COMPACT AND EFFICIENT ATOMIC HYDROGEN CLEANER FOR RESIST QUALIFICATION

TNO innovation for life

INTRODUCTION:

BEFORE A NEW RESIST CAN BE USED ON THE ASML EUV NXE:3X00 TOOLS THE RESIST HAS TO BE QUALIFIED ON OUTGASSING. SO CALLED NON-CLEANABLE CONTAMINATION IS OF PARTICULAR CONCERN. AFTER A WITNESS SAMPLE HAS BEEN EXPOSED TO A RESIST OUTGASSING ENVIRONMENT THE GROWN CARBON LAYER IS QUANTIFIED BY ELLIPSOMETRY. THEN THE SAMPLE HAS TO BE CLEANED BY ATOMIC HYDROGEN TO ENABLE IDENTIFICATION AND QUANTIFICATION OF THE NON-CLEANABLE COMPONENTS OF THE CONTAMINATION (FOR EXAMPLE BY XPS). THE QUALIFICATION PROCEDURE IS SHOWN IN FIGURE 1.

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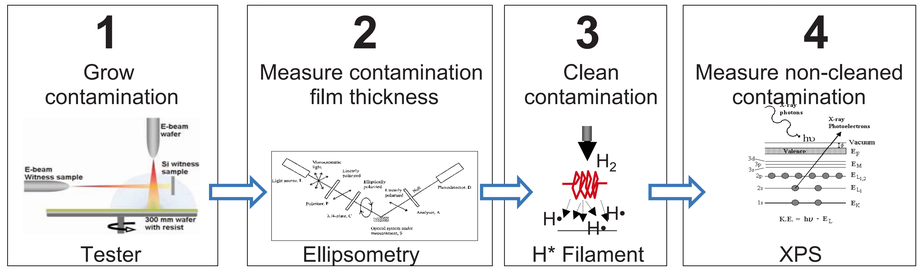
Qualification procedure has four main steps



Besides the resist outgas tester and cleaner the following is needed:

Resist exposures: Coat and development facilities for 300mm
Wafers with resist thicknesses <100nms

Quantification cleanable contamination: ellipsometry
Quantification non-cleanable contamination: XPS

Note: ToF-SIMS is not needed as XPS is sensitive enough

ASML

Slide 4

Figure 1: Source; Resist outgas testing; IEUVI TWG 2010; Noreen Harned: ASML.

DESIGN

TNO has designed and built a compact filament based atomic hydrogen cleaner. The design is shown in figure 2. This cleaner can be mounted at a CF40 flange in a vacuum setup, see figure 3.
The cleaner has a filament that is protected by a stainless steel cage against accidental touching. The hydrogen flow is inserted into the vacuum system close to the filament. The hot filament cracks part of the molecular hydrogen flow into hydrogen redicals used for carbon cleaning.

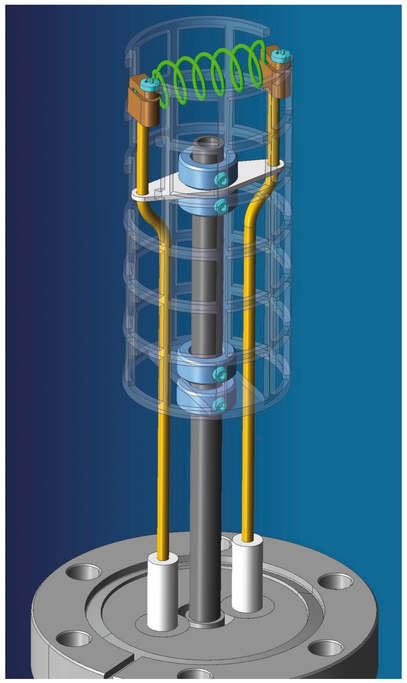


Figure 2: Atomic hydrogen cleaner

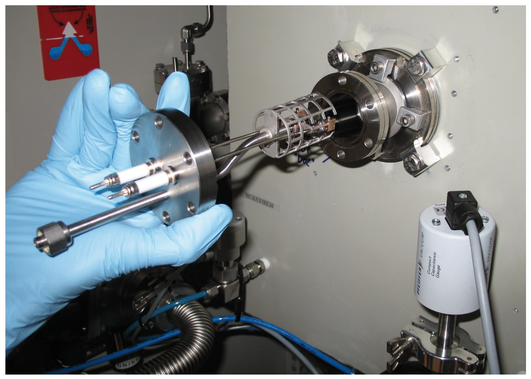


Figure 3: cleaner being installed into TNO setup

VALIDATION/ QUALIFICATION

Before delivery to our customer the performance of the cleaner is validated. There are two important requirements:

- Sample temperature shall not arise above 60°C
- Cleaning rate of at least 10 nm carbon in one hour

Validation of the maximum sample temperature is performed for each individual cleaner. A series of heat load experiments is performed to find the optimal setting for:

- Hydrogen flow
- System pressure
- Filament temperature

A typical heat load measurement result is shown in figure 5.
After the optimal settings for the cleaner have been determined the cleaning rate is validated.
The cleaning rate is validated by cleaning a 1” sample, coated with carbon, placed at 2 cm from the cleaner, see figure 4. The cleaning rate is calculated from the reduction in carbon layer thickness, which is measured by, e.g., ellisometry or optical transmission measurements.

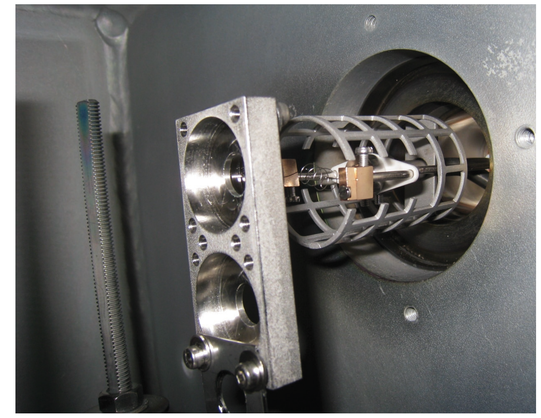


Figure 4: Cleaner within TNO setup with sample holder at 2 cm

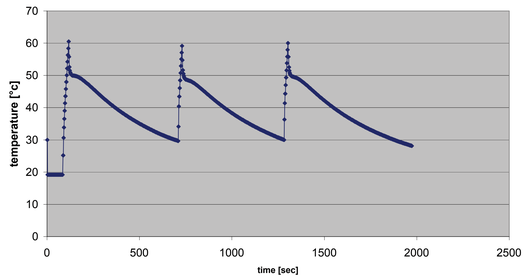


Figure 5: Typical heat load measurement

Shown in figure 6 is the cleaning rate of one of our cleaners before shipment to a customer. In the centre a cleaning rate of 12.4 nm/h is measured.

CONCLUSION

TNO has built a small cleaner as part of the required infrastructure for fast and cost-efficient qualification of resists. This cleaner can clean more that 10 nm per hour without heating up the sample above 60°C.
This cleaner can also be used for cleaning of other samples/materials that are contaminated with carbon during research or validation measurements. One example could be EUV reticles after a SEM measurement.

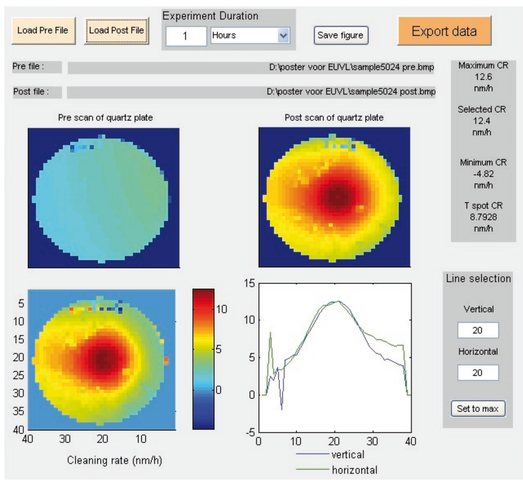


Figure 6: spatial cleaning rate of one of the shipped cleaners.