Sn cleaning of multi-layer mirrors with hydrogen radicals

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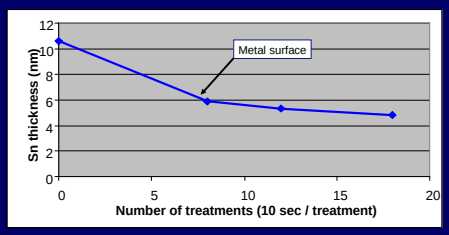
Abstract

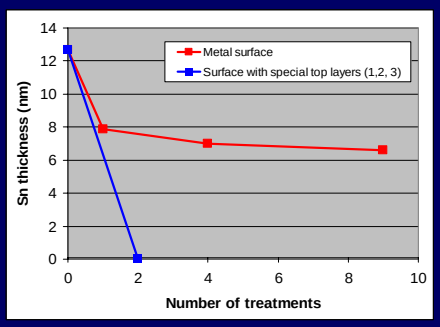
To meet lifetime requirements of collector optics in Sn based EUV sources a combination of debris mitigation and collector cleaning is investigated. Analyses of the current debris mitigation status as well as potential improvement of the lifetime due to the cleaning process will be presented.

We have been working on a Sn cleaning method using hydrogen radicals. Previously, we have demonstrated the use of this technique for grazing incidence EUV mirrors, showing full reflectivity recovery and cleaning rates up to 700 nm/hour. This time, we will show the use of this method for cleaning multi-layer mirrors. Various parameters are studied, such as for example the reflectivity of the mirror before and after cleaning, or the effect of a capping layer on the cleaning efficiency.

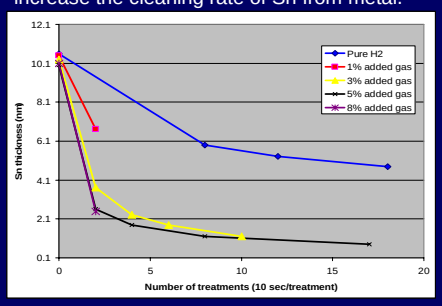
We have done further experiments to investigate Sn cleaning under realistic EUV source module conditions and materials. Additionally, optimisation schemes have been developed aimed at speeding-up the process of cleaning. This has been evaluated since it is important for actual EUV tool optimisation, where both the effectiveness and duration of the cleaning is of concern.



Main problem to solve: very slow cleaning rate of Sn from metal surfaces.

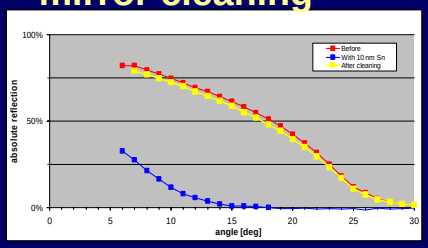


Solution 1: A special top layer can be used to increase the cleaning rate of Sn from metal.



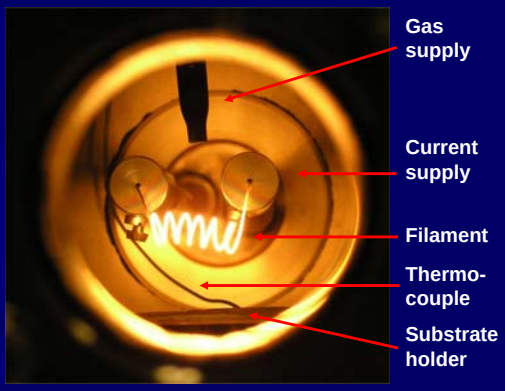
Solution 2: The addition of specific gases increases the Sn cleaning rate from metal.

Grazing incidence mirror cleaning

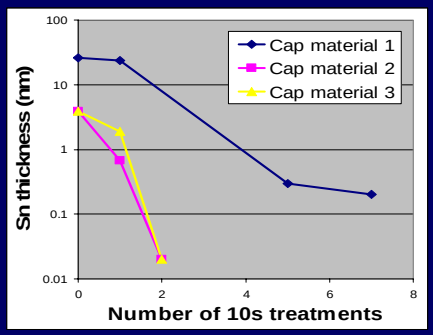


Previously, we have shown that hydrogen cleaning was successfully applied to clean a grazing incidence EUV mirror without causing detectable reflection loss to the mirror.

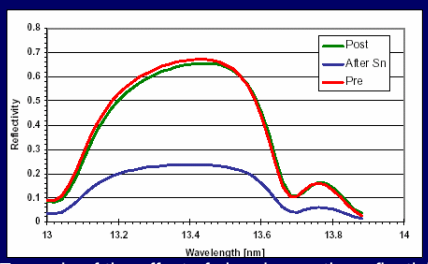
Cleaning reactor



Multi-layer H cleaning



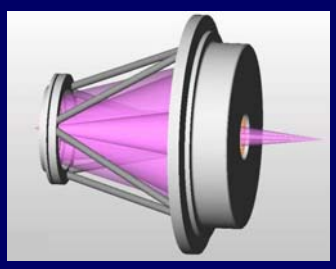
The effect of the multi-layer capping material on the cleaning rate of Sn (logarithmic scale).



Example of the effect of cleaning on the reflectivity of the multi-layer mirror (cap material 3). It can be seen that the mirror reflectivity can be fully restored.

Multi-layer collector mirror

- Presented by Sagem, EUV source workshop, May 2006.



Advantages of NI collector

- High collection angle.
- Uniform pupil fill (no multiple ring obstructions)
- Durability (far from source)

Next steps

- Test more types of capping layers.
- Integrate hydrogen cleaning in EUV source vacuum.

Conclusions

- H radicals are promising for cleaning of Sn contamination.
- A special top layer can be used to improve the cleaning rate of metal surfaces.
- Many capping materials of the multi-layer mirror are suited for hydrogen Sn cleaning.
- The presence of other gases in the vacuum can increase, or decrease the cleaning rate.
- By combining debris mitigation with collector cleaning, acceptable collector lifetimes can be achieved.

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