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#4

Optics contamination under pulsed EUV radiation

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INTRODUCTION

Challenge:
Optics lifetime is a major issue in EUVL.

Specifications:
For CoO reasons the optics life time must be 7-10 calender years (30,000 hours)

Solution:
A Contamination Control strategy is found that increases optics life time (see presentation, Weiss et al. and poster 5, Mertens et al.)

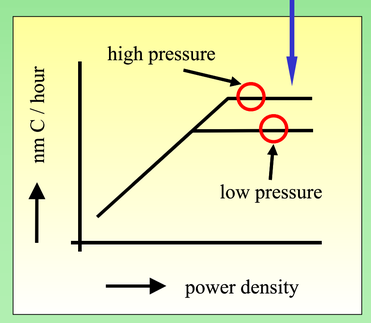
Issue:
Experimental results so far based on high rep rate (MHz range) / continuous radiation sources

Basic model (simplified; carbon growth)

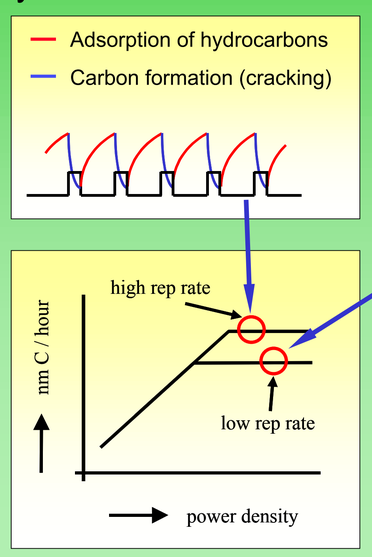
Optics contamination is caused by (EUV induced) secondary electron cracking of adsorbed molecules

Continuous

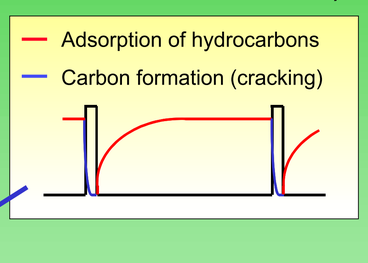
Jonkers-Bisschops model:
- Intensity limited regime
- Pressure limited regime



High rep rate
(synchrotron: 1 – 500 MHz)



Low rep rate
HCT - : 0.1 – 10 kHz)



At pulsed EUV, time aspects become relevant:
- **source rep rate**
- **electron emission speed**
- **chemical reaction speed**
- **adsorption and desorption kinetics**

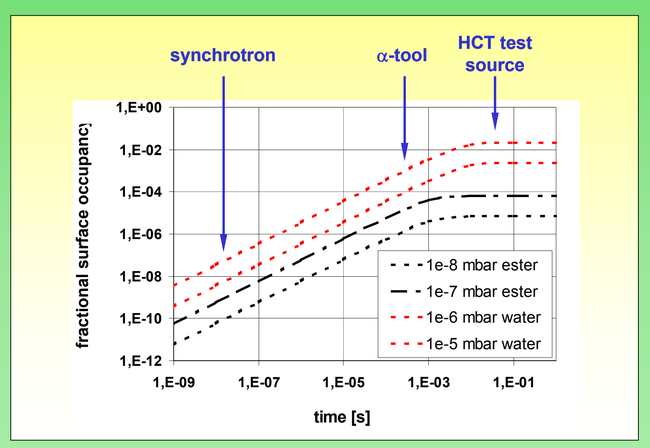
Adsorption and desorption kinetics

Adsorption and desorption kinetics can be described by several models. In this case the Langmuir model is taken. Due to the estimated repitition rates, it is assumed that the surface will never be covered by more than one monolayer.

Langmuir theory: molecules deposit on a surface with an exponential behavior in time, upto a certain equilibrium value, dependent on:
- type of surface (material and structure)
- type of molecule
- temperature
- pressure

The material-molecule combination determines whether physisorption or chemisorption occurs. This strongly affects the desorption energy (i.e., high for chemisorption, low for physisorption).

Indicative adsorption curve:



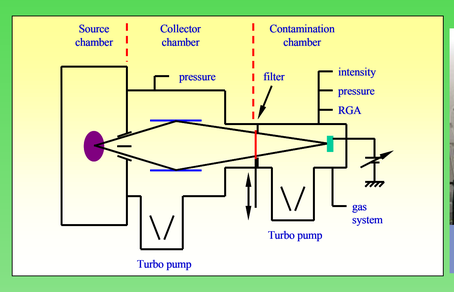
The above figure can be used to qualitatively judge whether differences between different sources will be found.

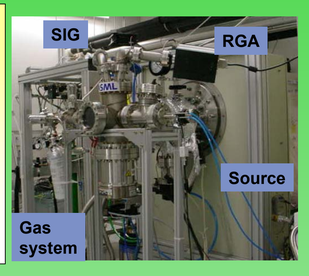
The outcome is strongly determined by input parameters (especially the desorption energy).

Initial pulsed EUV experiments: carbon growth

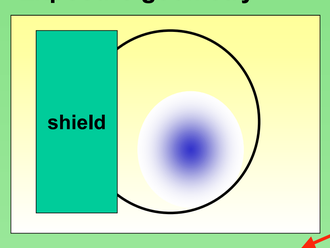
Experimental settings:

Source:	HCT, Xe gas discharge
Source repitition rate:	200 Hz
Pulse duration:	35 ns
Average power density:	1 mW/mm^2 (at sample)
Filters:	vacuum separation + optical filtering
Pressure: **ester** (modelHC)	**>> -tool spec (several orders)**
Ar	5 10^{-5} mbar
Exposure duration:	2 ·10^6 shots ~ 3 hrs



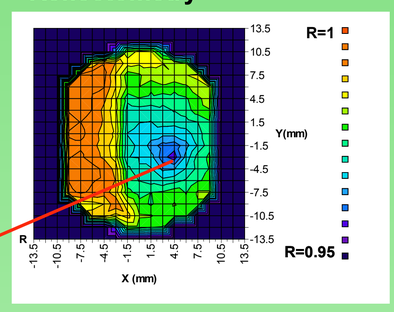


Exposure geometry



R/R_0 = - 3.5 ± 1 %

Reflectometry



Hydrocarbon pressure is extremely high compared to tool conditions! (for experimental reasons).

Contamination rate at HCT source seems less compared to synchrotron source. To draw proper conclusions, reliable Input for model is required : more experiments are in progress.

CONCLUSIONS

- **Simplified model available**
- **Different contamination rates between sources will be covered by kinetics:**
  Rate carbon-growth at HCT will be slower than synchrotron, -tool will be intermediate (first experiment at HCT confirms this)
- **Experiments are in progress to detail out reactions/model**