



Recent Progress of Electron Multi-Beam Mask Writer

Elmar Platzgummer

IMS Nanofabrication AG
Vienna and Brunn am Gebirge
Austria

Optical **P**roximity **C**orrection

Inverse **L**ithography **T**echnology

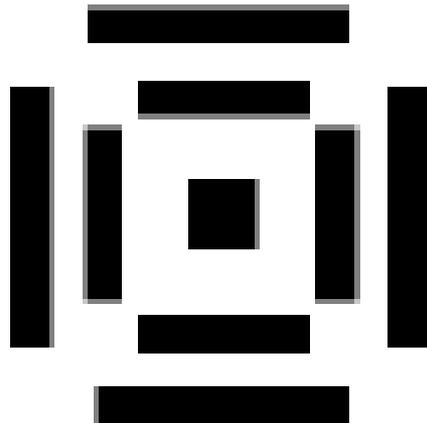
45 nm
node

without
OPC



28 nm
node

normal
OPC



14 nm
node

normal
ILT



7 nm
node

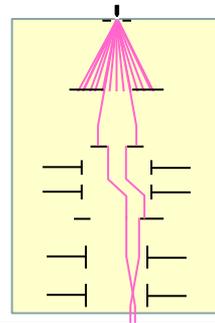
ideal
ILT



VSB

Variable Shaped Beam
mask writer

one beam
of variable shape



6" Mask Blank

- # shots ↑↑↑
- Average shot size ↓↓
- Exposure Dose ↑↑

⇒ Use of multi-beam solution is mandatory for future nodes!

MBMW

Multi-Beam
Mask Writer

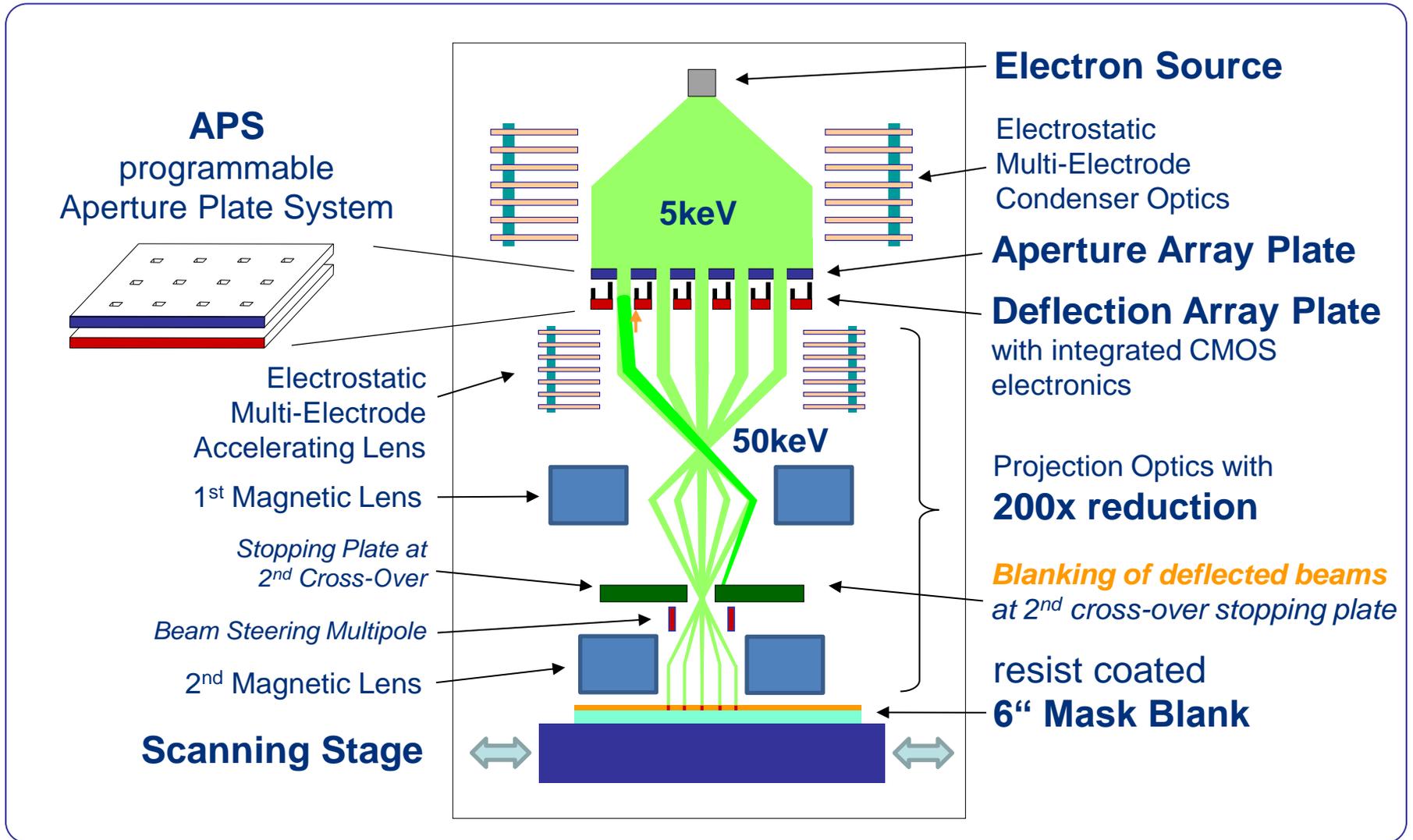
262-thousand
programmable beams
of equal small shape



6" Mask Blank

- Small Beam Shape: 20nm, 10nm
- Designed for high resist dose to ensure small line edge roughness
- Write time independent of pattern complexity, incl. Non-Manhattan curvilinear patterns

Multi-Beam Mask Writer Tool Principles



IMS production facility at Brunn am Gebirge (near border of Vienna) 5



- ❑ 450 m² clean room area, 550 m² presently being added



Multi-Beam Column on air-bearing Stage Platform

- **Exposure of 128mm x 104mm field on 6" mask blank**
(scanning stage)

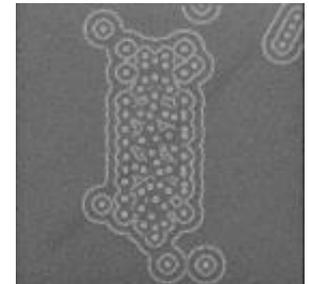
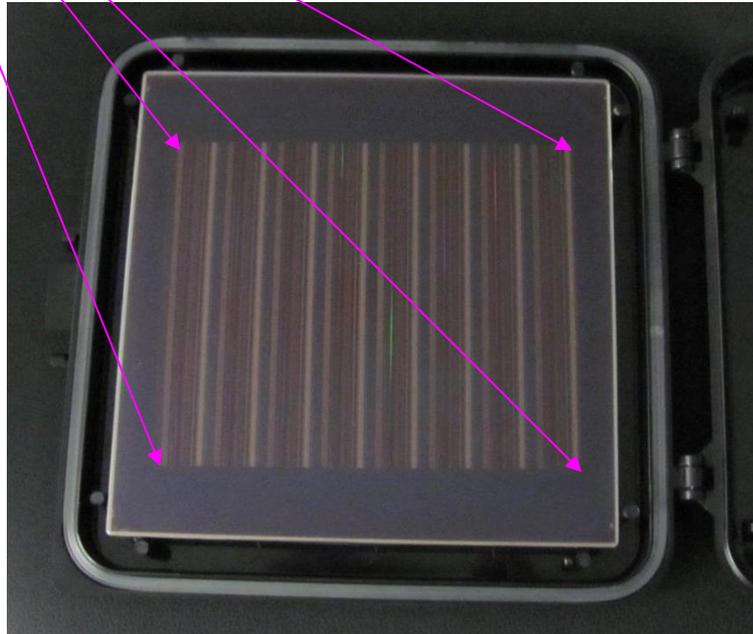
- Stripe length: 128 mm

- Stripe width: 80 μm

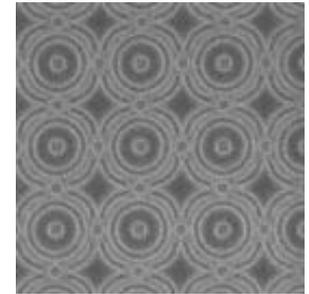
- # of stripes: 1300

- **Stage velocity: 3.5 mm/s**

- ⇒ **Write time: 13.2 h**

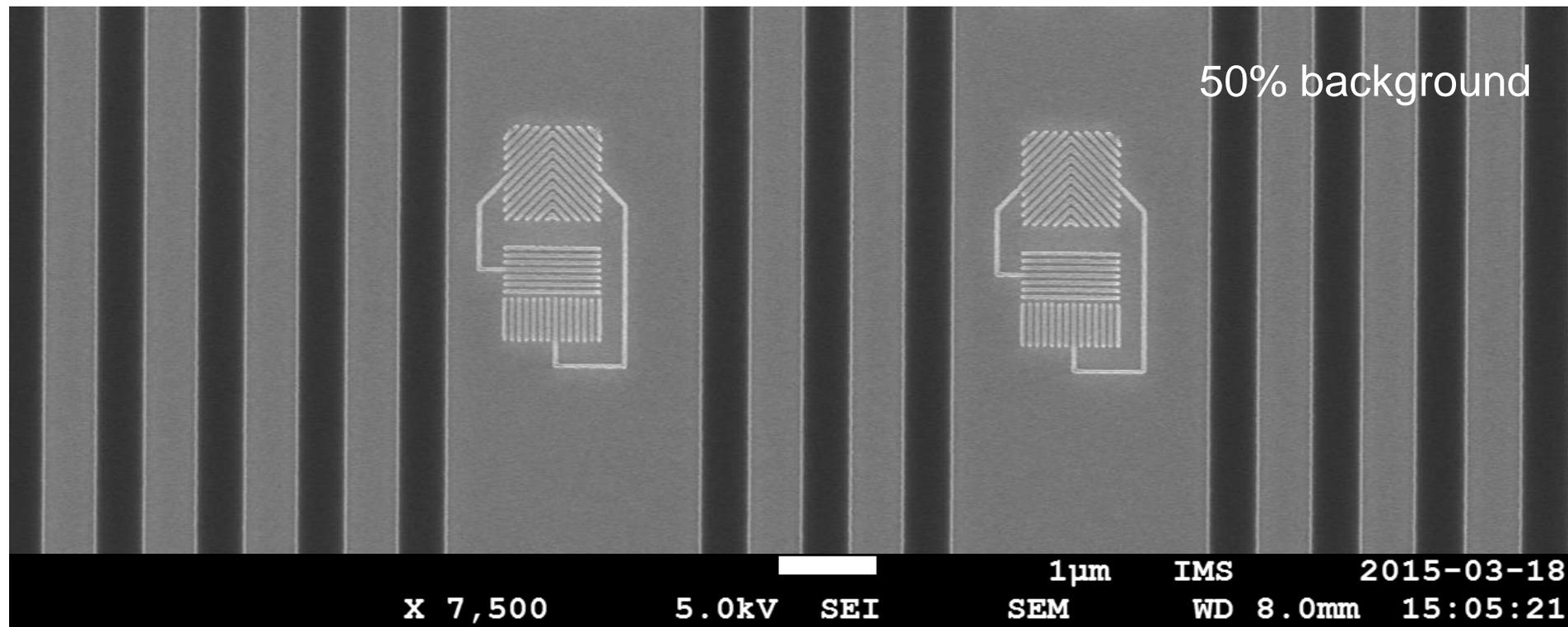


30nm ILT



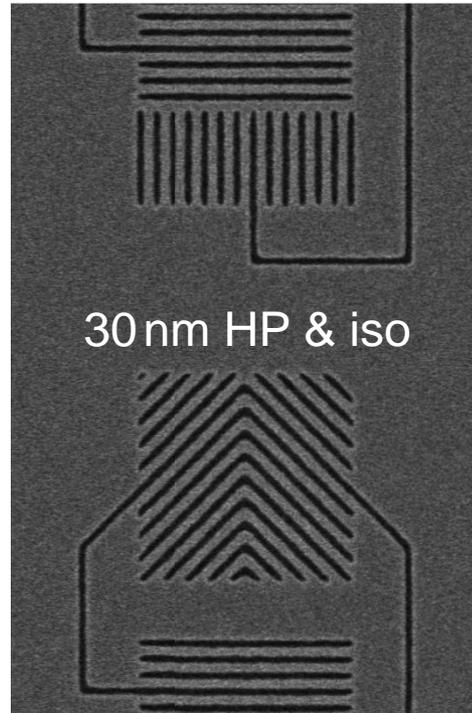
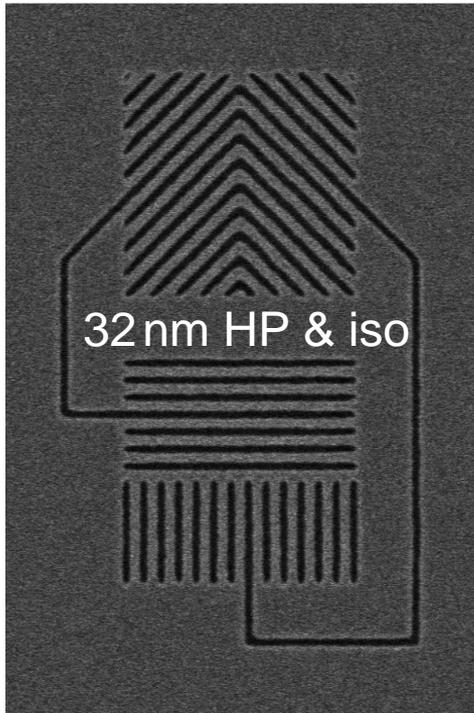
Standard e-beam Corr.	PEC Proximity Effect Corrections	fully implemented
	FEC Fogging Effect Corrections	fully implemented
	LEC Loading Effect Corrections	fully implemented
	GMC Grid Matching Corrections	fully implemented
	GCD Global CD Corrections	fully implemented
	CEC Charging Effect Corrections	available, tests ongoing
Special Corr.	Defective Beam Corrections	fully implemented
	Stripe Butting Corrections	fully implemented
	Drift Corrections (auto calibration)	fully implemented
	More...	

32nm half-pitch & iso line
nCAR (negative chemically amplified resist)
exposure dose: $80 \mu\text{C}/\text{cm}^2$



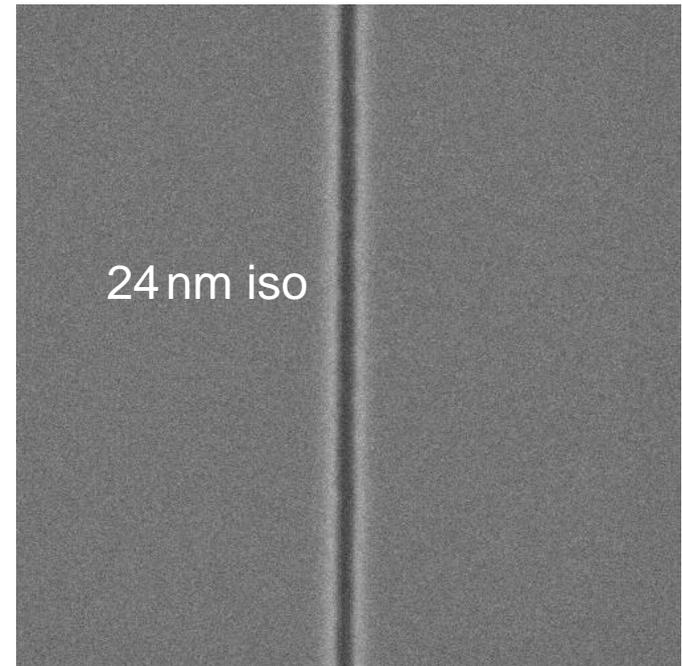
with multi-beam proximity effect and fogging effect corrections

32nm and 30nm half-pitch & iso lines
pCAR (positive chemically amplified resist)
exposure dose: $100 \mu\text{C}/\text{cm}^2$



24nm iso line
in Non-CAR (ZEP520A)
exposure dose: $170 \mu\text{C}/\text{cm}^2$

etched into MoSi



	Status: September 2015
Mask minimum Primary Feature Size	30 nm hp
LCDU – Local CD Uniformity 3sigma	0.6 nm
Stripe Boundary CD Uniformity 3sigma	1.0 nm
GCDU – Global CD Uniformity 3sigma	1.1 nm
Local Registration 3sigma	0.9 nm
Global Registration 3sigma	1.7 nm

- ❑ The overall writing architecture works well – **multi-beam is real !**
- ❑ The multi-beam mask writer lithography results obtained so far look promising, further improvements are in progress.
- ❑ Beam and platform stability are generally good, more automation will help user friendliness and fab integration.
- ❑ The main advantages of the multi-beam mask writer come from (i) complex patterns, (ii) small feature sizes, and (iii) high dose.
- ❑ **2015: Multi-Beam Mask Writer Beta Tools**
2016: Multi-Beam Mask Writer HVM Tools

The world's 1st Electron Multi-Beam Mask Writer

30 nm
HP & iso



pCAR
100 $\mu\text{C}/\text{cm}^2$

Thank You for Your Attention !