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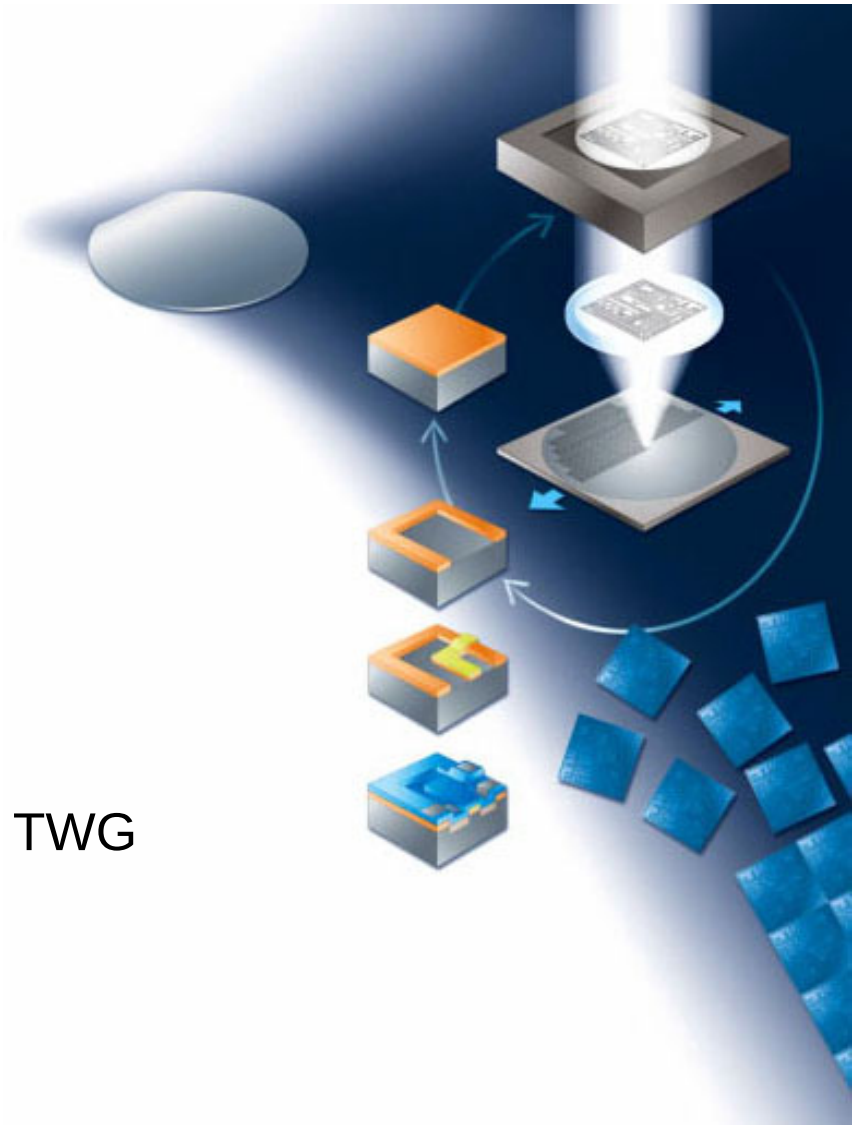
Lithography Optics Division



EUVL
Optics lifetime and contamination
European update

IEUVI Optics Contamination/Lifetime TWG
Thomas Stein

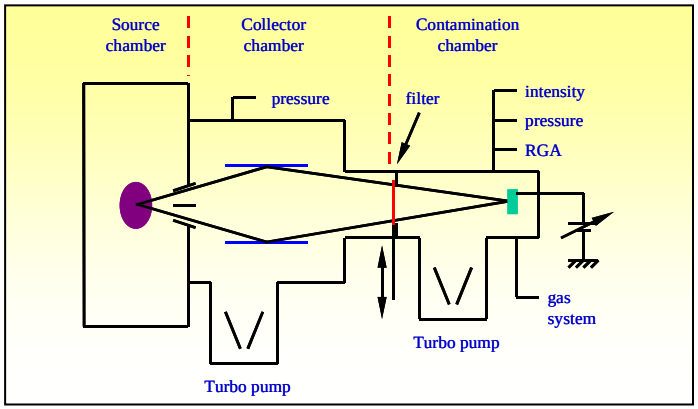
19.10.2006

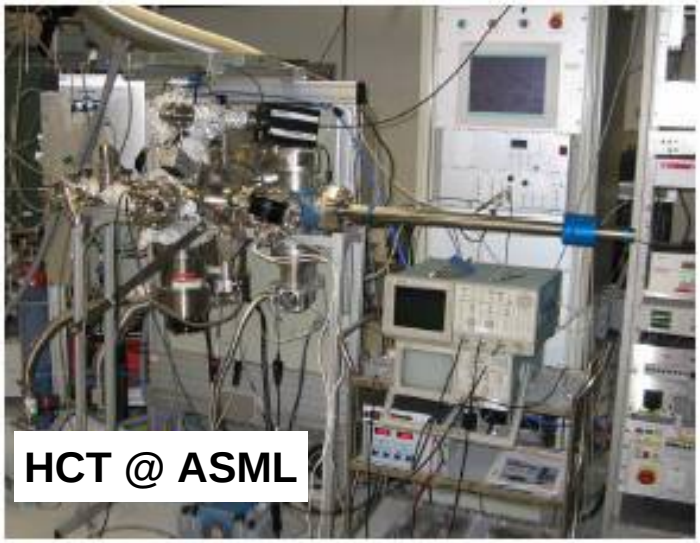
Overview

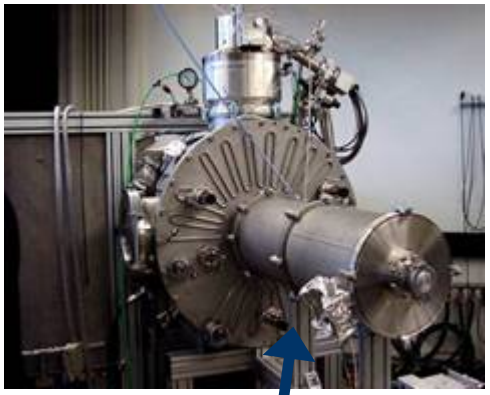
- General and strategy
- Recent results
- Outlook HVM

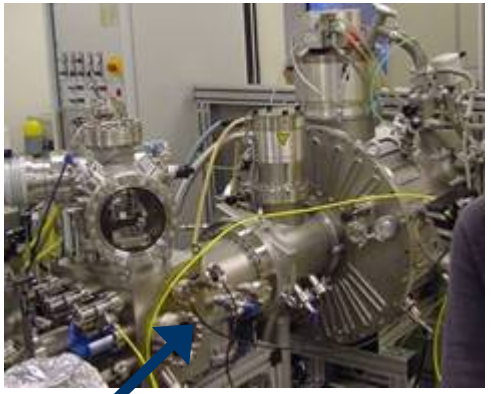
Pulsed beamlines for optics contamination investigation

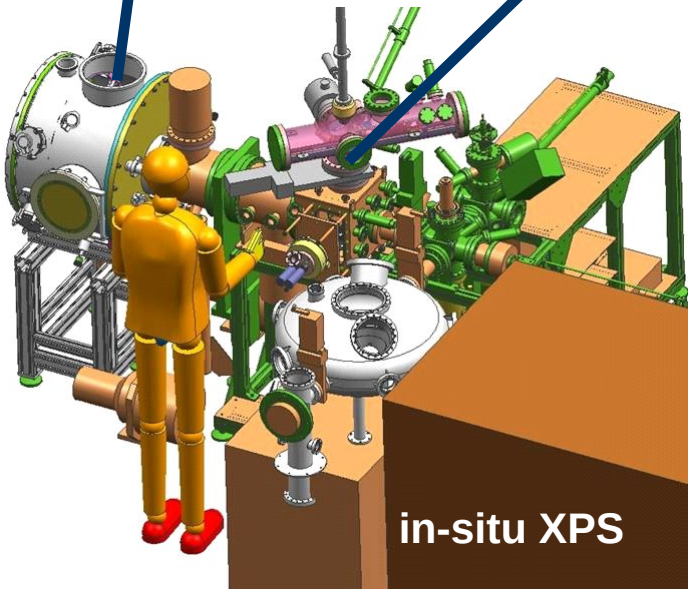
*HCT = hollow-cathode-triggered discharge source











EBL @ TNO

Source collector geometry and cleaning similar to ADT

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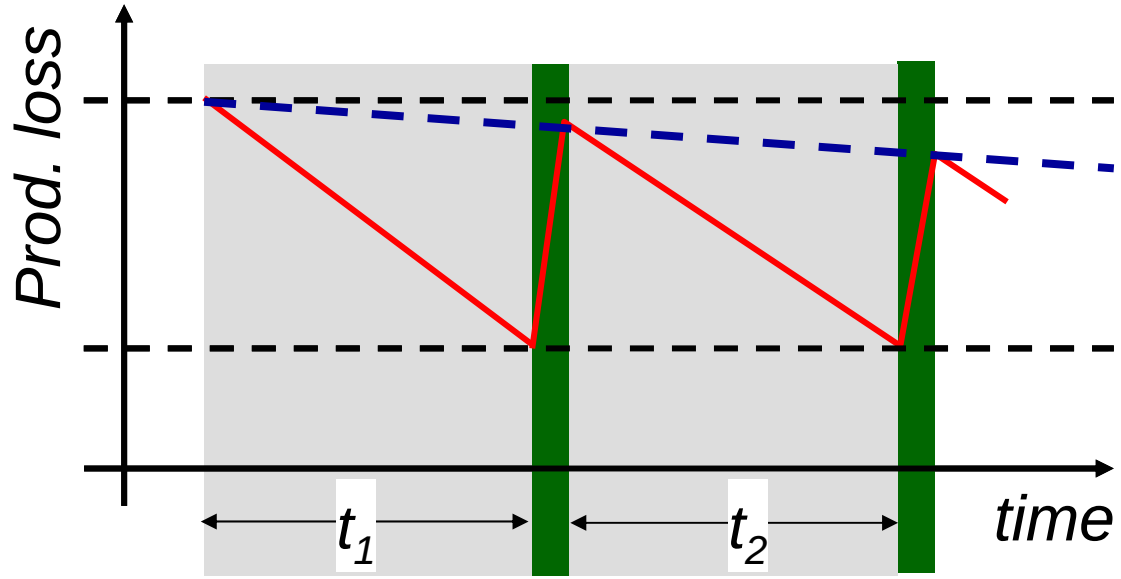
General optics usage strategy

- **Clean, grease-free vacuum system**
- **Repetitive exposure and cleaning**
- **time between cleaning decreases over time (non-cleanable losses)**

initial MTBC = t_1 **average MTBC = t_1 : 2**



0 % (initial)

irreversible losses
(determining N_{max})

-10% productivity

$t_2 < t_1$

LT = MTBC * N_{max}

N_{max}: maximum number of possible cleaning cycles

MTBC = mean time between cleanings

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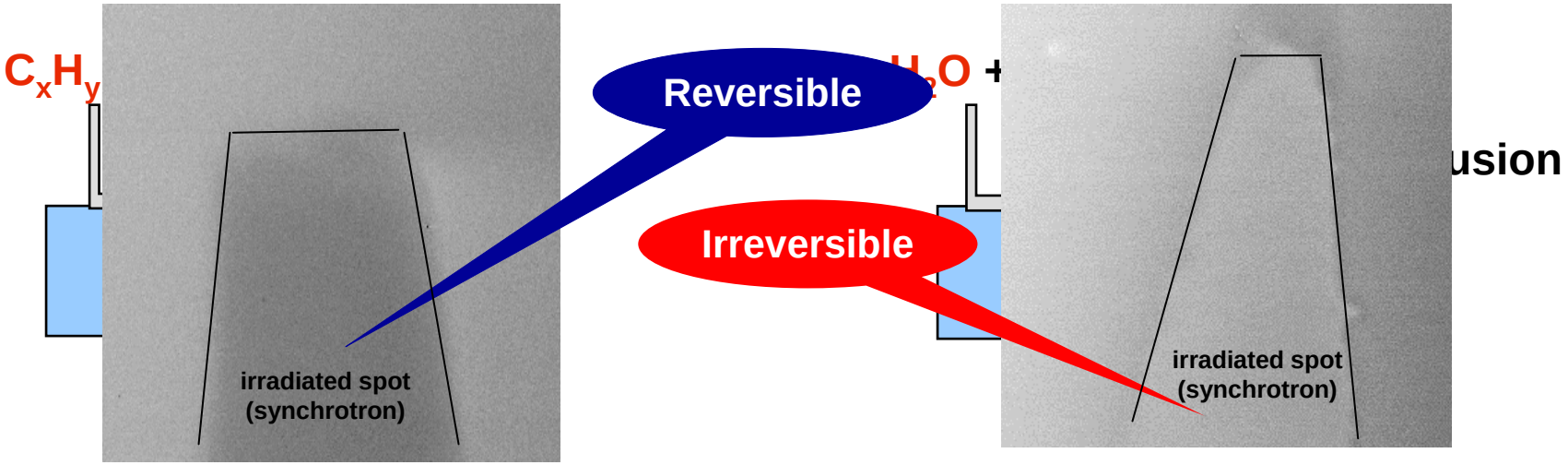
Contamination mitigation is required to maintain tool productivity

Carbon growth:

1% loss per nm carbon

Oxidation:

3% loss per nm additional oxide



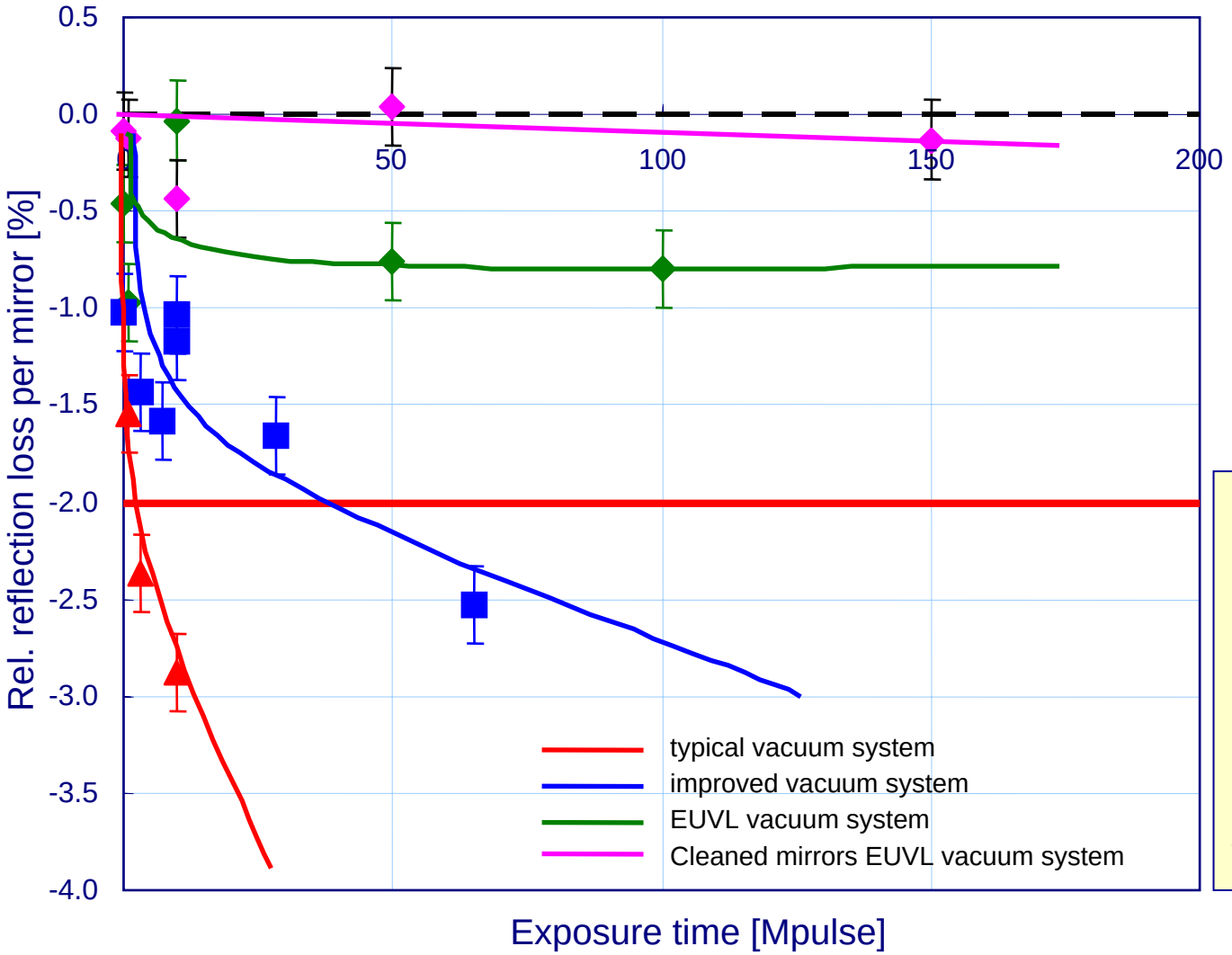
Optics contamination mitigation strategy includes

- clean vacuum environment (materials, gases, equipment…)
- selection of materials applied in vacuum
- oxidation resistant mirror coatings
- carbon cleaning, without mirror degradation

} intensity and pressure dependence of mirror degradation ? → next slides

Note: reflectivity loss does impact tool productivity rather than imaging performance

Overview carbon growth behaviour under different conditions



Given experimental data, we expect mild carbon growth for clean lithotool vacuum environment.

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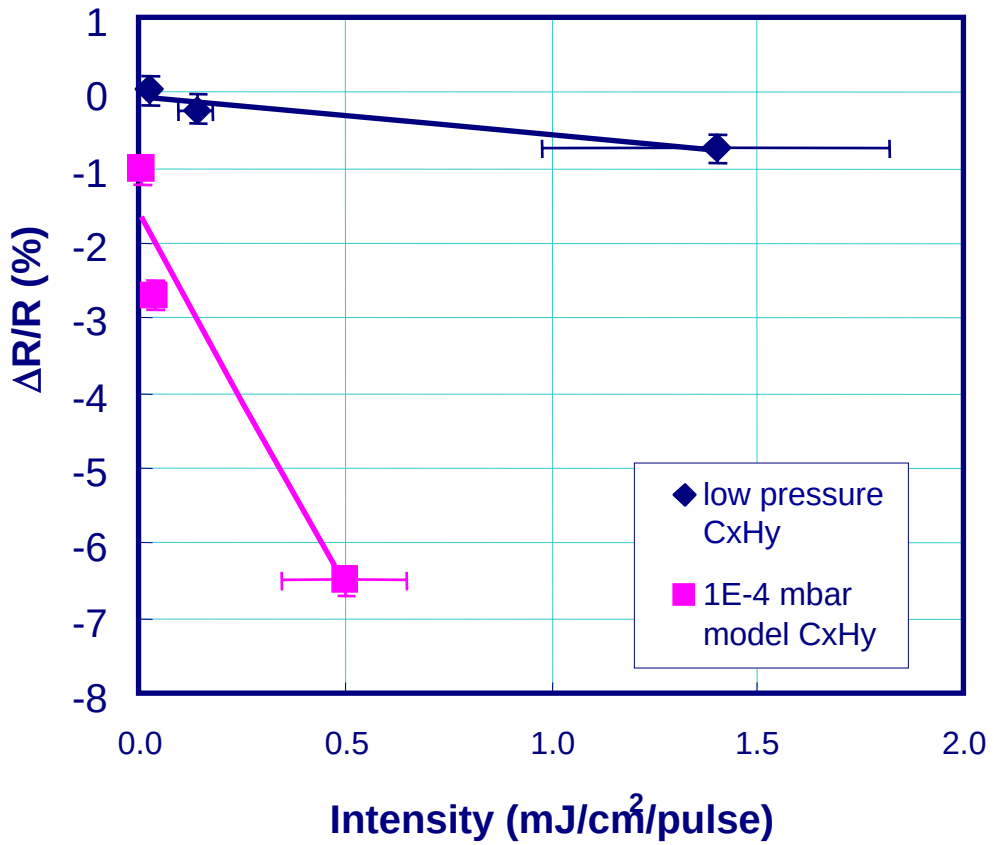
Linear dependence of intensity vs. carbon growth



- Intensity is a scaling parameter → linear dependence for contamination rate with respect to intensity
- intensity and pressure dependence of carbon growth has been shown

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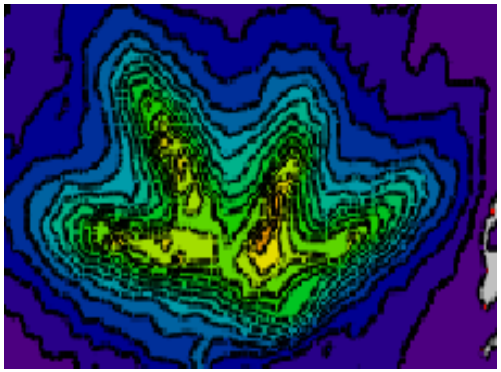
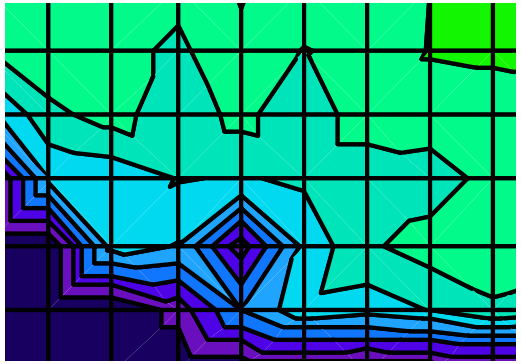
Amount of C-growth on mirrors depends on EUV intensity

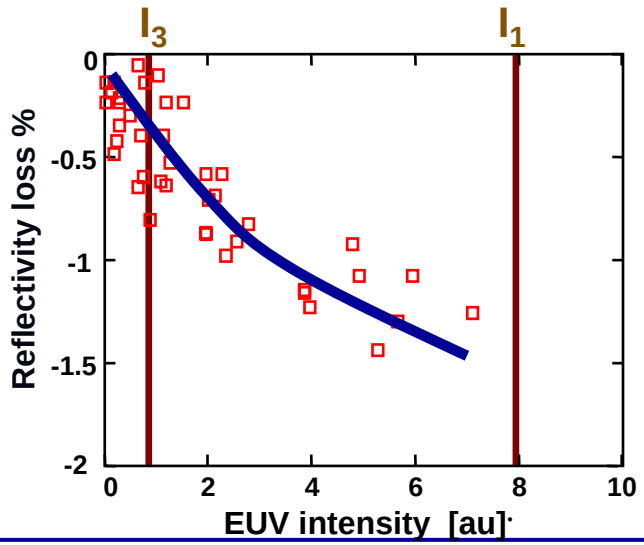
Illumination profile



reflectivity map



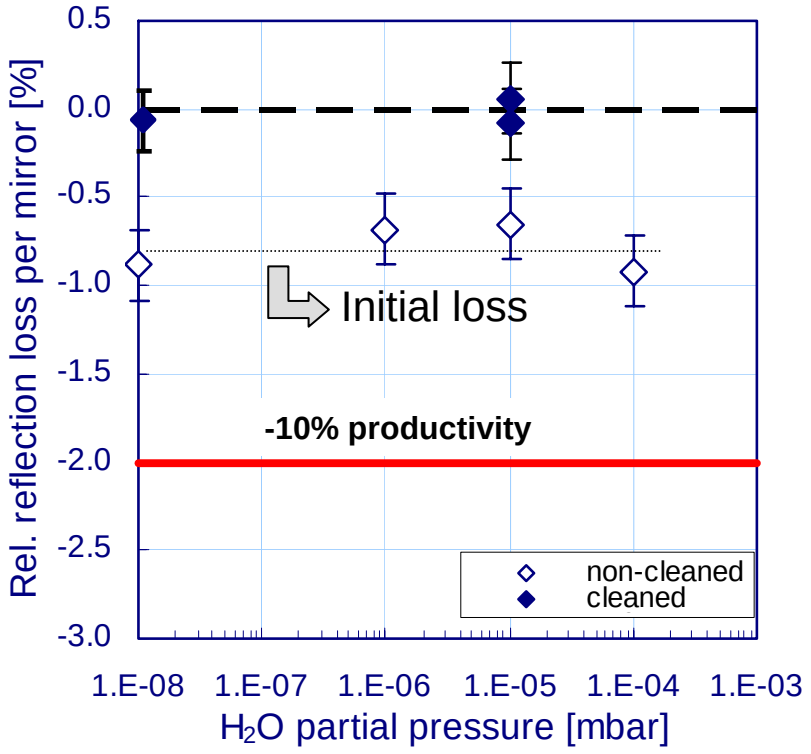
Local reflectivity loss vs EUV power



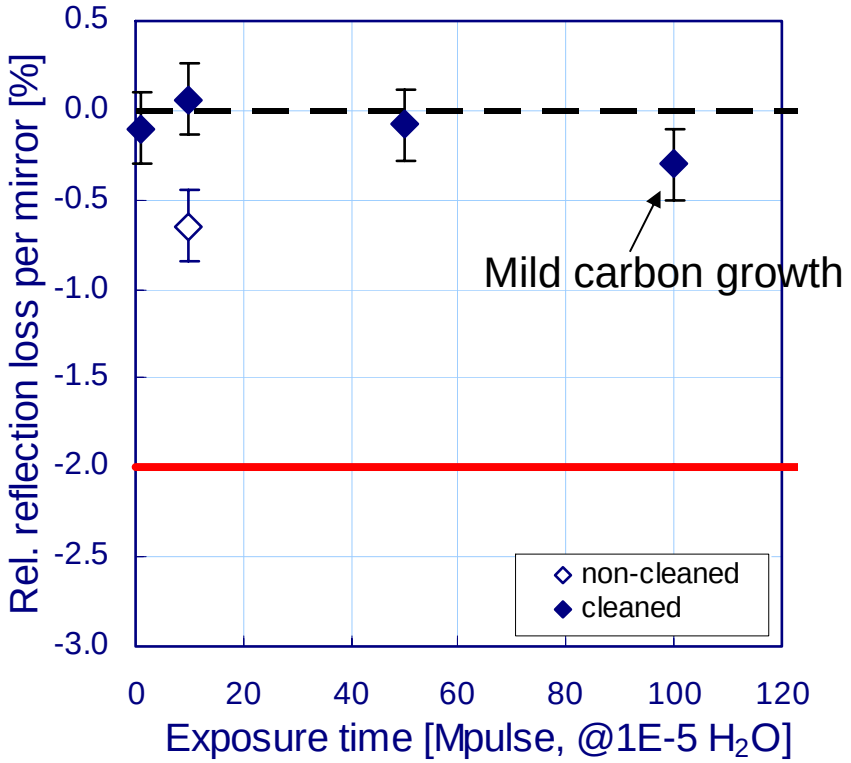
- the first mirrors in the illuminator see the highest EUV intensity and thus the highest carbon growth rate
- Intensity at the POB mirrors is substantially lower

Optics reflectivity is dominantly influenced by carbon growth

Influence of H_2O



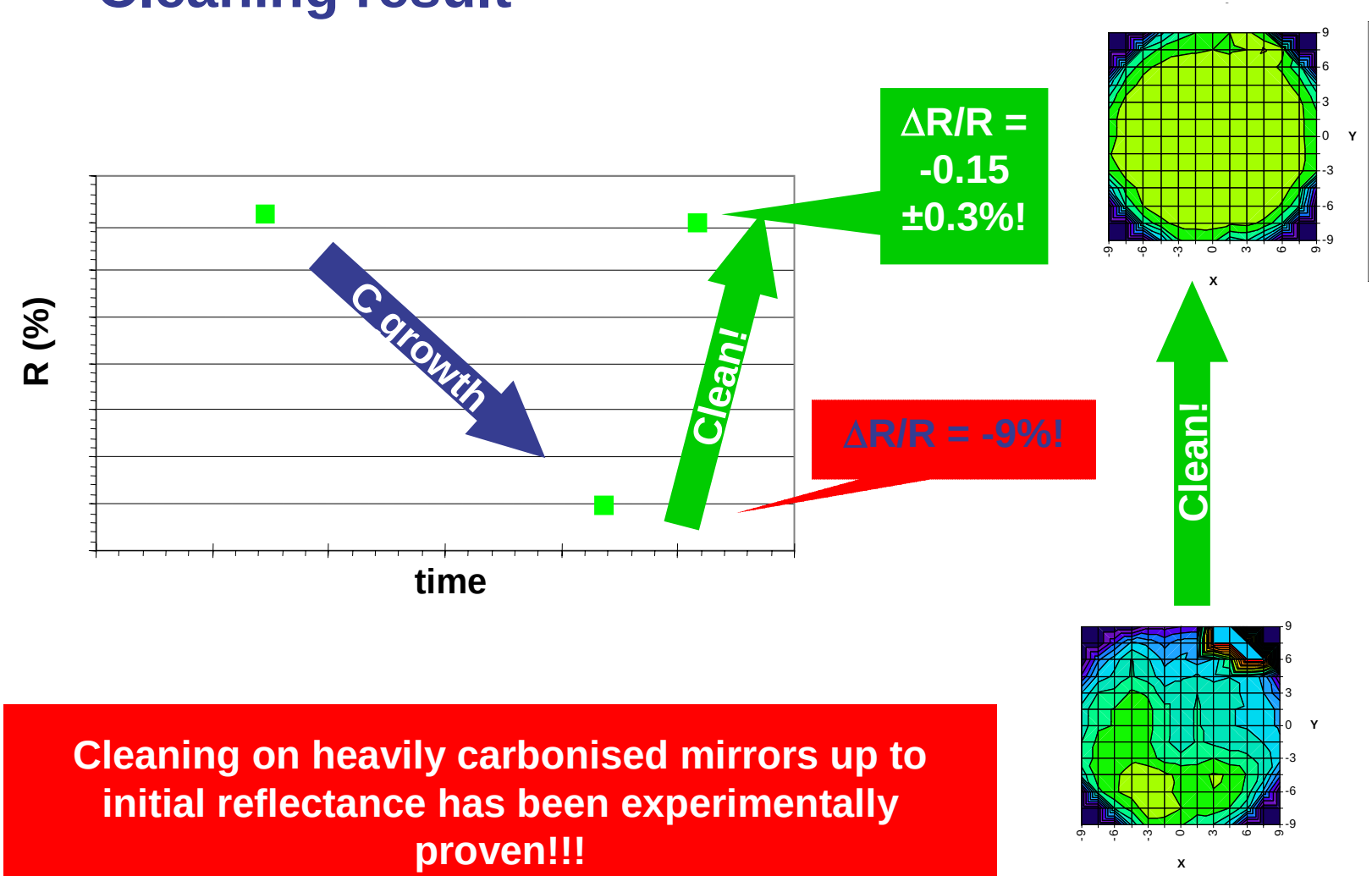
Influence of C-growth



- Oxidation due to water pressures upto 1E-05 mbar not observed
- Carbon growth is dominantly contributing to productivity with time

C-growth is removable with cleaning

Cleaning result



Cleaning on heavily carbonised mirrors up to initial reflectance has been experimentally proven!!!

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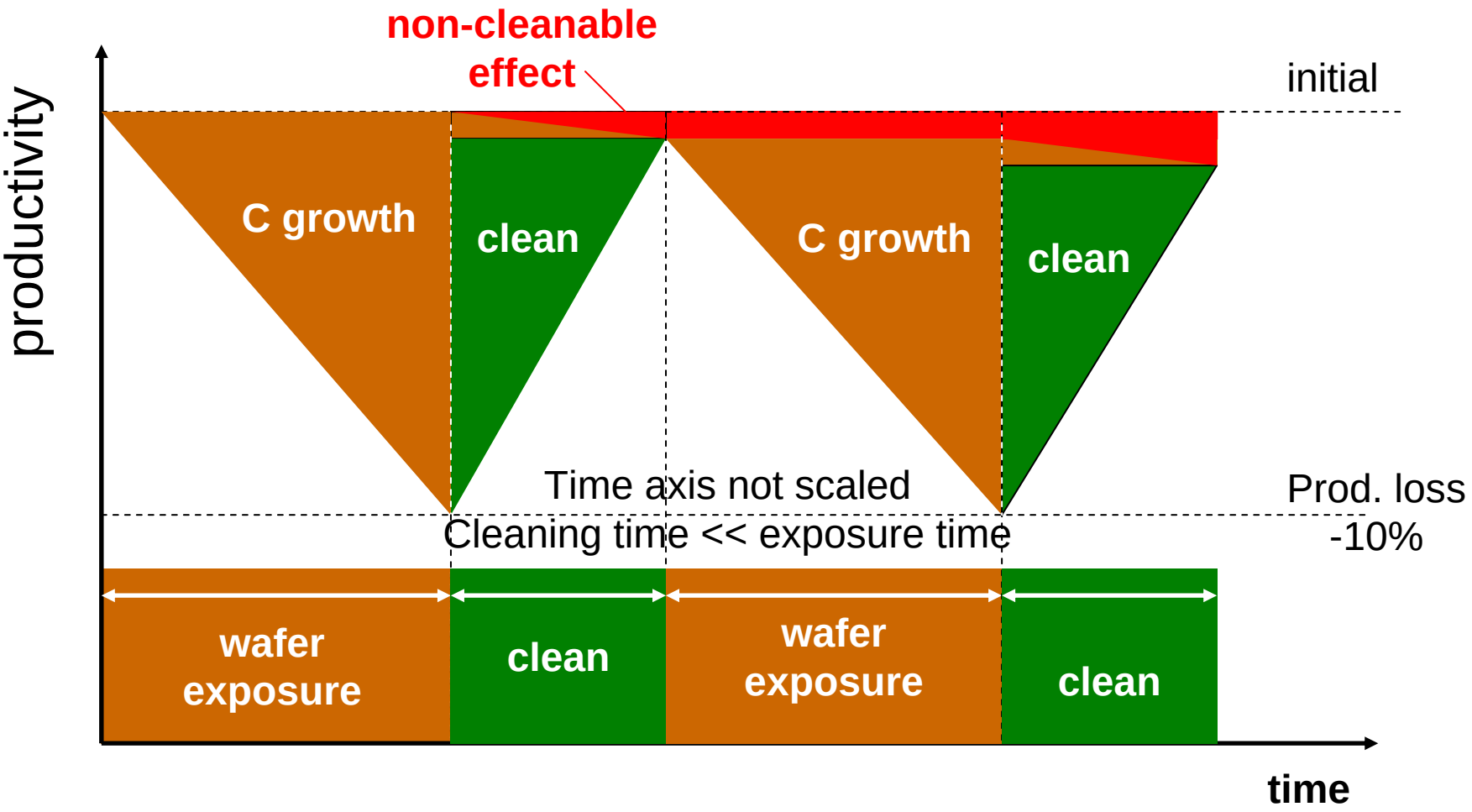
Lifetime/contamination mitigation strategy (ADT)



Depending on environmental conditions and source power several thousand wafers can be exposed between cleaning actions

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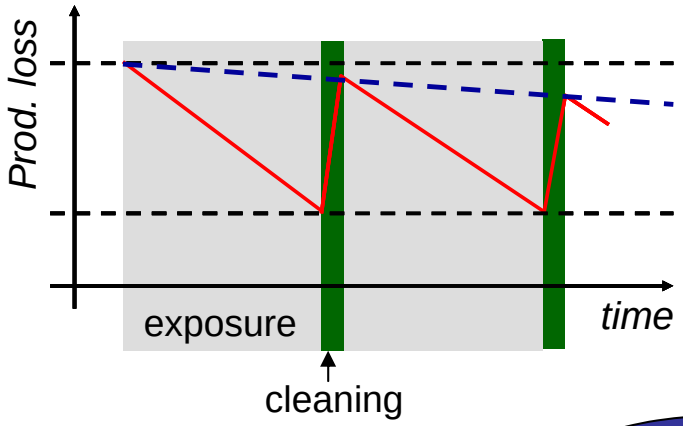
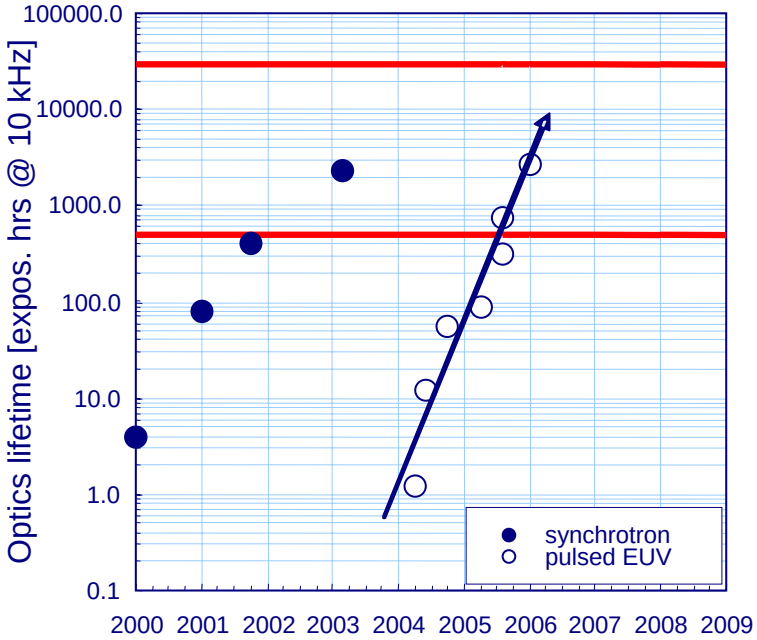
Working focus for HVM optics contamination work





Illumination
> 10.000 hrs

Experimental
MTBC
> 100 hrs

Experimental
 # cleanings
x 10-100

Scaling

x 10-100

Improvement in all relevant fields needed for HVM lifetime requirements.

We are not there yet, but we are on track for HVM optics lifetime ....

Acknoledgements

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