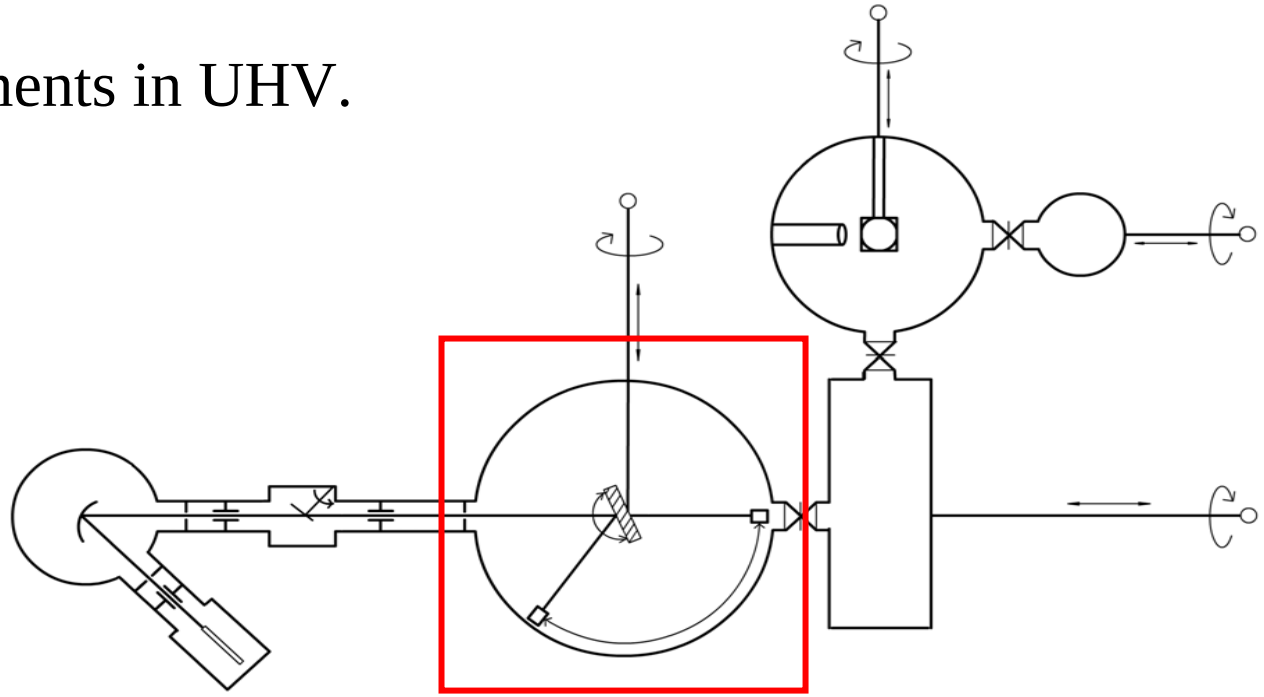
Deposition of optical coatings

- Single and multilayer coatings deposited in UHV.
  - Thermal evaporation (resistive or e-beam).
  - Ion beam sputtering.
  - Up to seven different materials in a multilayer.



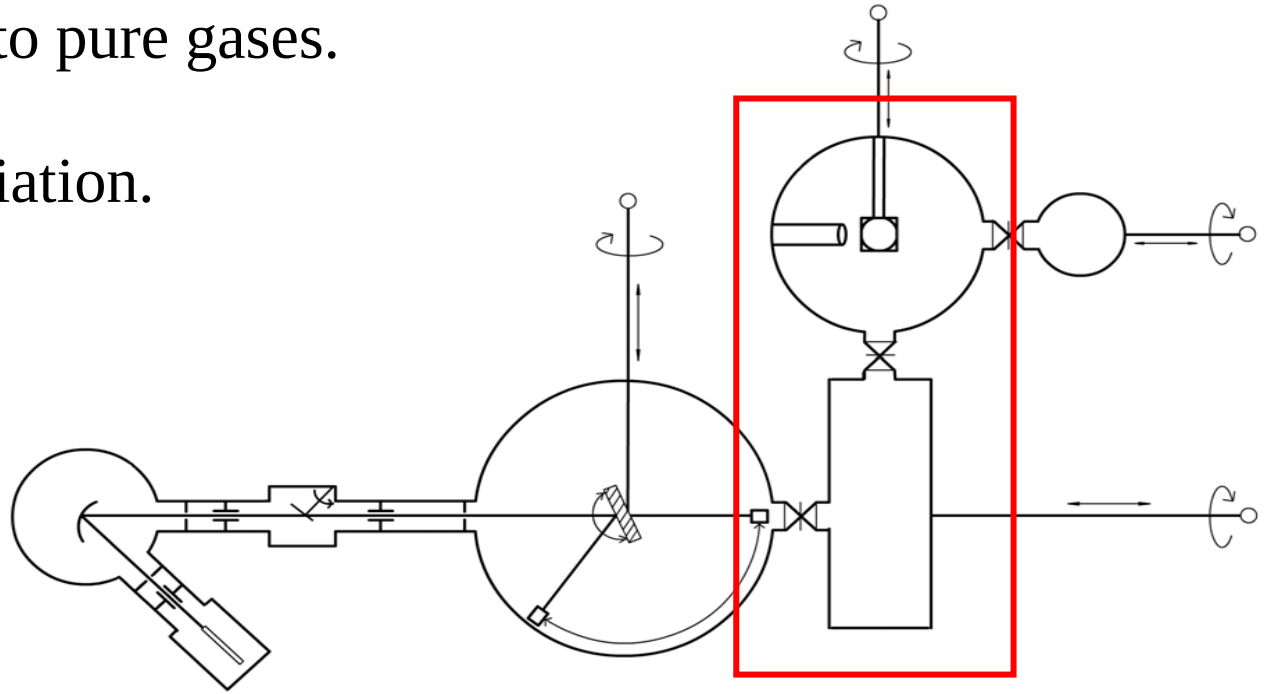
Optical coatings characterization

- Absolute reflectance and transmittance measurements.
  - Incidence angle from normal to grazing.
  - Two perpendicular planes of incidence.
  - In situ measurements in UHV.



In situ treatments

- Ageing measurements after increasing periods of storage time.
- Simulation of LEO conditions: Controlled exposure to molecular and atomic oxygen.
- Controlled exposure to pure gases.
- Near ultraviolet irradiation.
- Heating in UHV.



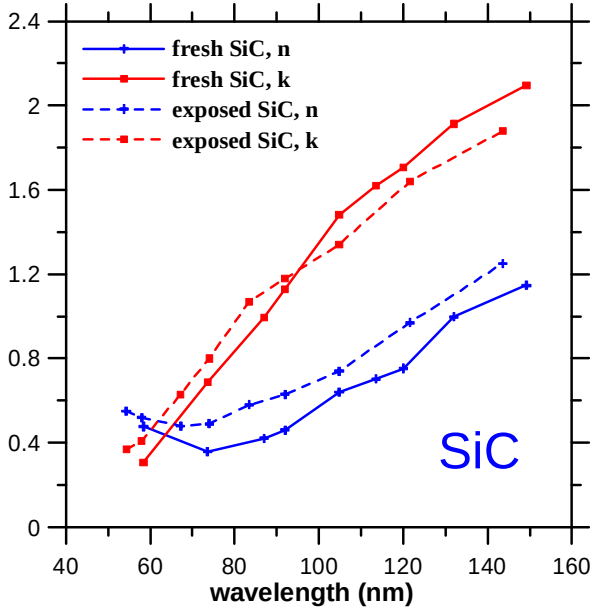
Optical constants determination

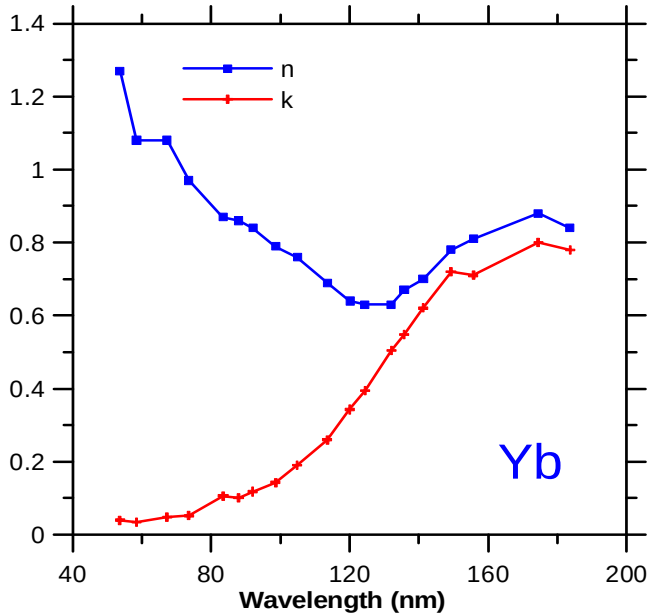
- Knowledge of optical constants is crucial to proper coating design.

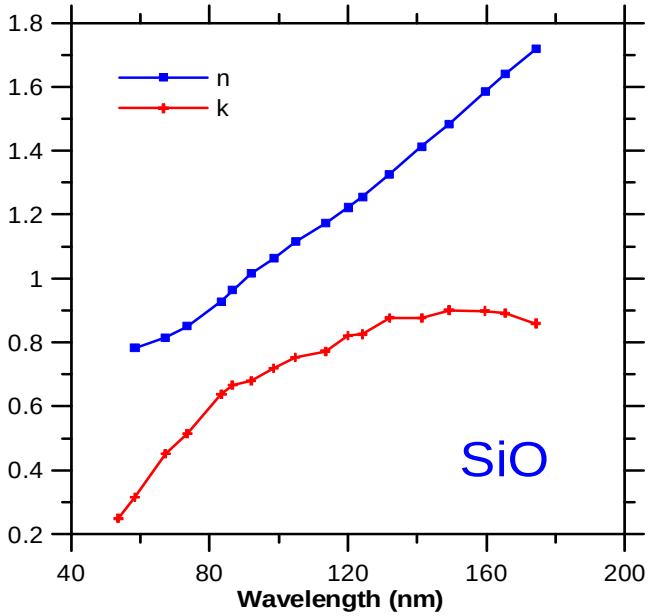
- In the VUV most materials exhibit high absorption and low reflectance.

- Optical constants of most materials in the VUV are unknown or vary among different authors.

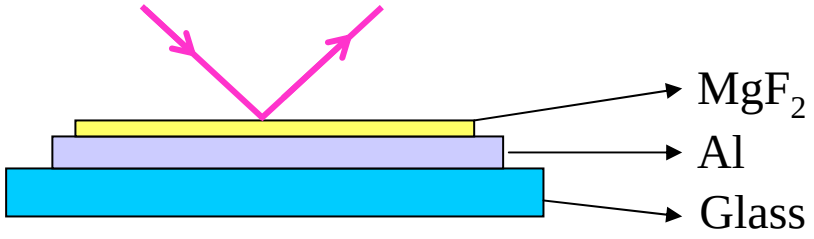
Optical constants determination







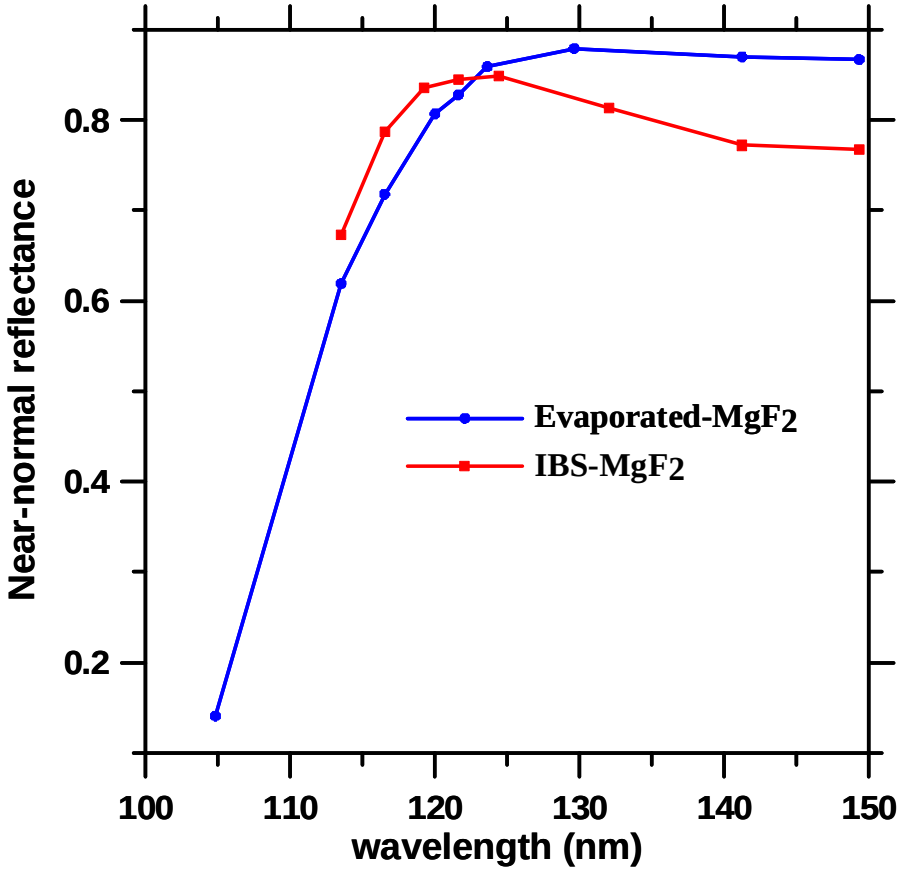
Optical coatings: Al/MgF_2 FUV mirrors



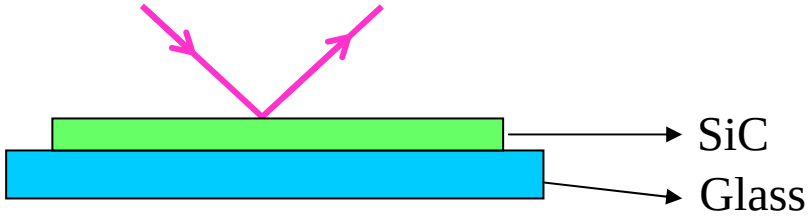
Al is the material with highest R down to 83 nm. After air exposure it becomes useless in the VUV.

Al/MgF_2 bilayers are a standard coating for high reflectance in the VUV.

Changing deposition technique from evaporation to ion beam sputtering improves R at short wavelengths.



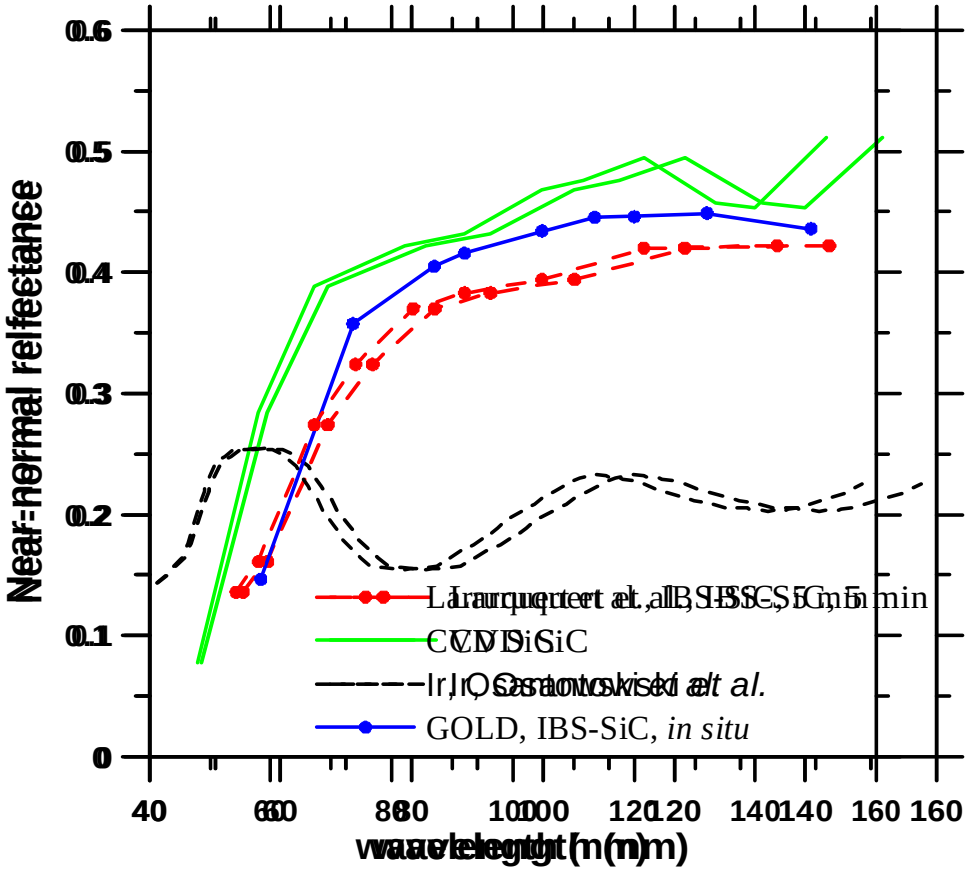
Optical coatings: SiC EUV mirrors



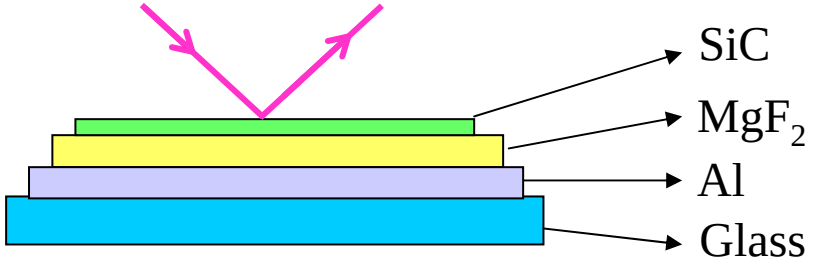
In the EUV the best R is obtained with CVD SiC coatings, that are prepared at high substrate temperature.

The alternative are SiC or B_4C coatings deposited by ion beam sputtering.

In situ optical constants of IBS SiC thin films have been reported for the first time by GOLD.



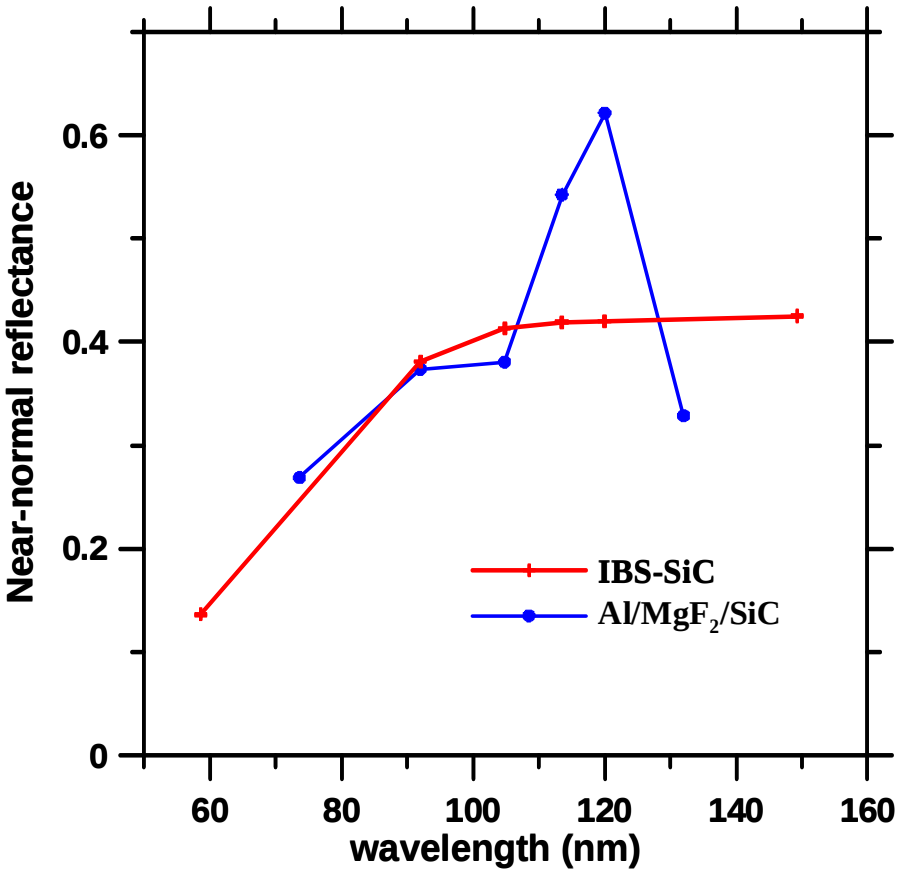
Optical coatings: Al/MgF_2/SiC EUV mirrors



Multilayers for the EUV can not use large number of layers.

R can be enhanced through the use of a few layers.

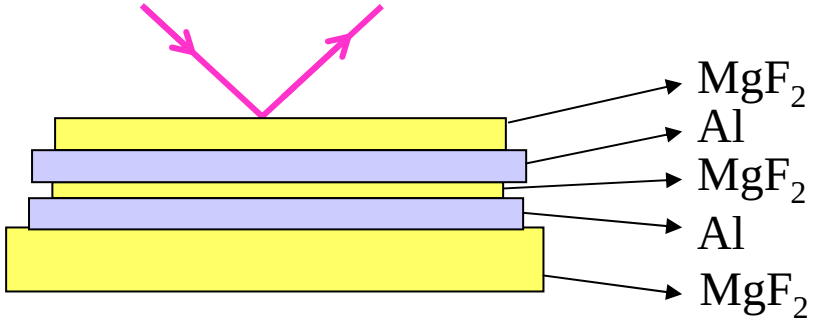
R of Al/MgF_2/SiC is 62% at 120 nm, or 20% higher than SiC R.



Optical coatings: Al/MgF_2 FUV transmision filters

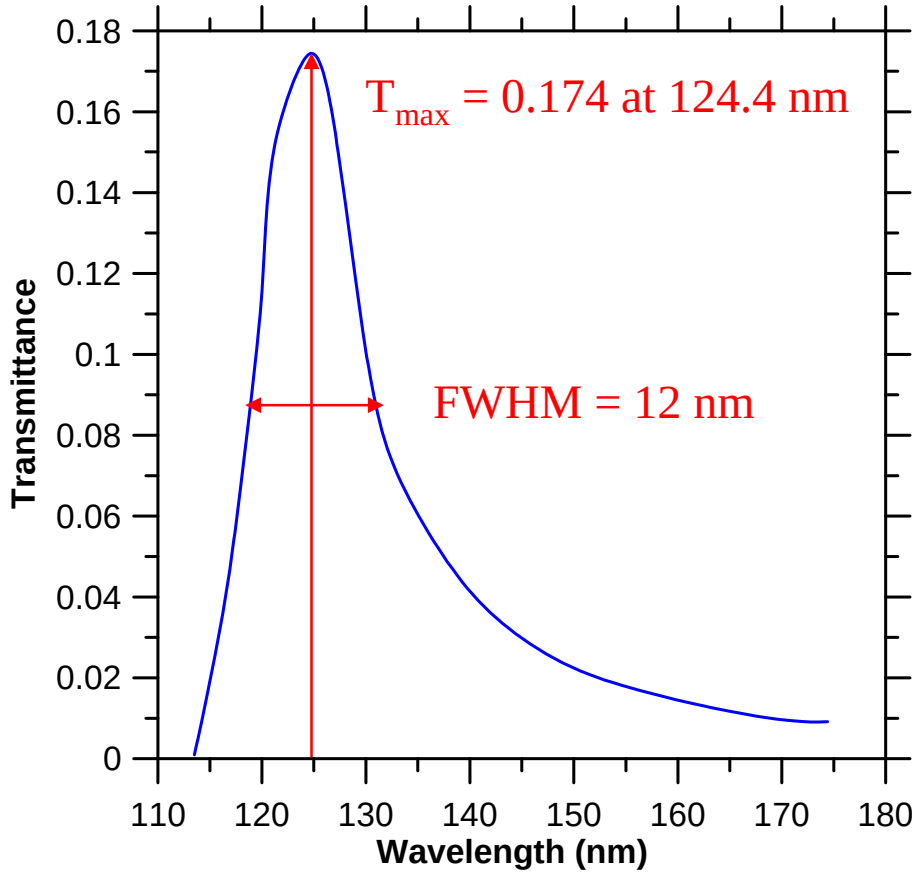
- GOLD has carried out a study of coatings for filtering at the shorter wavelengths of FUV.
- Al/MgF_2 transmission filters where selected as the most suitable.
- New filters were designed and prepared at GOLD.
- GOLD has expressed interest in participate in the manufacture and test of filters for the WSO.

Optical coatings: Al/MgF_2 FUV transmision filters

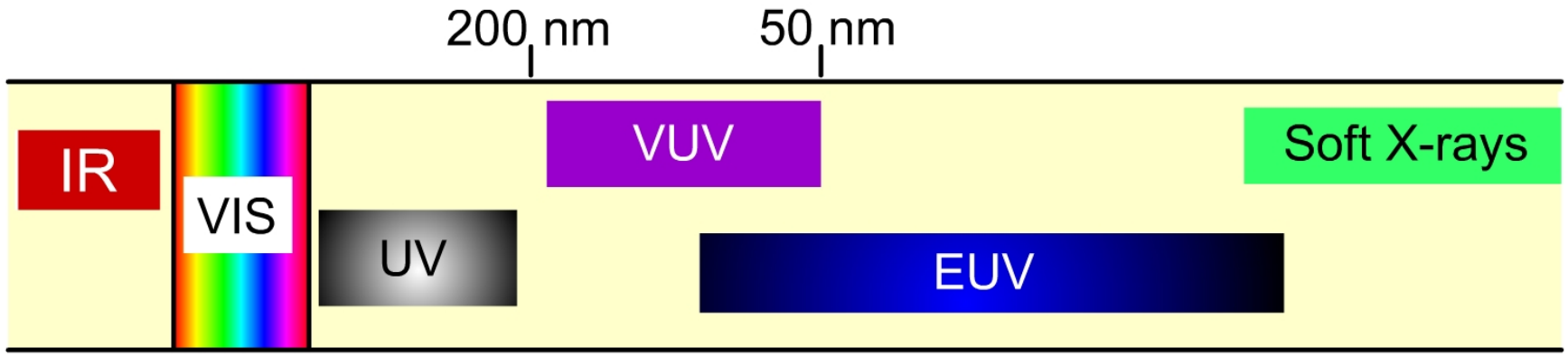


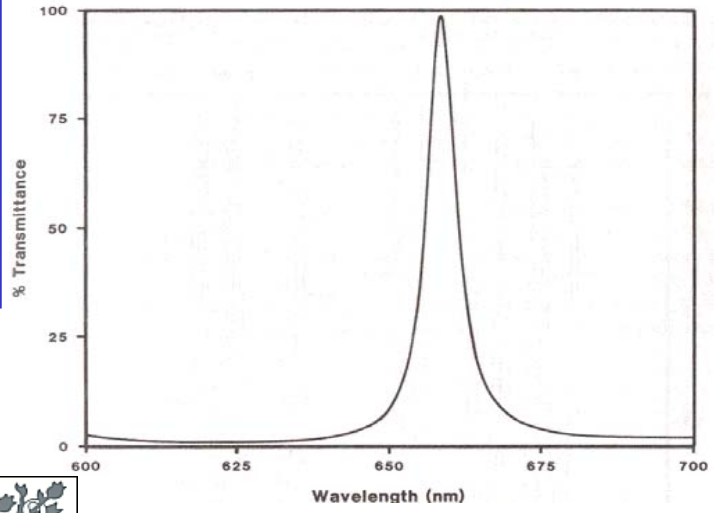
The variation of layers thickness allows tunning and out-of-band rejection.

Our filters performance is equivalent with filters from commercial suppliers.



Optical coatings: EUV reflection filters





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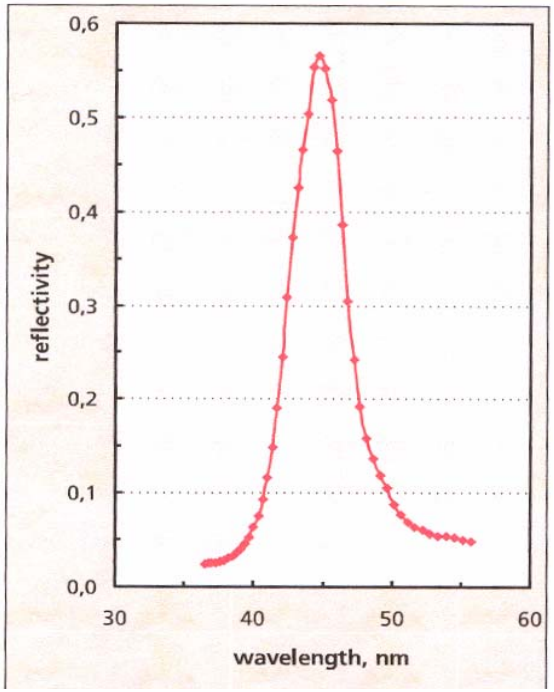
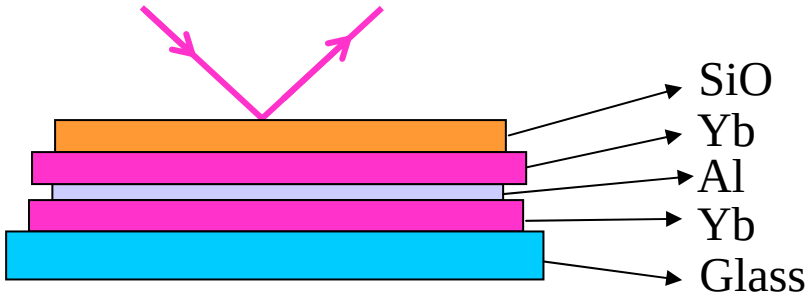


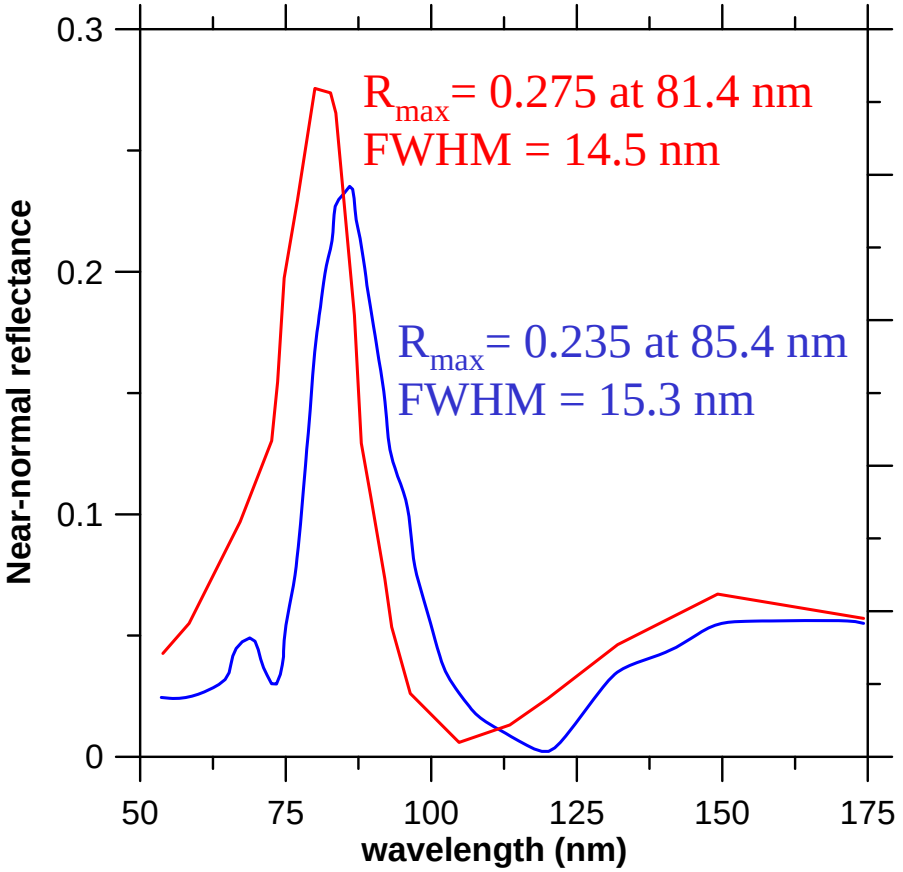
Optical coatings: Al/Yb/SiO EUV reflection filters



Yb has very good filtering properties in the EUV, but it is also very reactive.

SiO is used as a protective layer.

Future studies: Stability after air contact, interface difusion, roughness and ageing under working conditions.

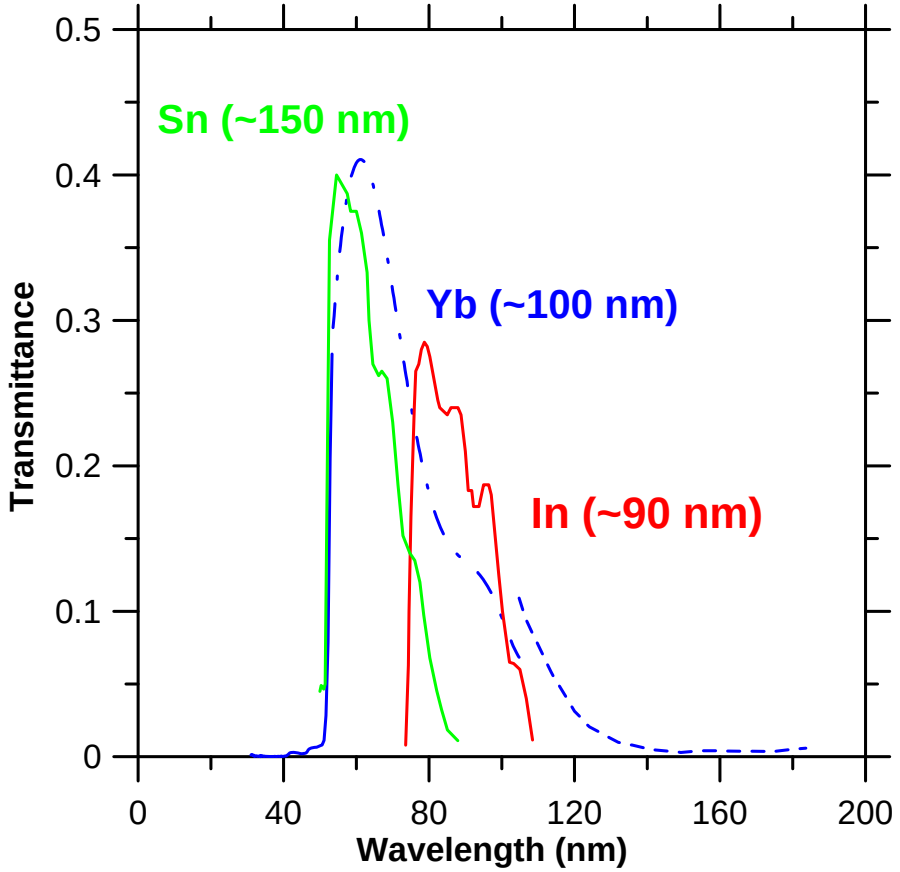


Optical coatings: Transmission EUV filters

Yb has a high transmittance band from 50 to 124 nm.

The good filtering properties of Yb in the EUV could be used in a transmission filter.

The problem of protection of the self-supported Yb film remains open.



Thank you

Optical coatings: Al/MgF_2 FUV transmision filters