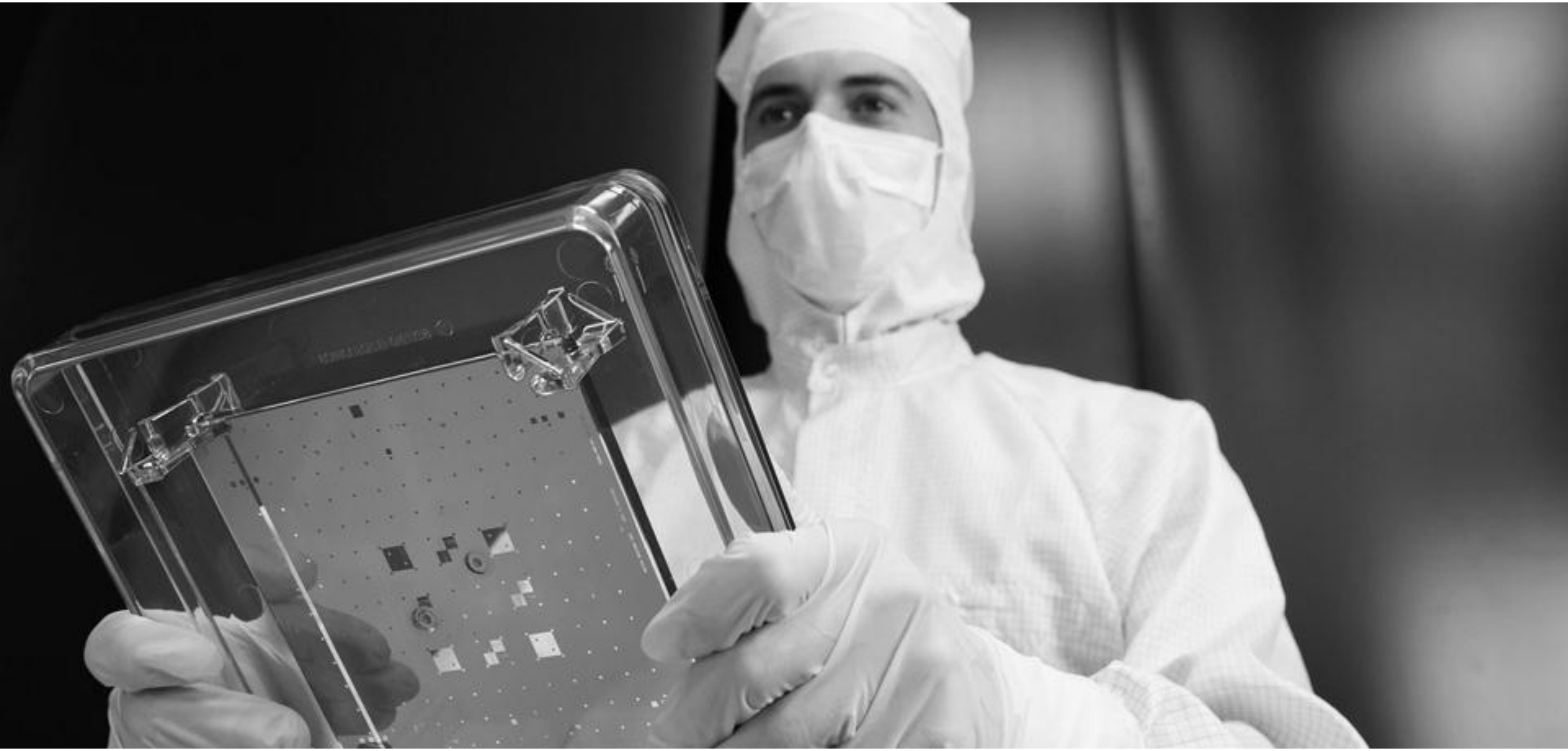
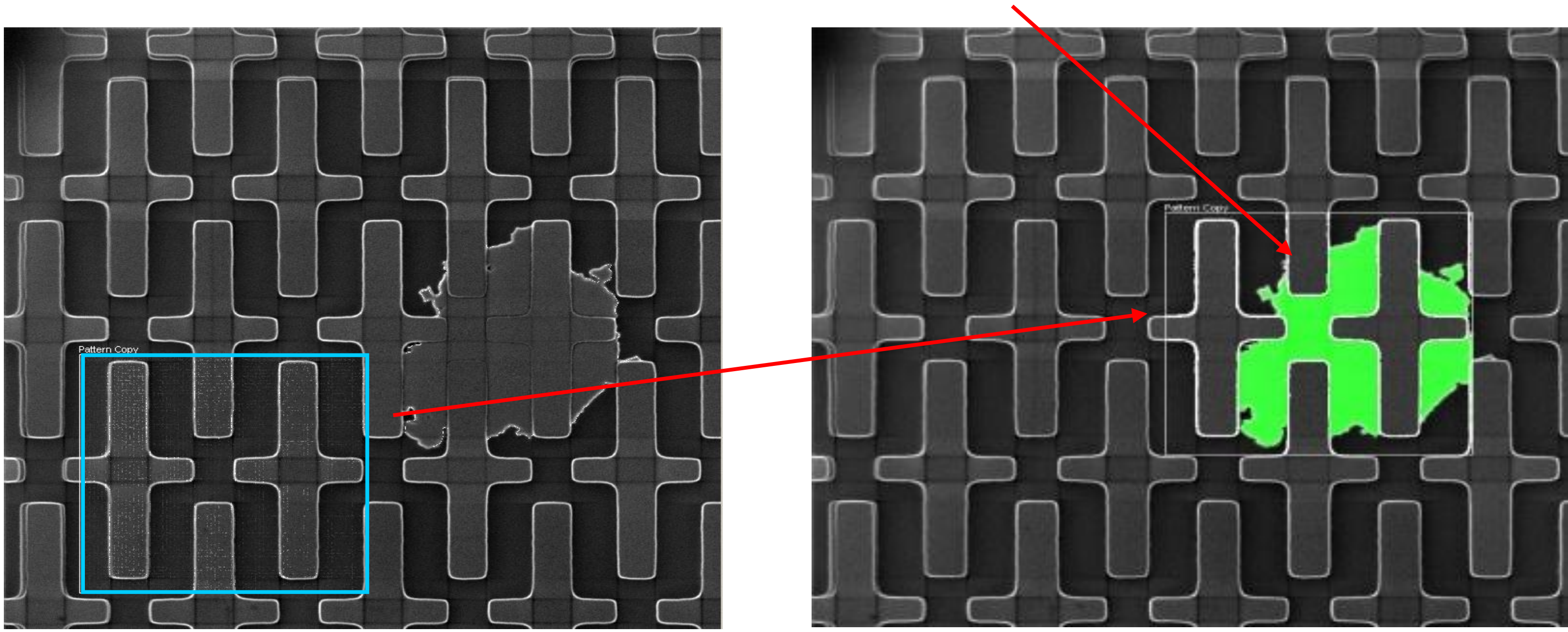
ebeam Initiative
20 April 2015 in Yokohama - Japan



Basic introduction

Automatically generated repair shapes



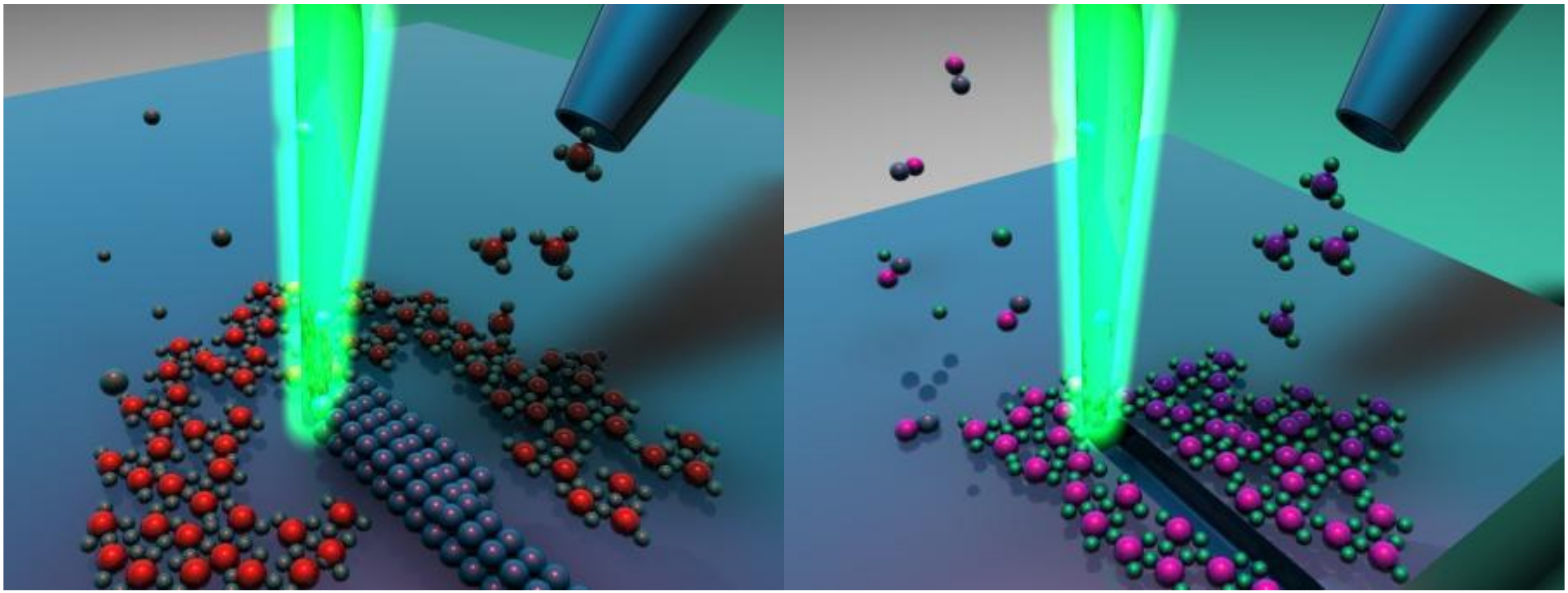
Defect-free reverence taken from same image in this example

Repair shape created and aligned by software

⇒Fully automated repair shape generation

⇒So generated repair shape can be tweaked to fit process (e.g.: biased)

Basic introduction



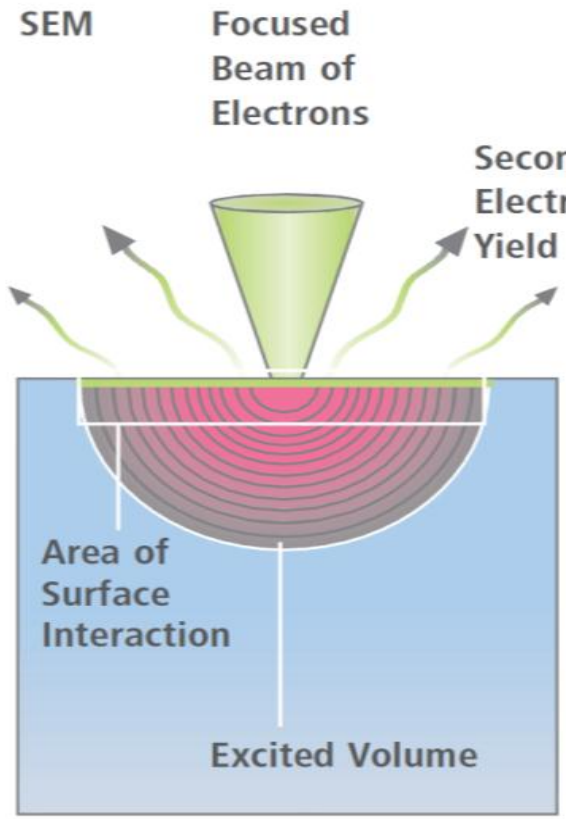
- Absorption of precursor molecules
- Exposure with focused electron beam. Two possible reactions:
  - **1: Reaction and immobilization of precursor → Deposition**
  - **2: Reaction with substrate and volatilization → Etching**

Photomask trends

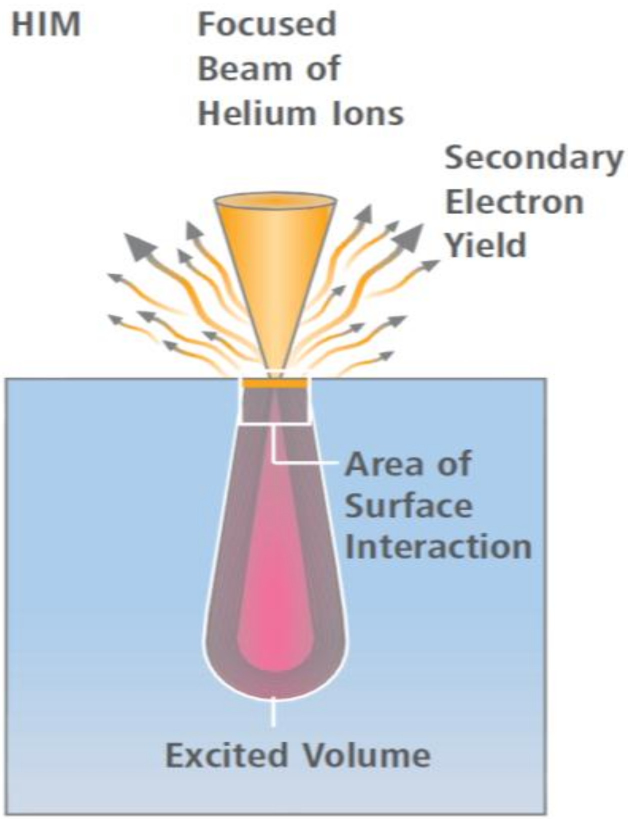
Trends in photomask repair:

- New mask materials especially **H**igh **D**urable (**HD**) and/or **H**igh **T**ransmission (**HT**)
- EUV and 193 coexist - success criterion is 3-5% delta CD in AIMS
- Minimum critical defect size is going down significantly

Energy transfer mechanism in beam induced chemistry

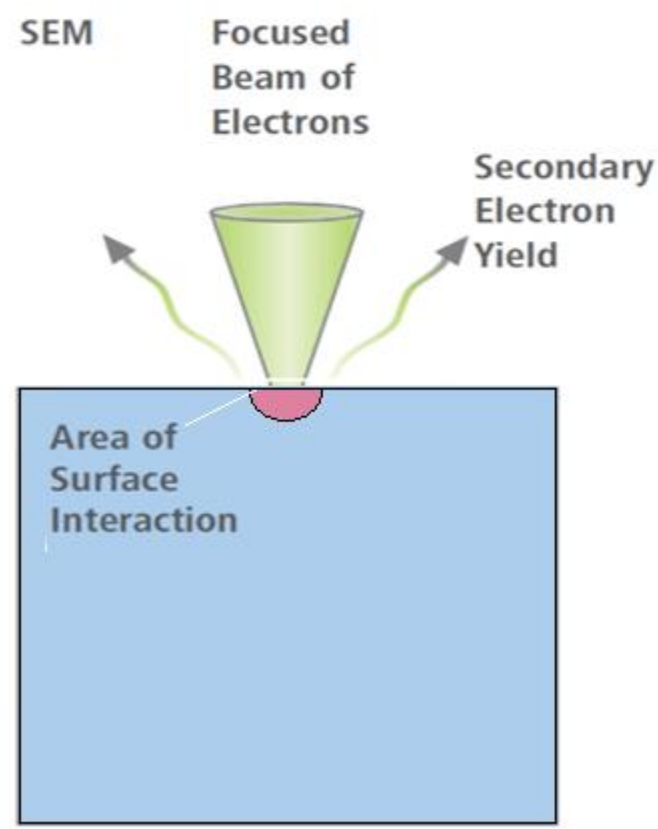


e-beam

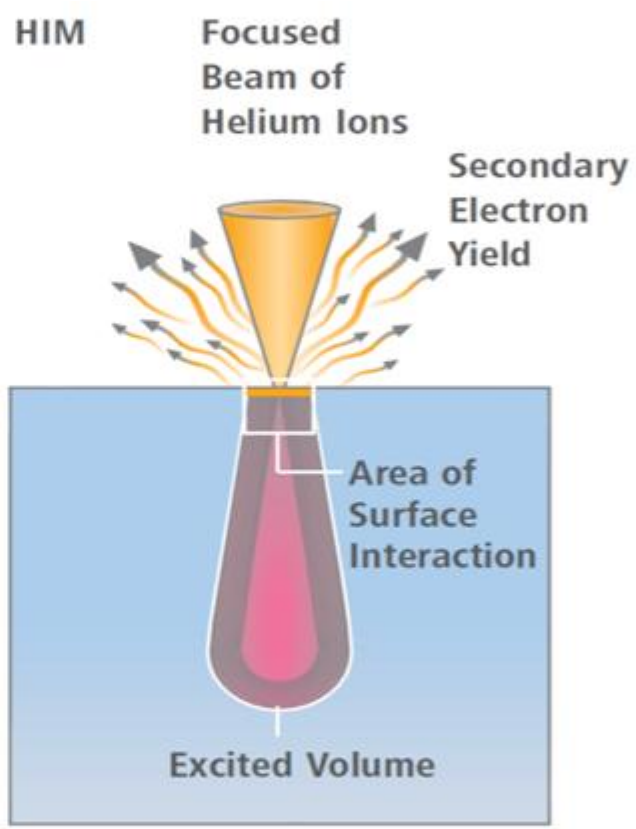


Light ion beam

Energy transfer mechanism in beam induced chemistry



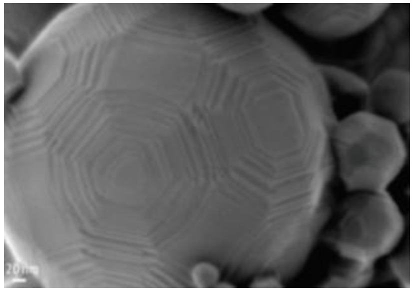
Low energy e-beam



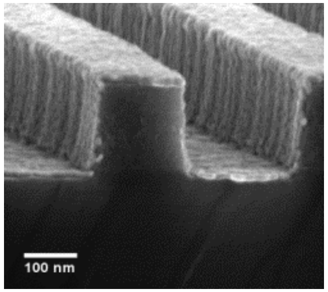
Light ion beam

In-house evaluation of two beam technologies

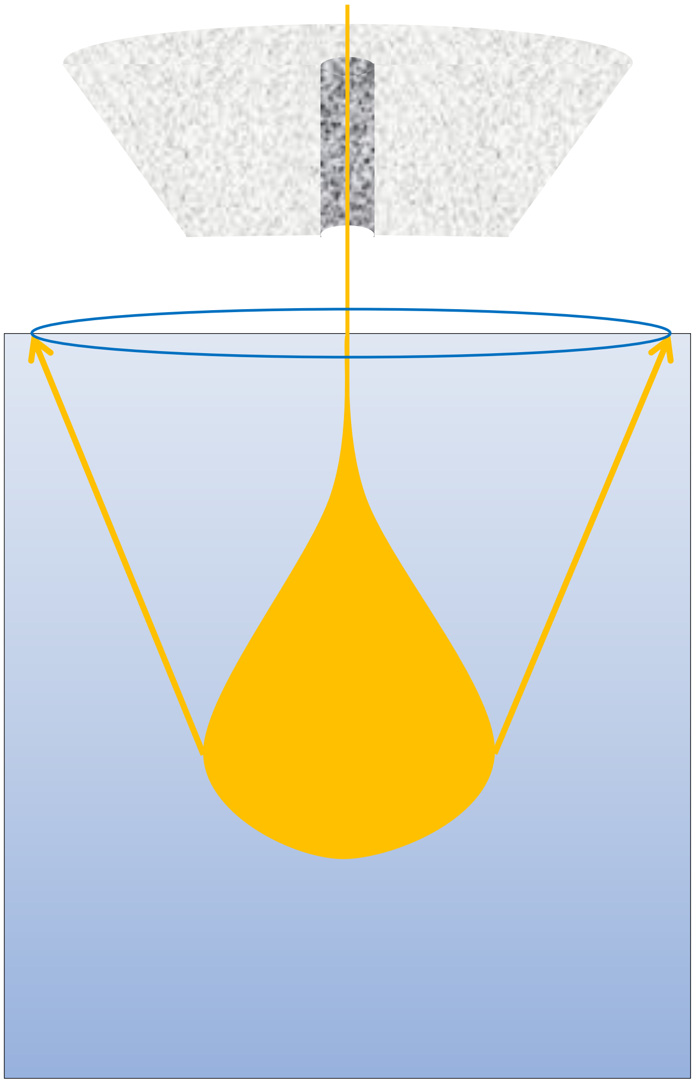
Low voltage e-beam system

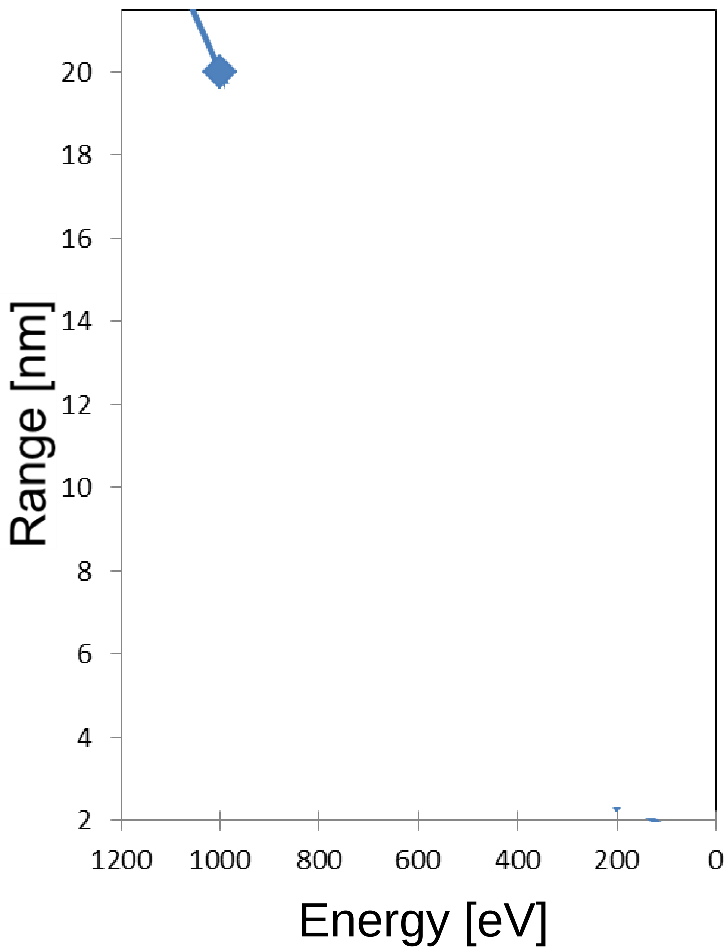


Gas field ion source (GFIS) system

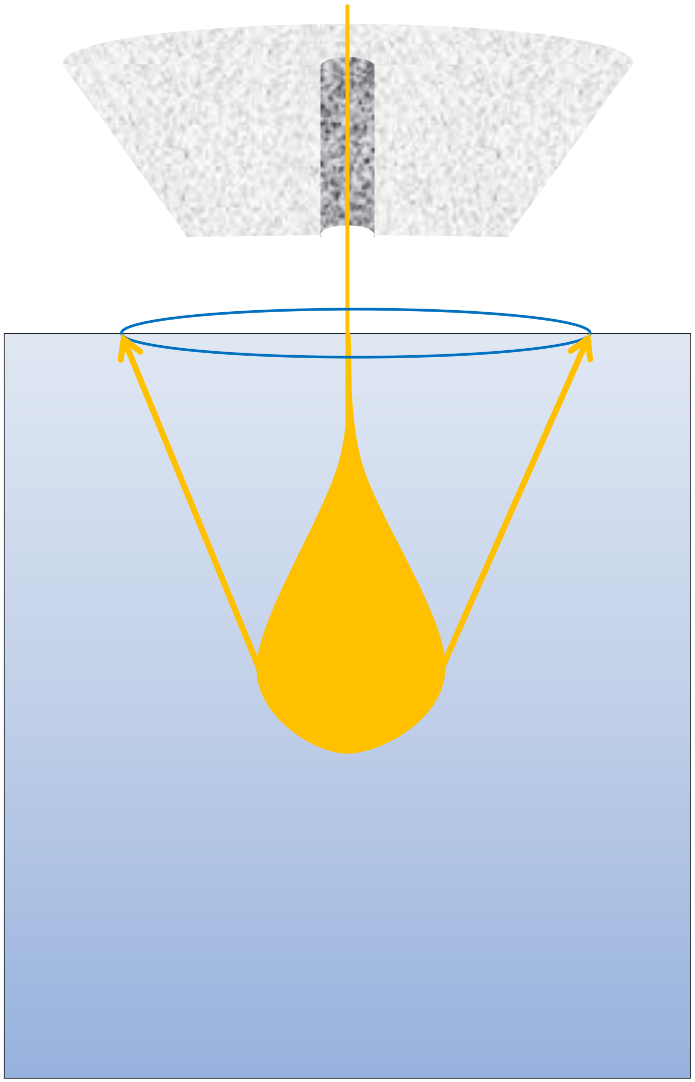


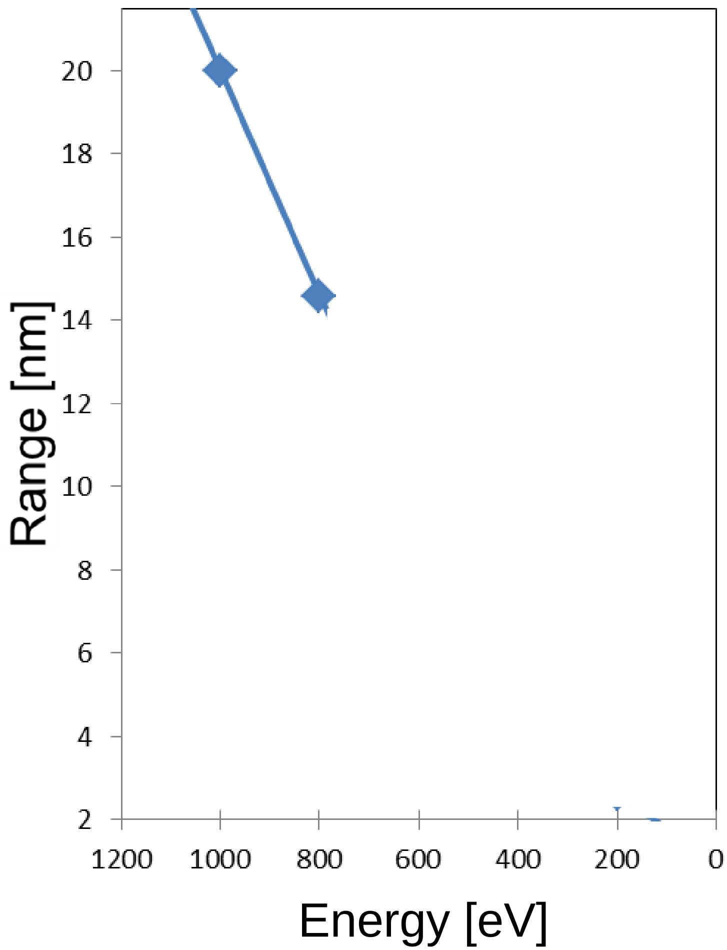
Energy transfer mechanism in beam induced chemistry



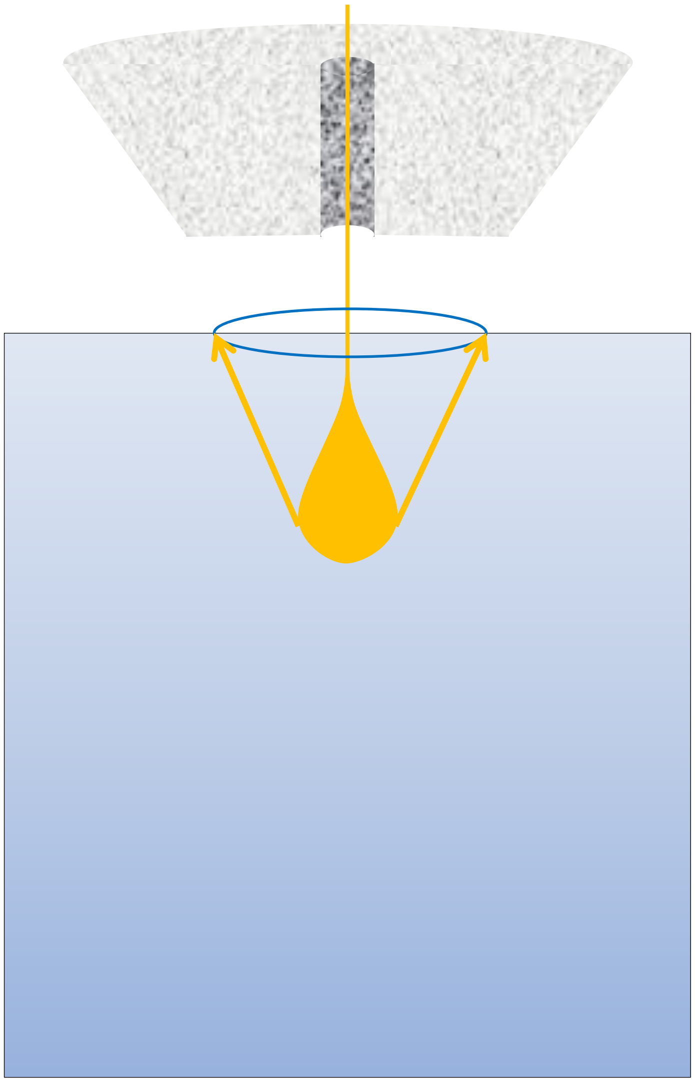


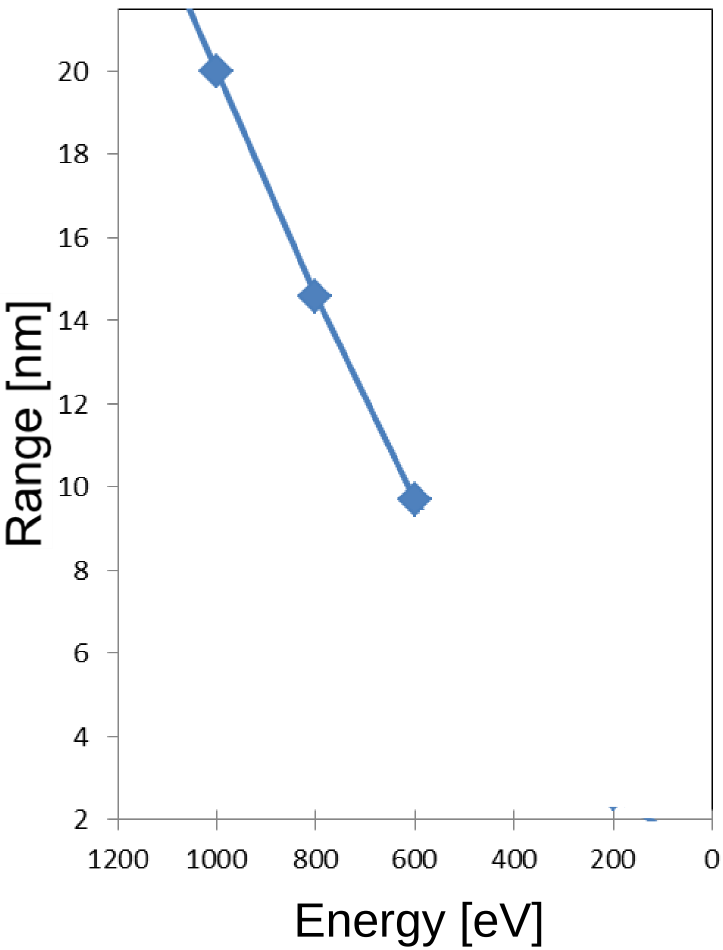
Energy transfer mechanism in beam induced chemistry



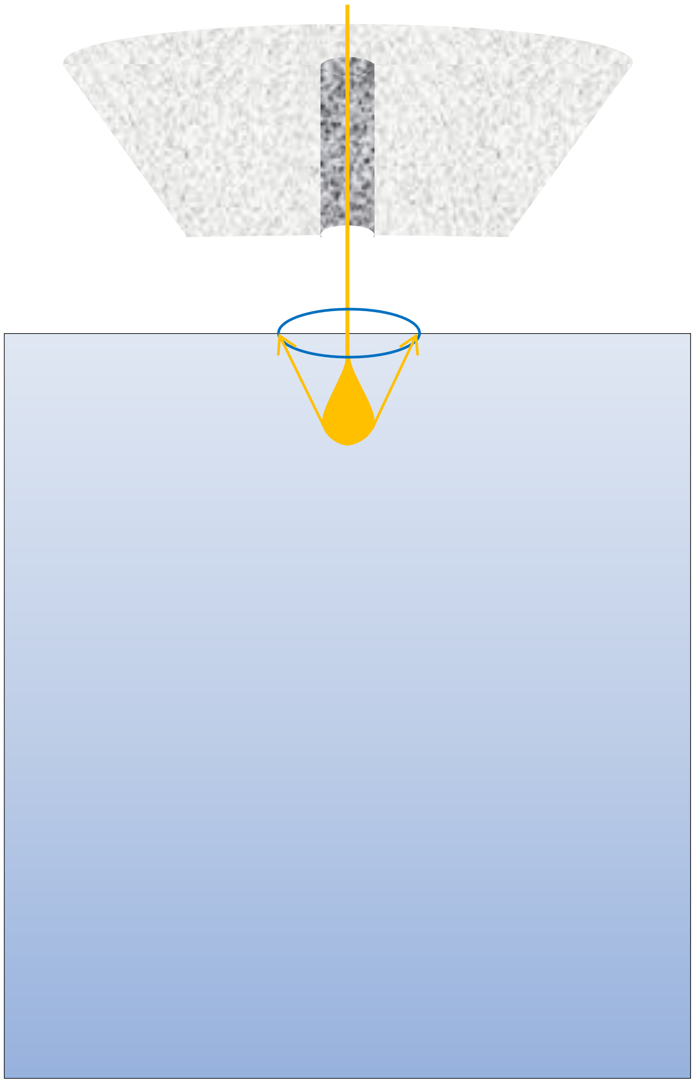


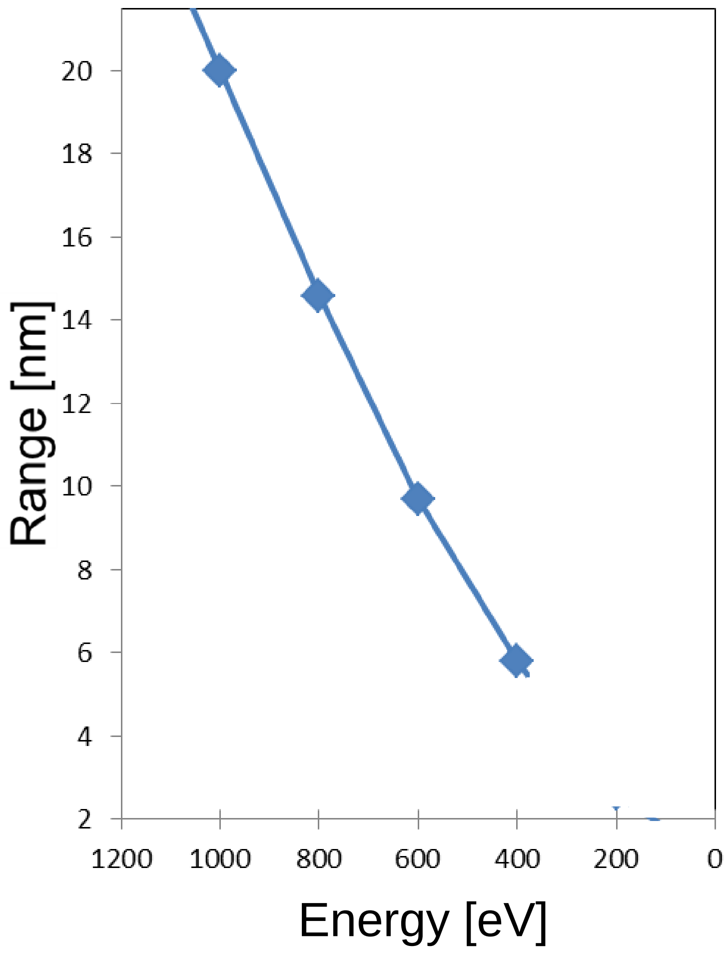
Energy transfer mechanism in beam induced chemistry



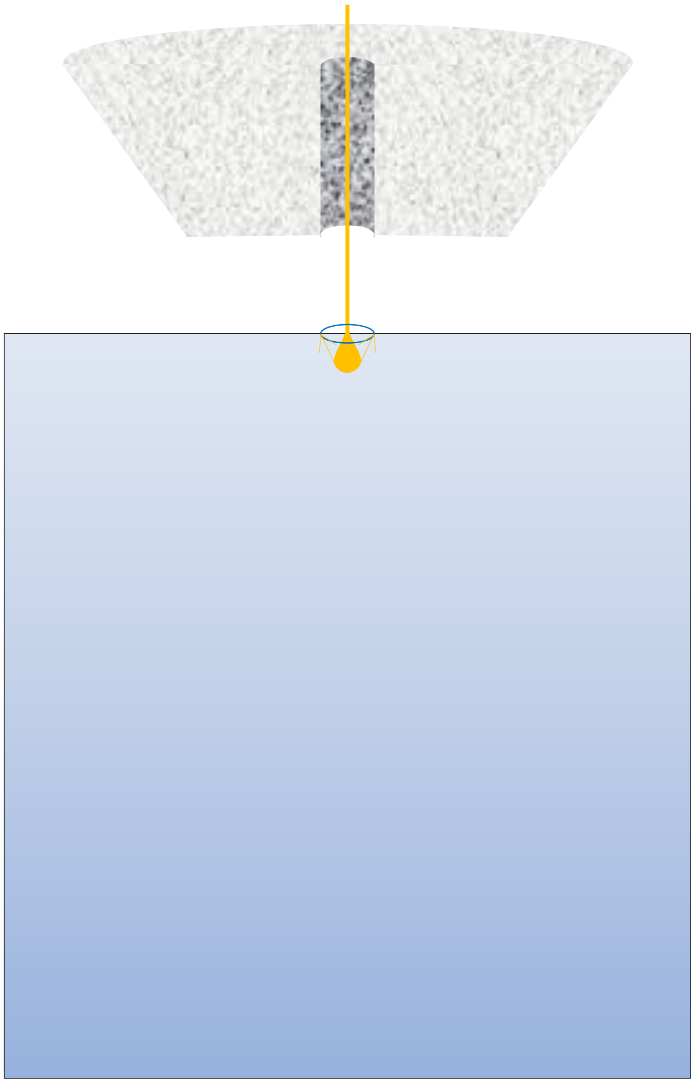


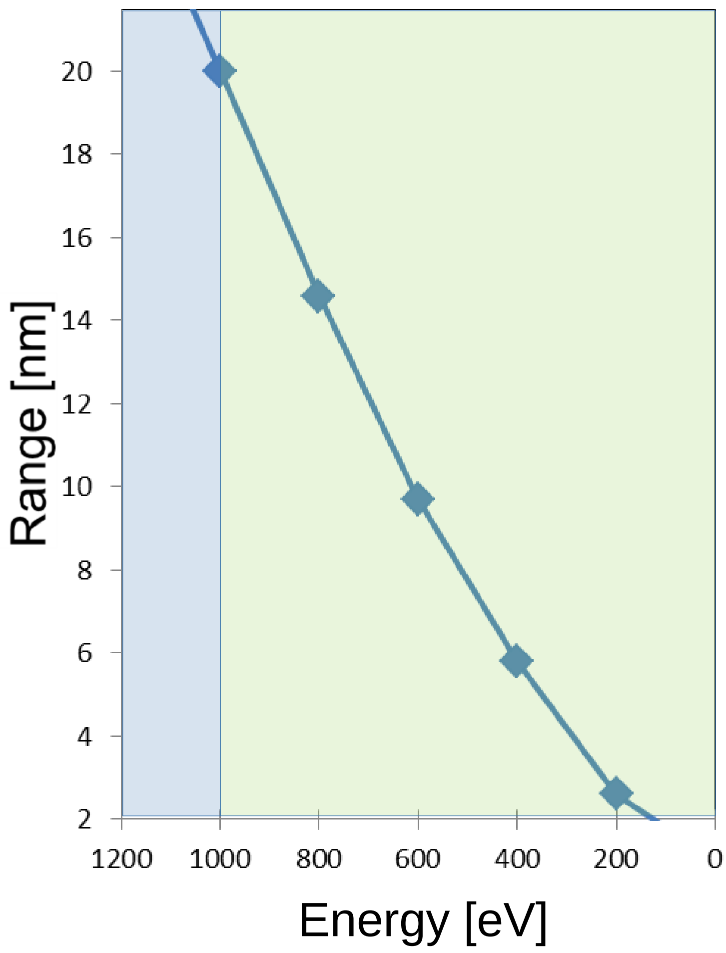
Energy transfer mechanism in beam induced chemistry





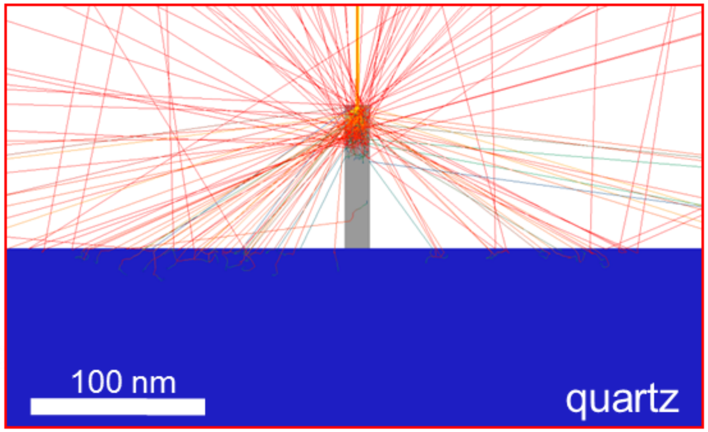
Energy transfer mechanism in beam induced chemistry



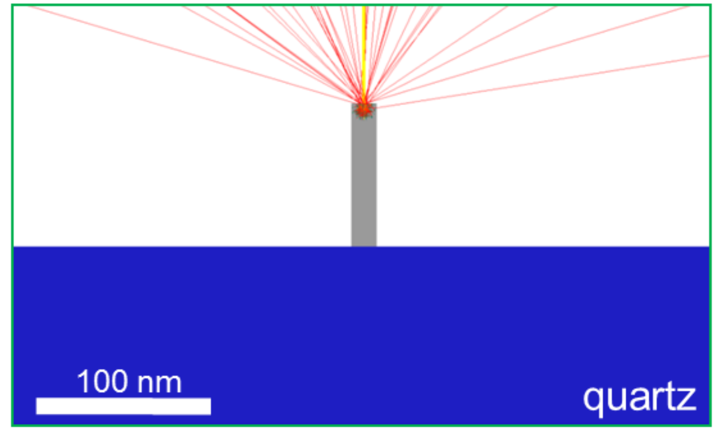


Low-energy electron beam - Minimum repairable feature size

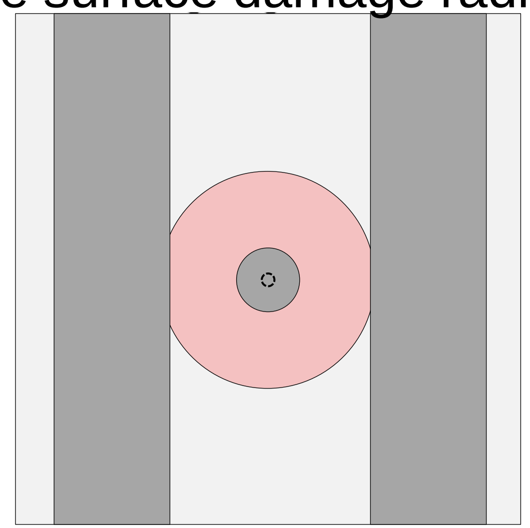
High beam energy



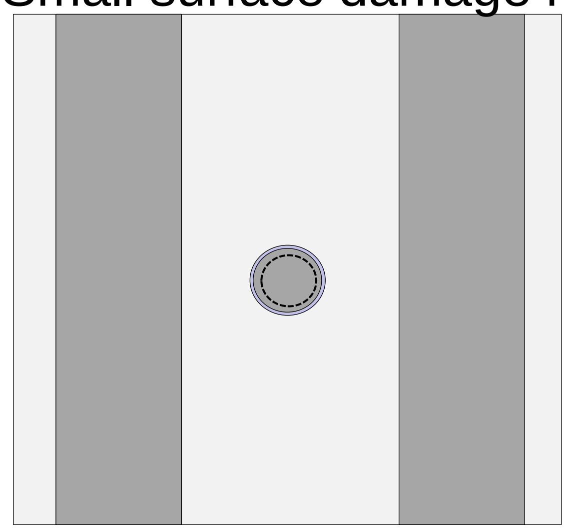
Low beam energy



Large surface damage radius

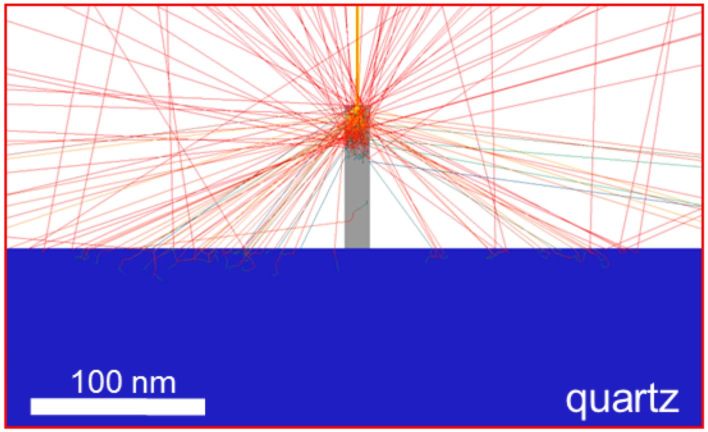


Small surface damage radius

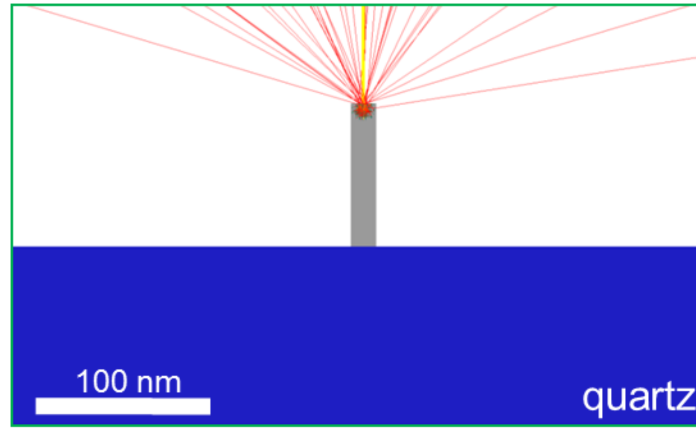


Low-energy electron beam - Minimum repairable feature size

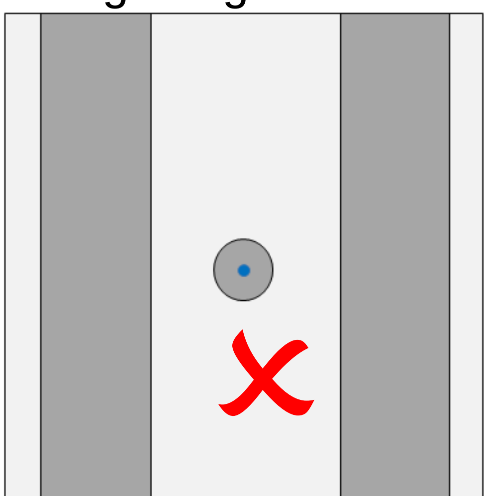
High beam energy



Low beam energy

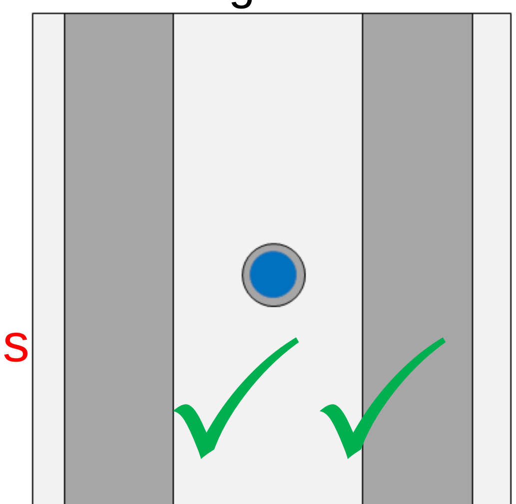


Large edge bias



Repair impossible:
required bias is larger than defect radius.

Small edge bias



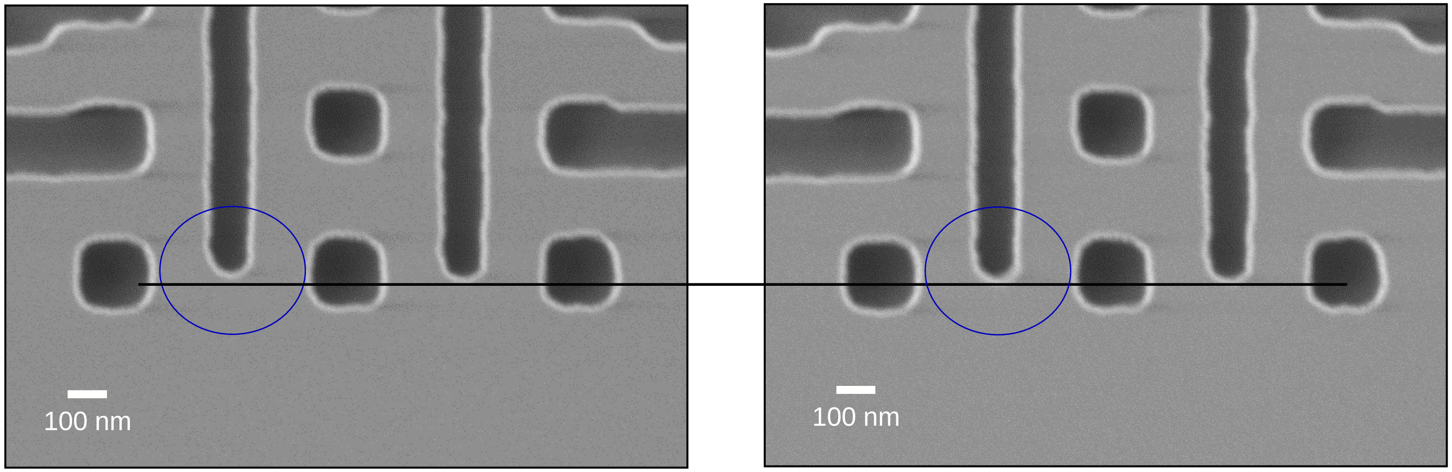
Repair enabled:
Bias well below defect size

MeRiT neXT technology:
Minimum repairable defect size

- Line-end shortening: 15 nm
- Mask: NIL, chrome-less

- Applied bias: 0 pixel

Pre-repair **Post-repair**

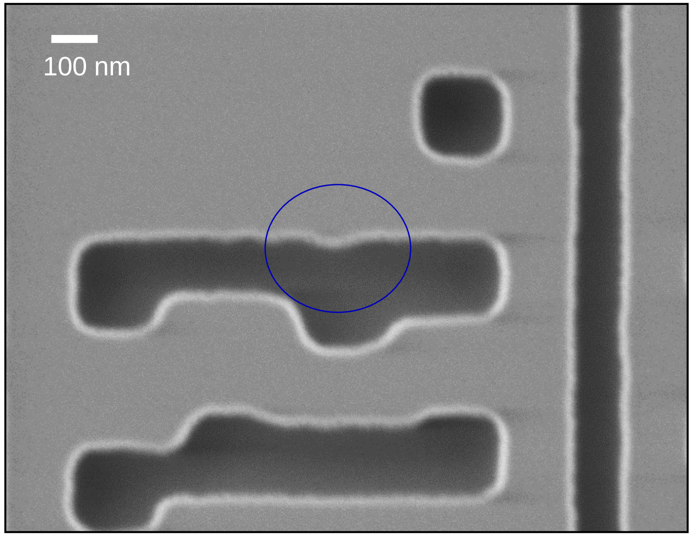


MeRiT neXT technology: Minimum repairable defect size

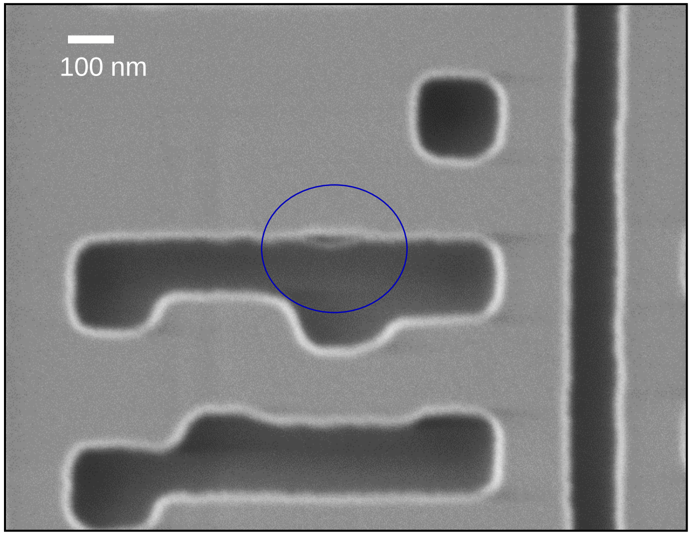
- Mouse bite: 16 nm x 100 nm
- Mask: NIL, chrome-less

- Applied bias: 0 pixel

Pre-repair

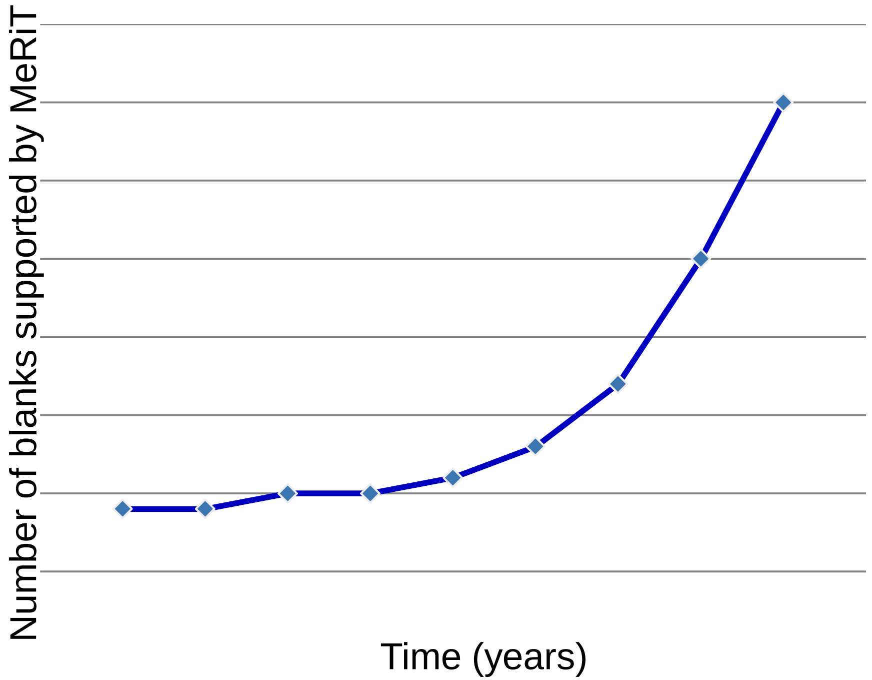


Post-repair



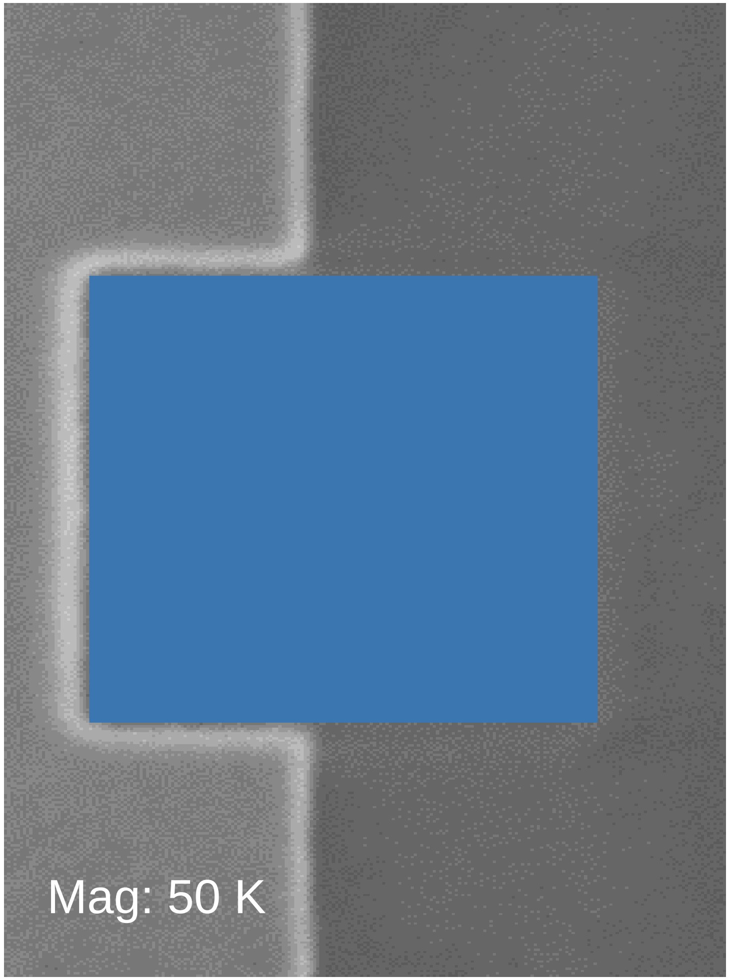
e-beam based repair roadmap - supported blank types

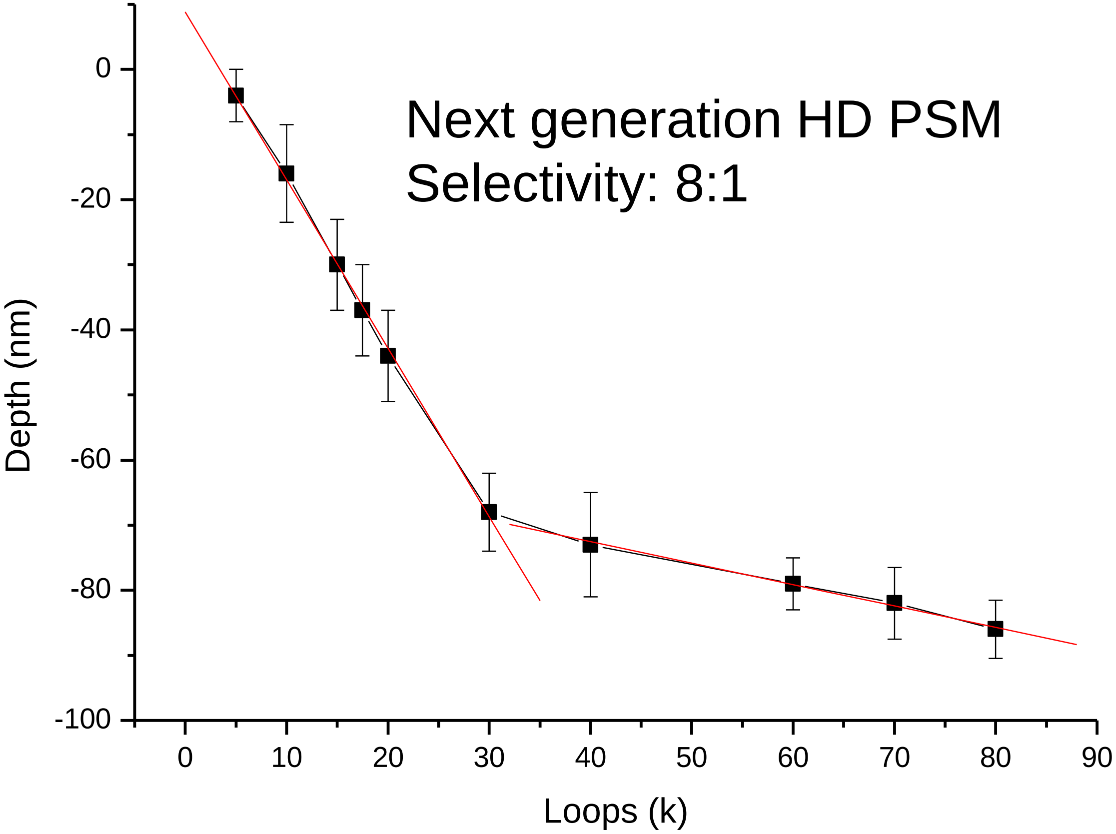
- Over a decade the number of blank types supported by MeRiT technology increased heavily
- Close collaboration with blank suppliers to align roadmaps
- Novel process possibilities with every MeRiT generation



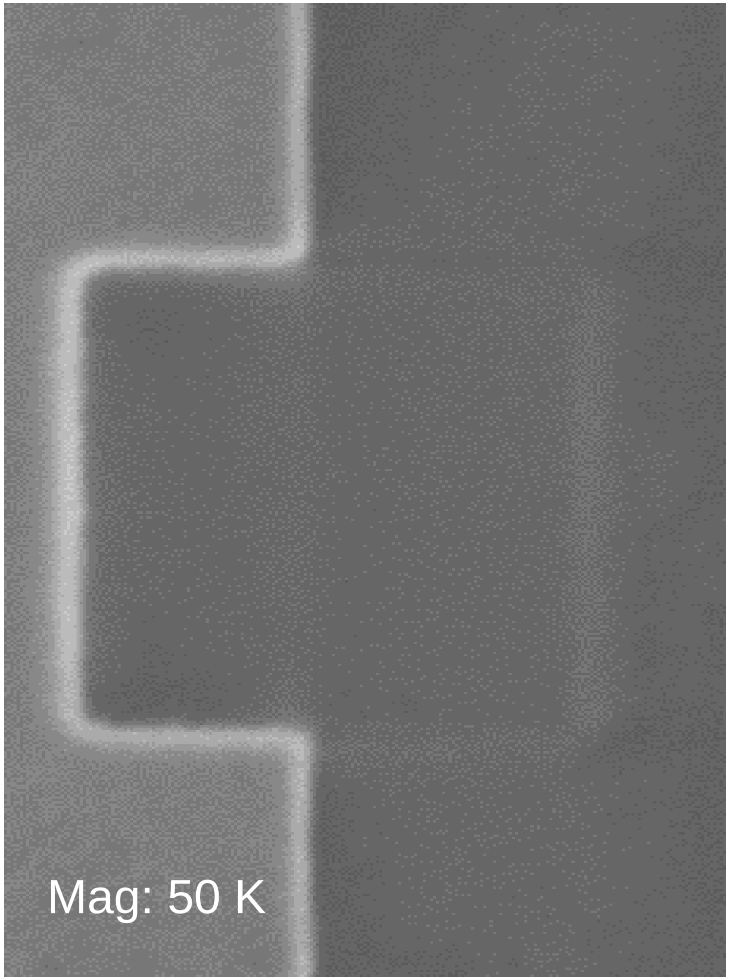
Material	Selectivity
EUV / Ru	75:1
Chromium / Qz	10:1
A61A / Qz	2:1

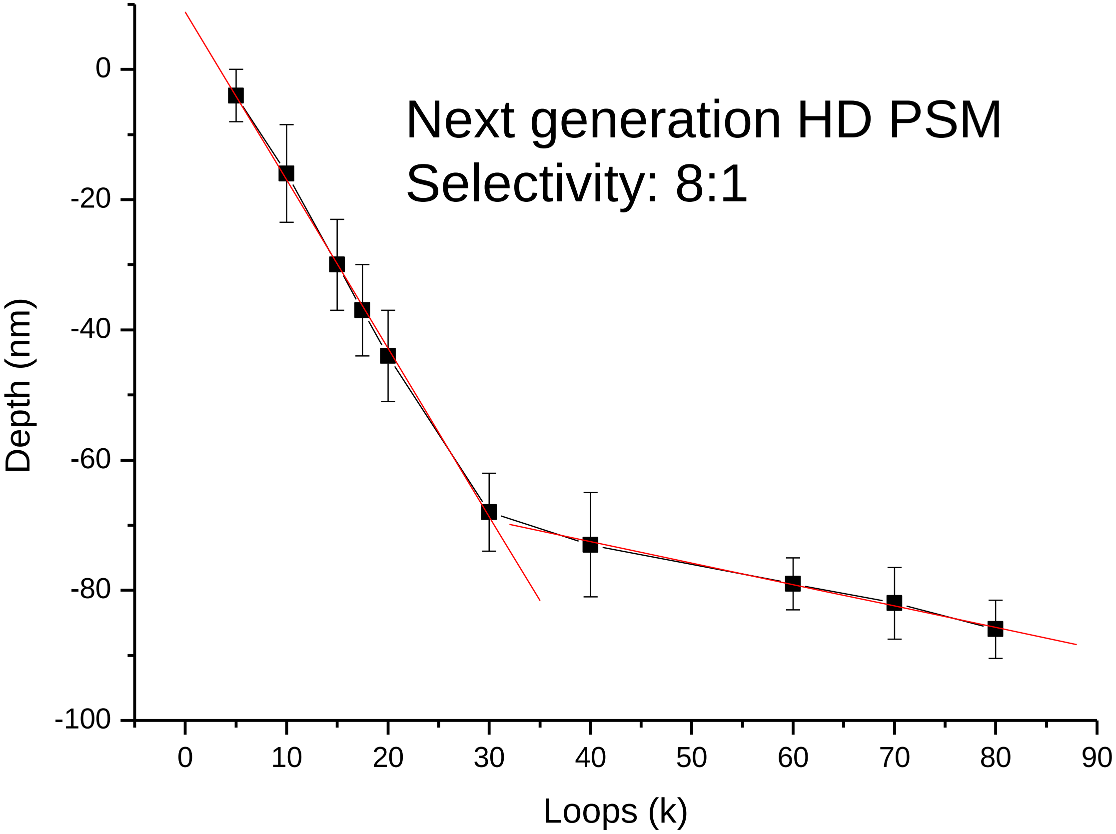
MeRiT neXT:
First results HD PSM



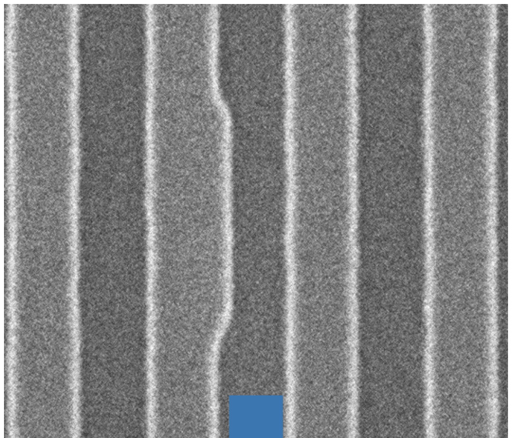


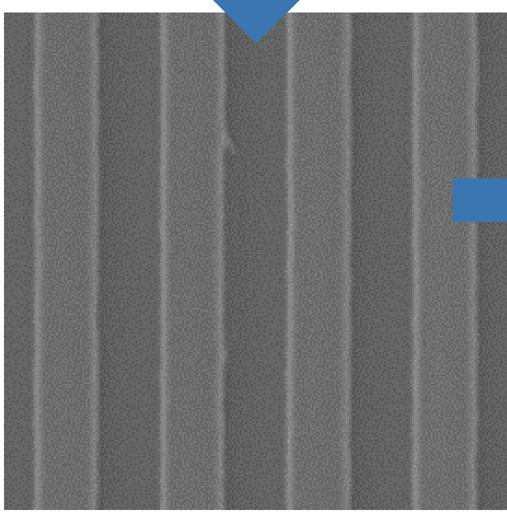
MeRiT neXT:
First results HD PSM



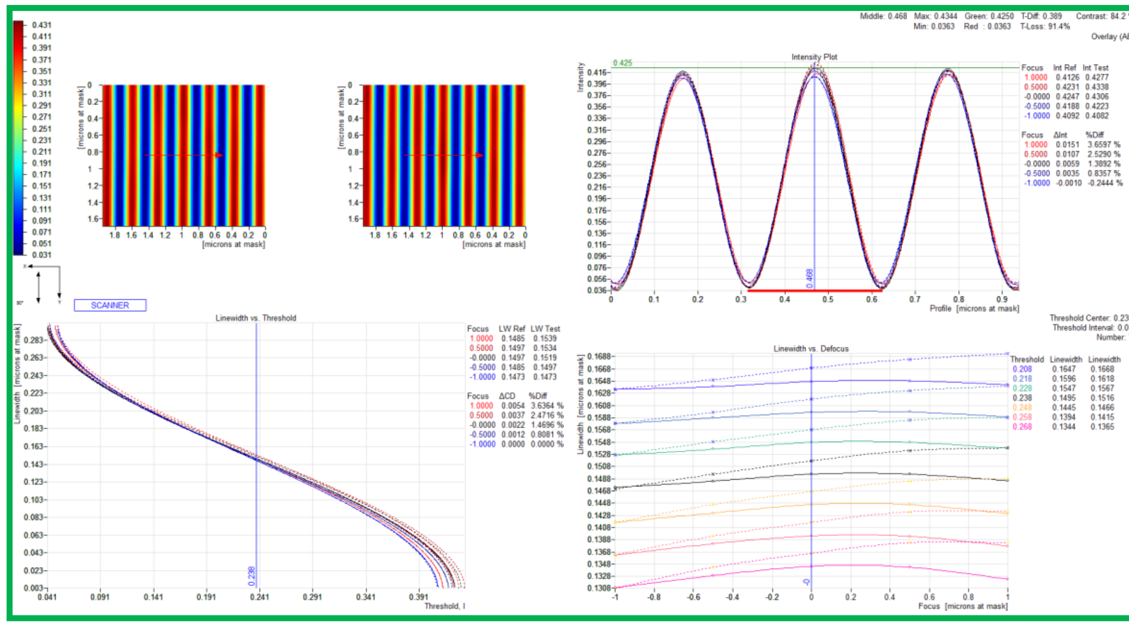


MeRiT repair performance on HD HT-PSM
- extension repair



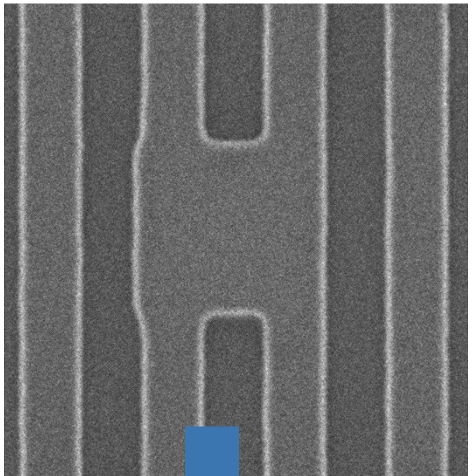


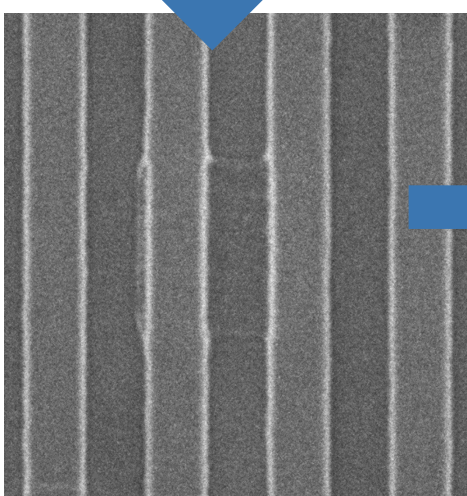
30-nm-extension repaired in-spec (380 nm full pitch)
By single step, fixed-loop process



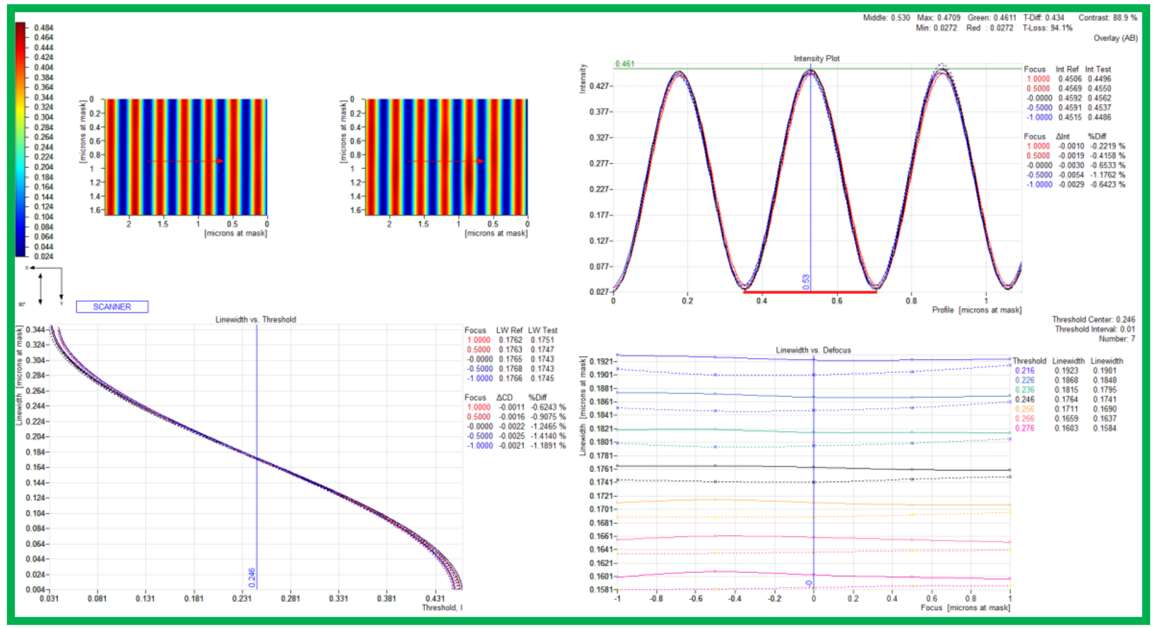
➔ AIMS through focus delta CD less than ±2%

MeRiT repair performance on HD HT-PSM - bridge defect with extension repair





Bridge defect with extension:



➔ AIMS through focus delta CD less than +2%

Summary

- Extension of mask repair for smaller nodes can be enabled using lower energy
- Industry trends like HD-PSM or HT-HD-PSM have been repaired successfully
- e-beam based repair supports both 193 nm and EUV technology (clear and dark defect repair)
- e-beam process resolution scales according to industry demands

We make it visible.