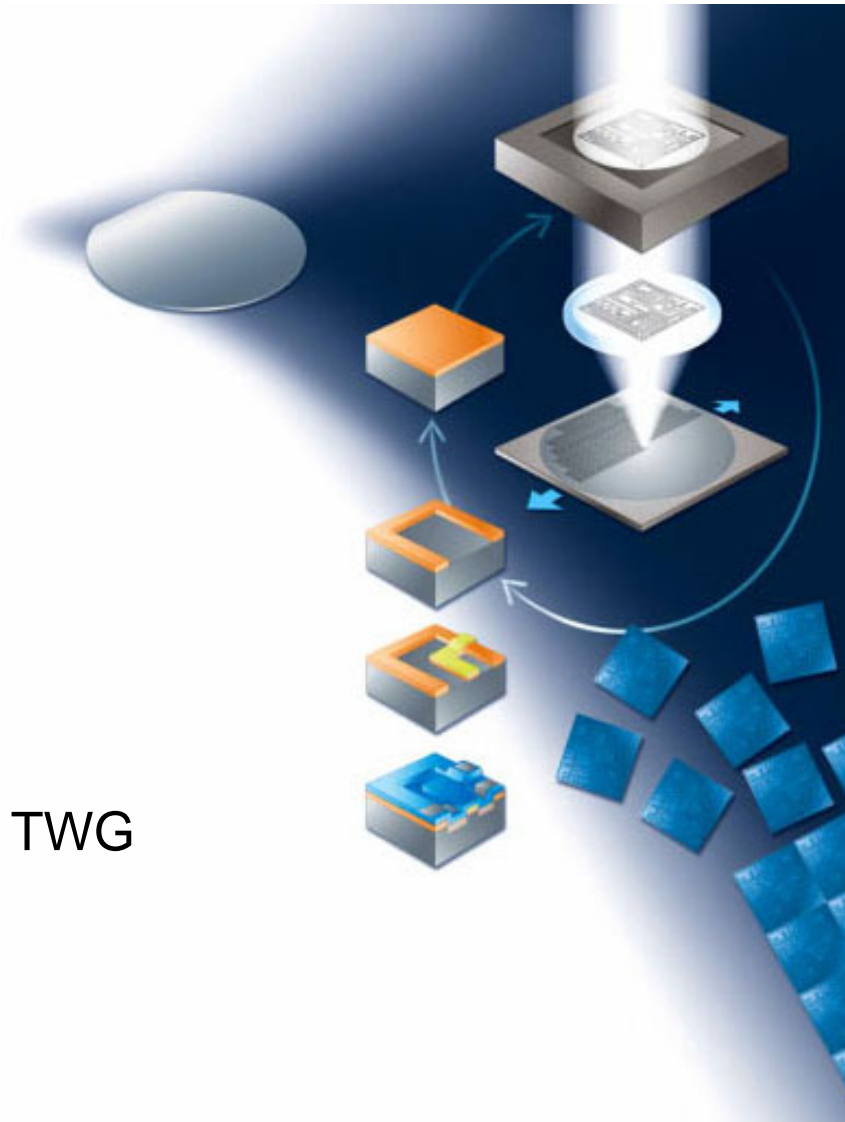


Lithography Optics Division

EUVL
Optics lifetime and
contamination
European update

IEUVI Optics Contamination/Lifetime TWG
Thomas Stein

19.10.2006



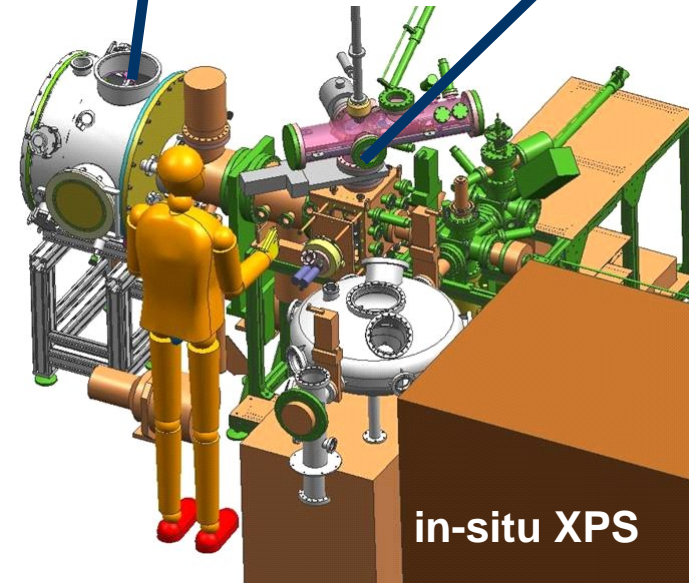
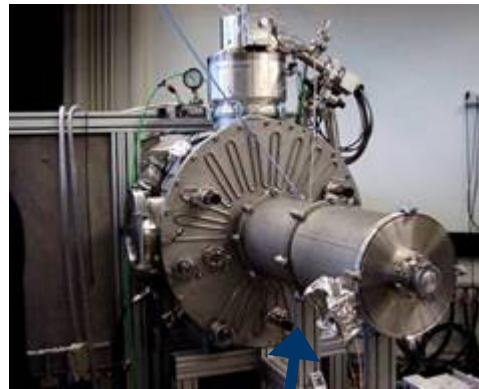
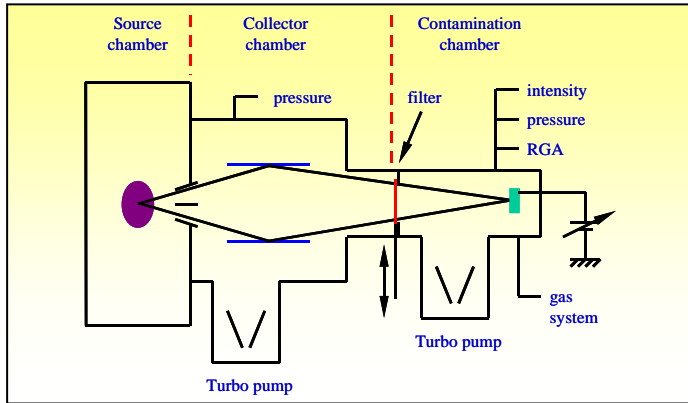


Overview

- General and strategy
- Recent results
- Outlook HVM

Pulsed beamlines for optics contamination investigation

*HCT = hollow-cathode-triggered discharge source

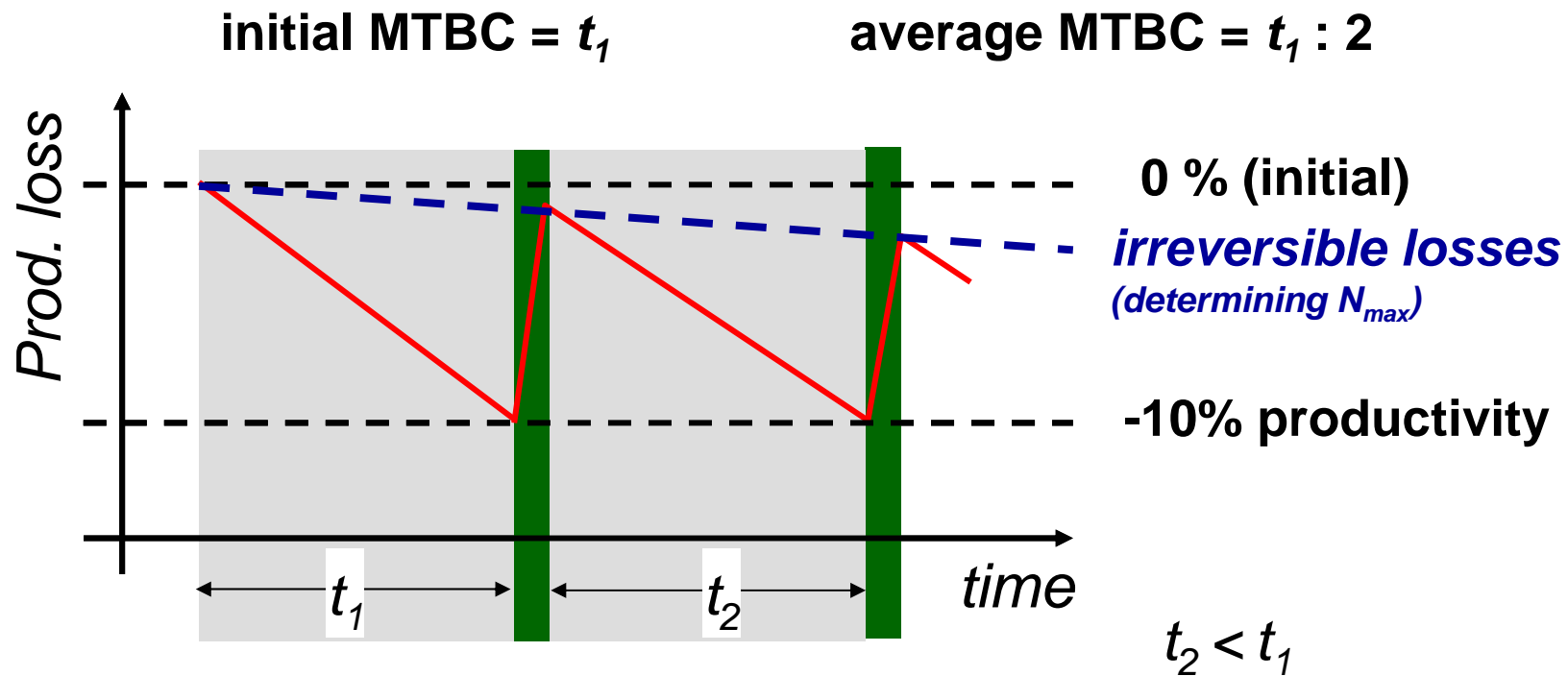


EBL @ TNO

Source collector geometry and cleaning similar to ADT

General optics usage strategy

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



LT = MTBC * N_{max}

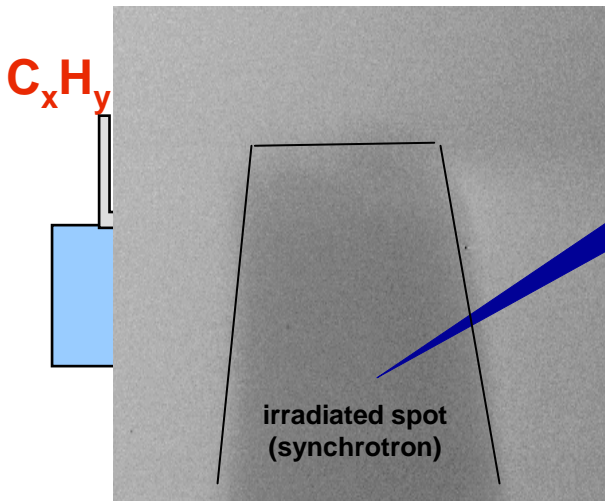
N_{max} : maximum number of possible cleaning cycles

MTBC =
mean time
between cleanings

Contamination mitigation is required to maintain tool productivity

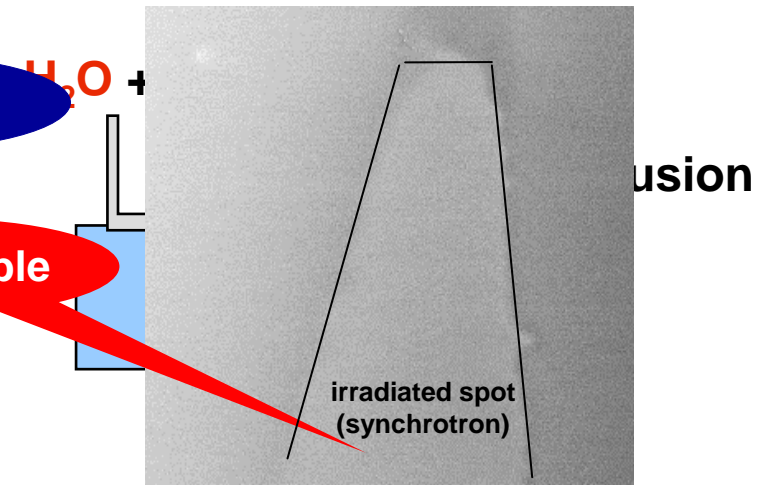
Carbon growth:

1% loss per nm carbon



Oxidation:

3% loss per nm additional oxide



Reversible
Irreversible

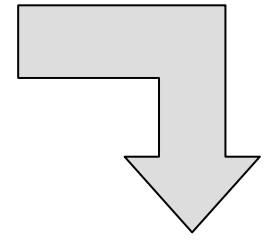
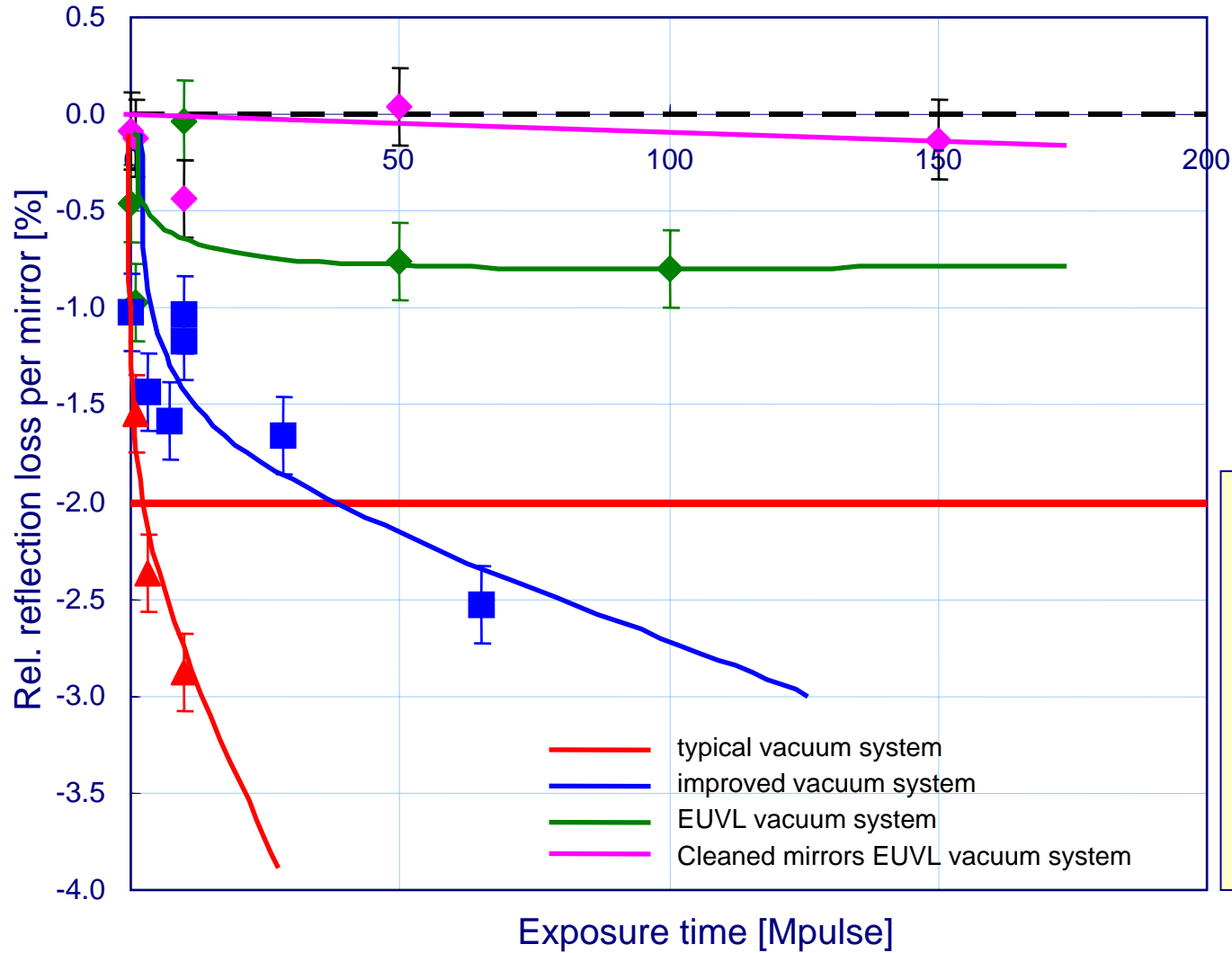
Optics contamination mitigation strategy includes

- 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

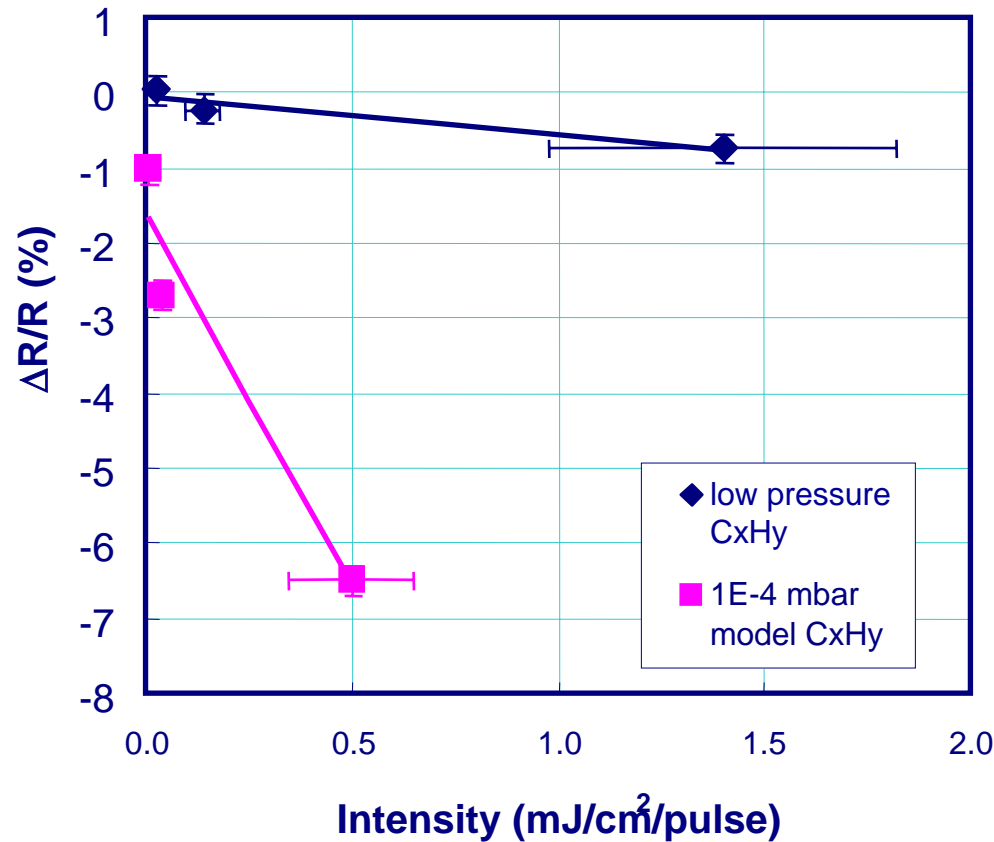
Overview carbon growth behaviour under different conditions



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

T Stain I E I M I Ontire Contamination/ I f i t i m e T M / Q Baralona 10 10 2016

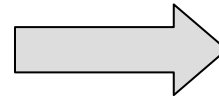
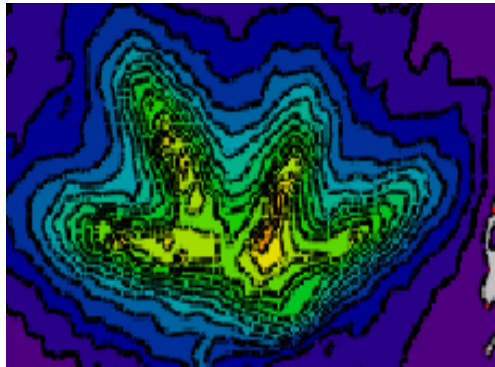
Linear dependence of intensity vs. carbon growth



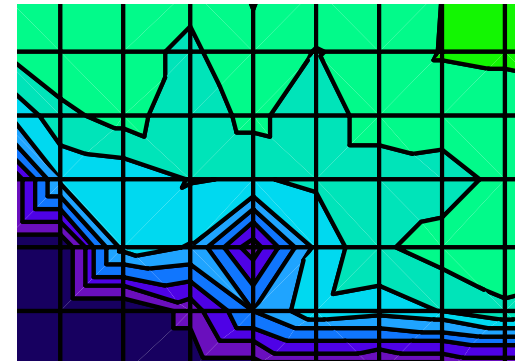
- Intensity is a scaling parameter → linear dependence for contamination rate with respect to intensity
- intensity and pressure dependence of carbon growth has been shown

Amount of C-growth on mirrors depends on EUV intensity

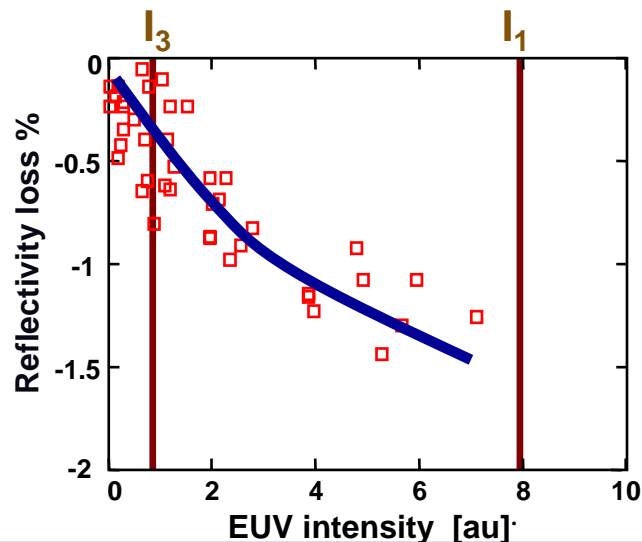
Illumination profile



reflectivity map



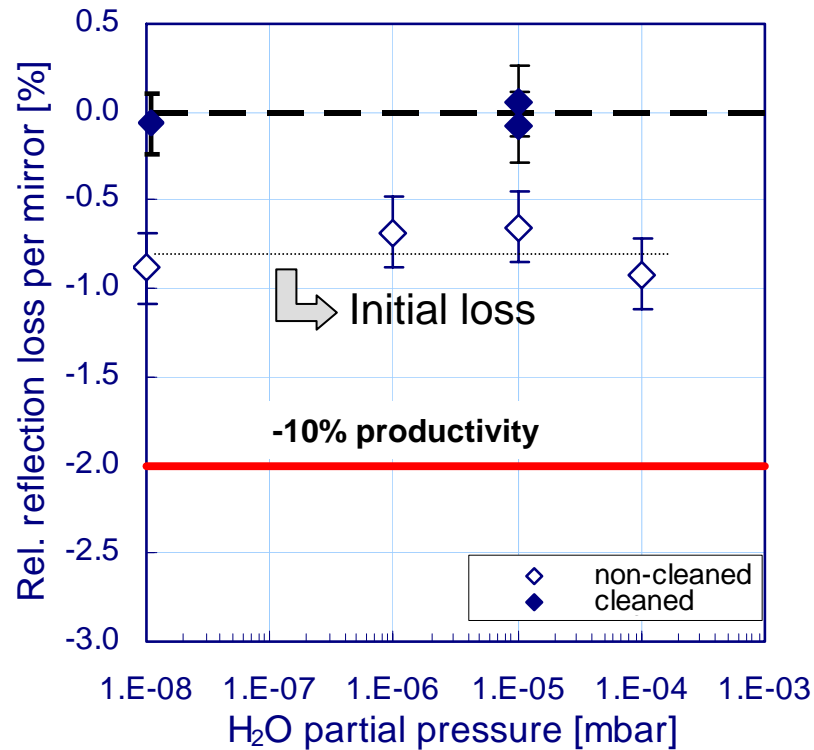
Local reflectivity loss vs EUV power



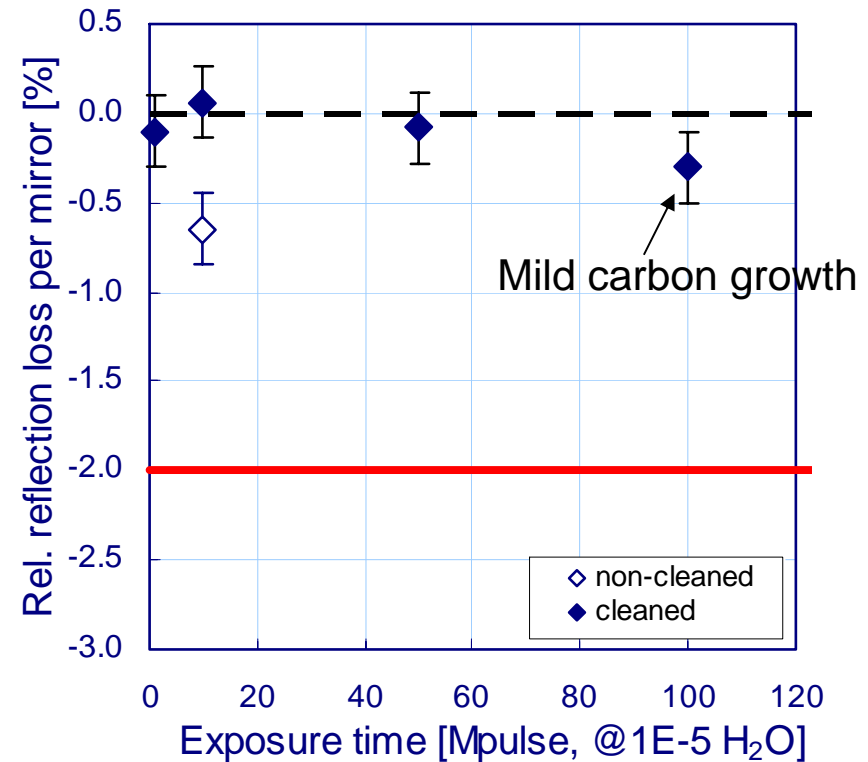
- the first mirrors in the illuminator see the highest EUV intensity and thus the highest carbon growth rate
- Intensity at the POB mirrors is substantially lower

Optics reflectivity is dominantly influenced by carbon growth

Influence of H₂O



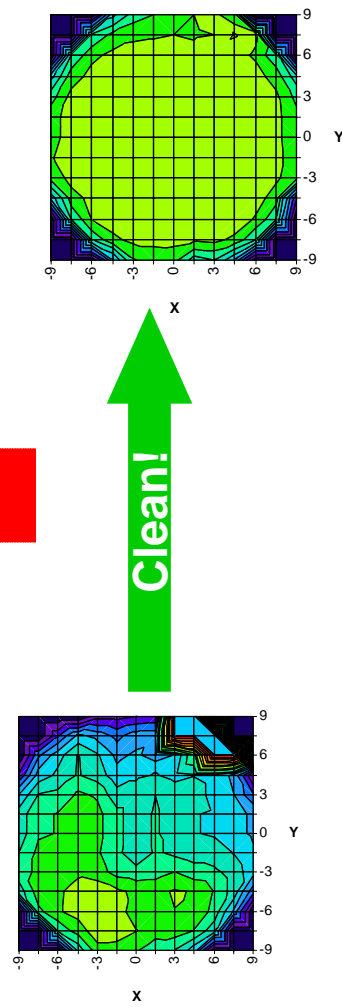
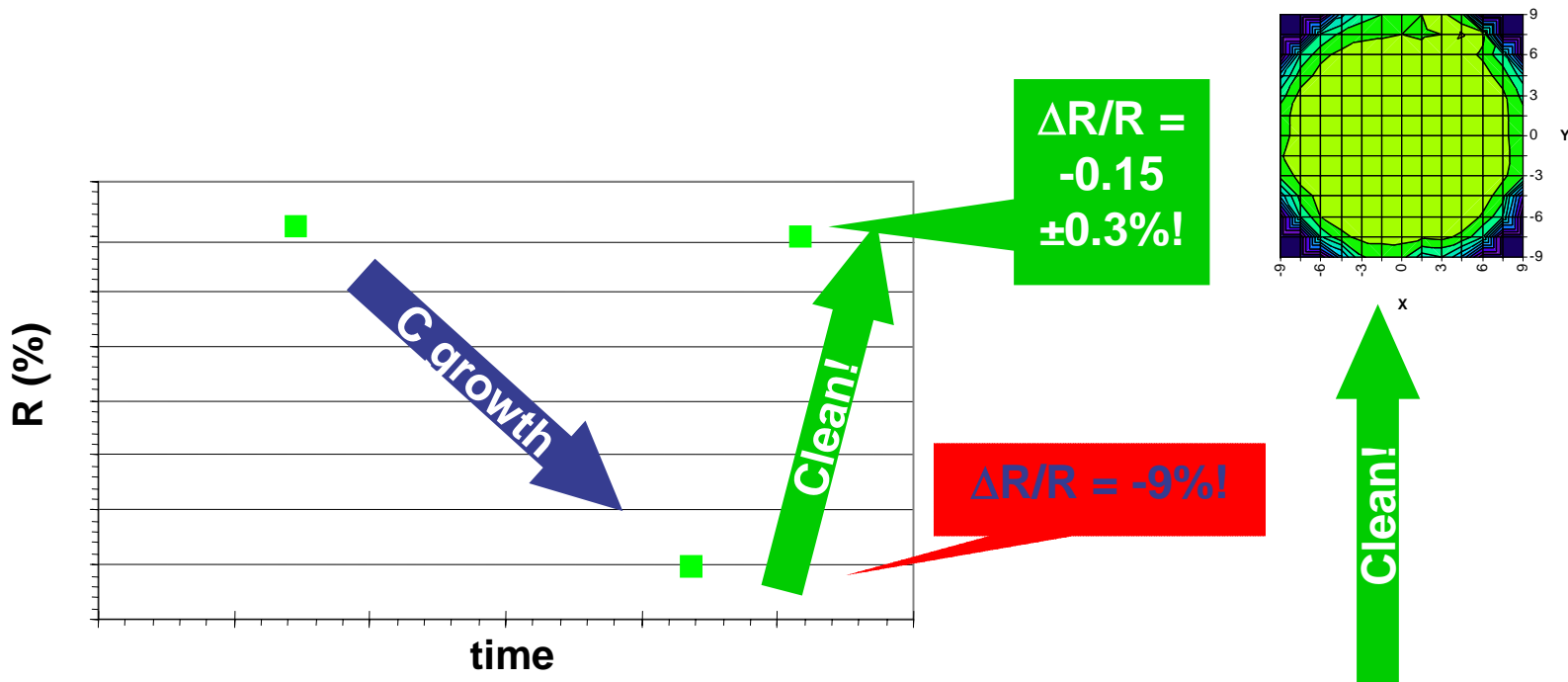
Influence of C-growth



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

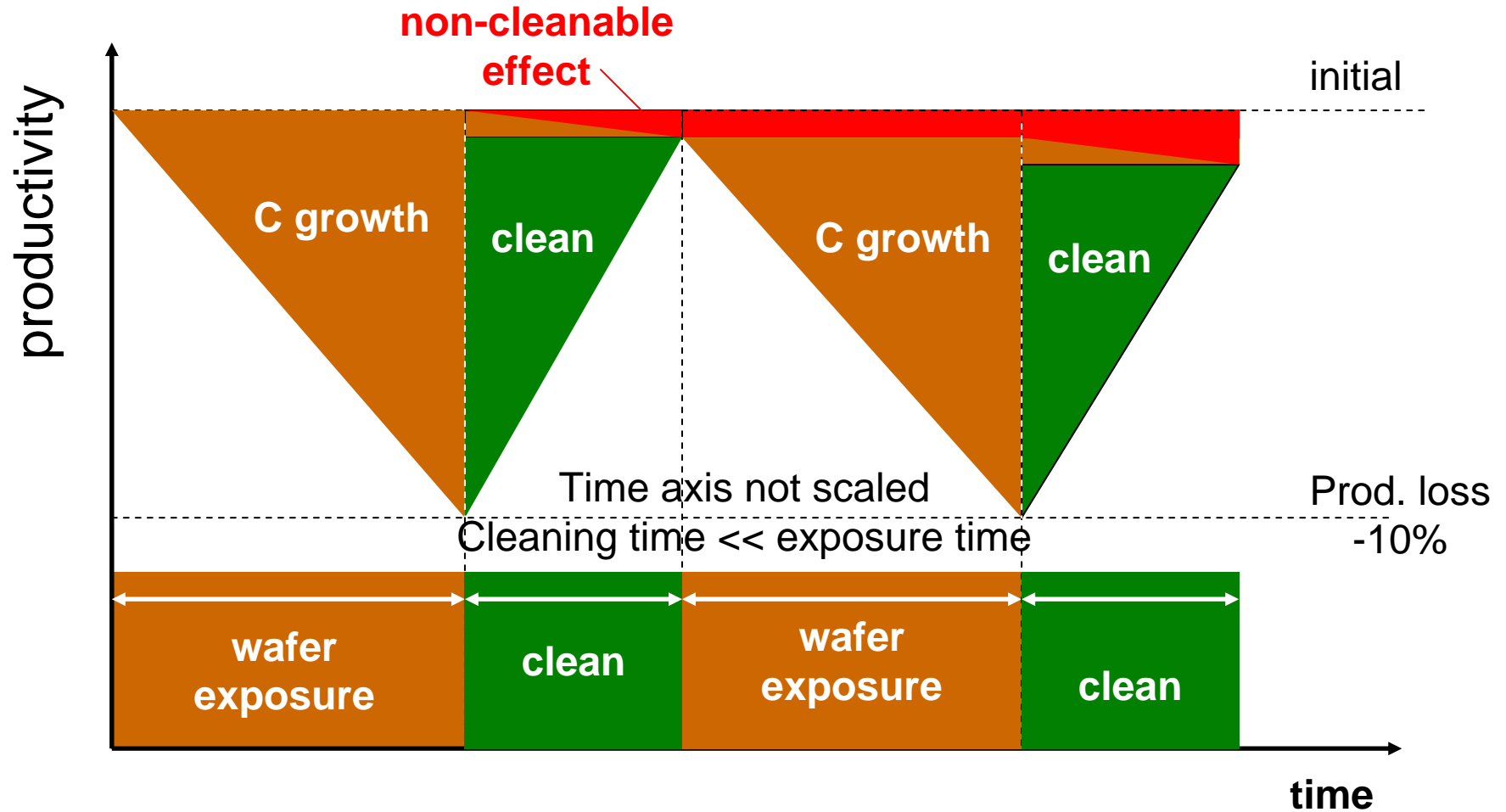
C-growth is removable with cleaning

Cleaning result



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

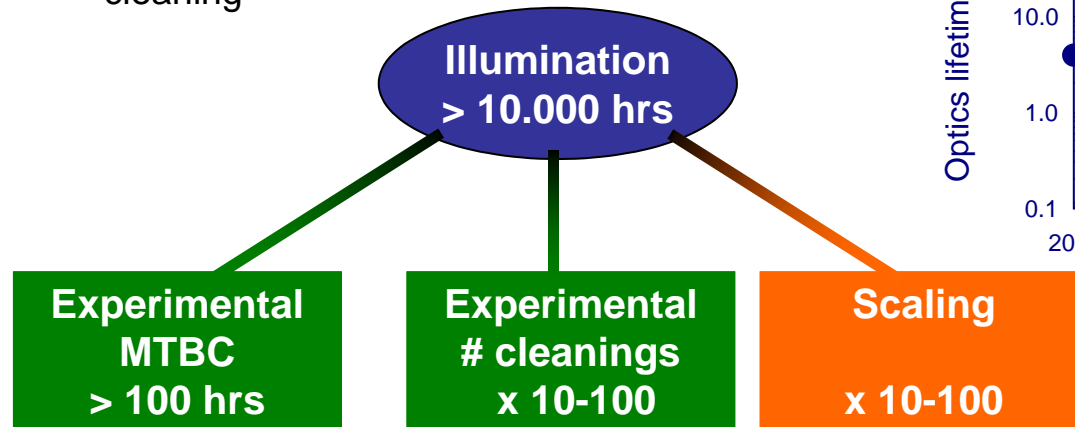
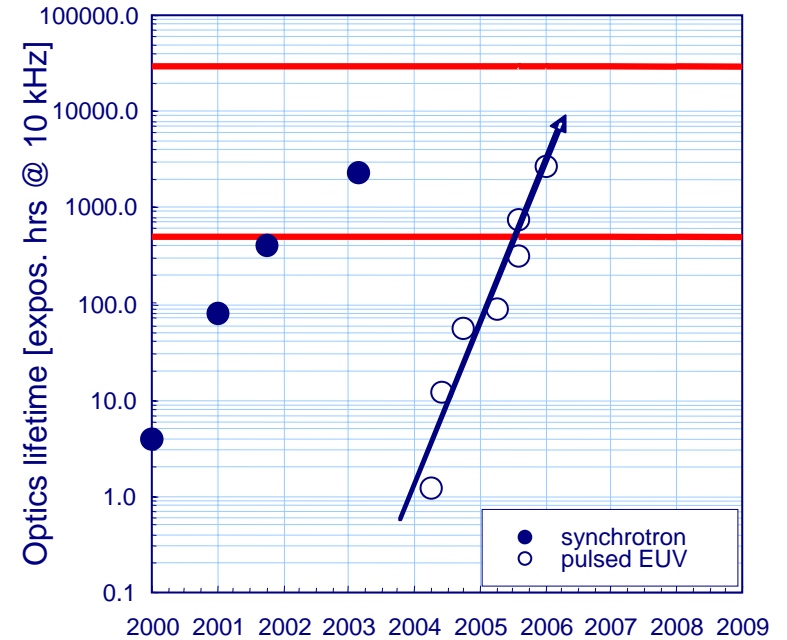
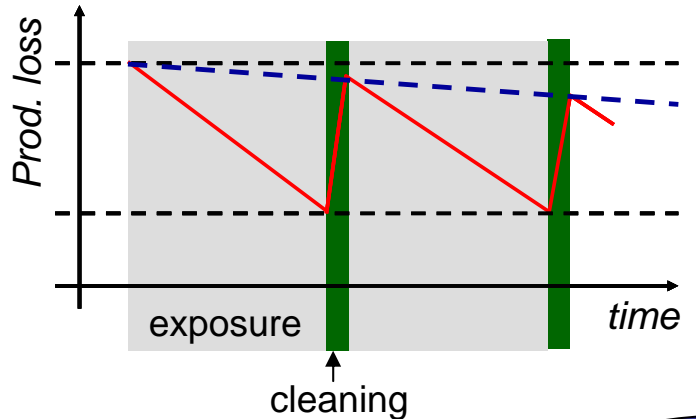
Lifetime/contamination mitigation strategy (ADT)



T. Stein, IEUVI Optics Contamination/Lifetime TWG, Barcelona, 19.10.2006

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

Working focus for HVM optics contamination work



Improvement in all relevant fields needed for HVM lifetime requirements.

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

Acknowledgements



Carl Zeiss SMT AG, Oberkochen, Germany



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ALS, Berkeley, USA