E-beam Strategies

- Motivation
- Stage movement strategies
- EBL writing strategies

Motivation

Applications of EBL

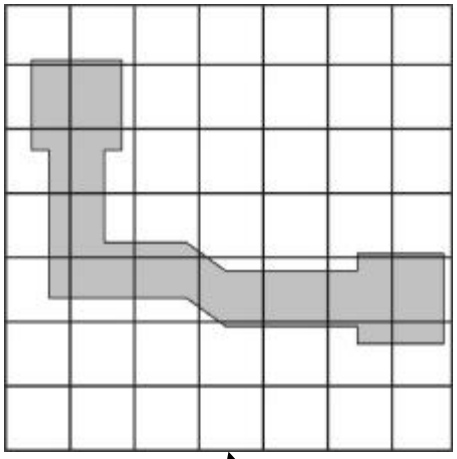
- **mask fabrication (e.g. chromium on glass)**
- **direct write (rapid prototyping)**
- **nano devices in R&D**
- **….**

⟶ **different writing strategies required**

Recommended Literature:
SPIE HANDBOOK OF MICROLITHOGRAPHY, MICROMACHINING AND MICROFABRICATION Volume 1: Microlithography, Chapter 2.1

Stage Movement Strategies

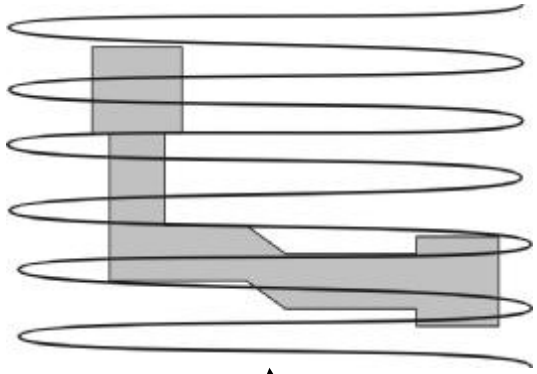
stationary stage



fields

versus

moving stage

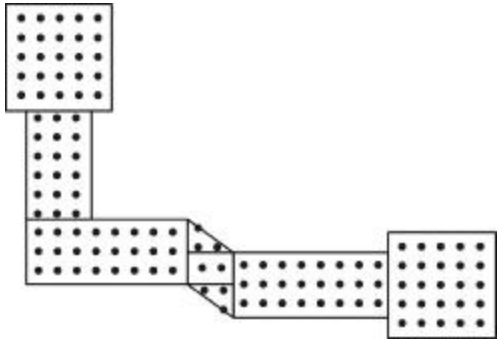


stripes

"write-on-the-fly“

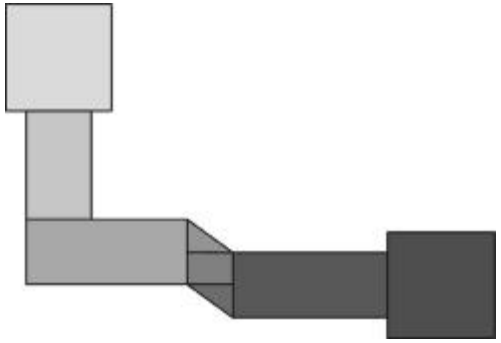
EBL Writing Strategies

round (gaussian) beam

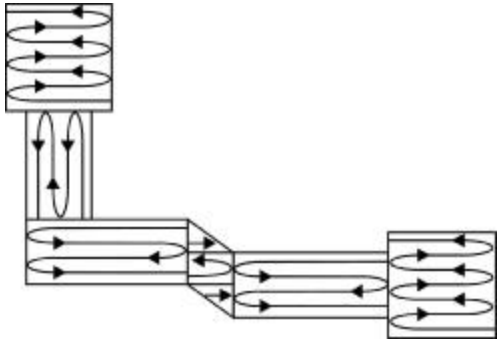


versus

shaped beam



vector scan



versus

raster scan

Raith

EBL Writing Strategies

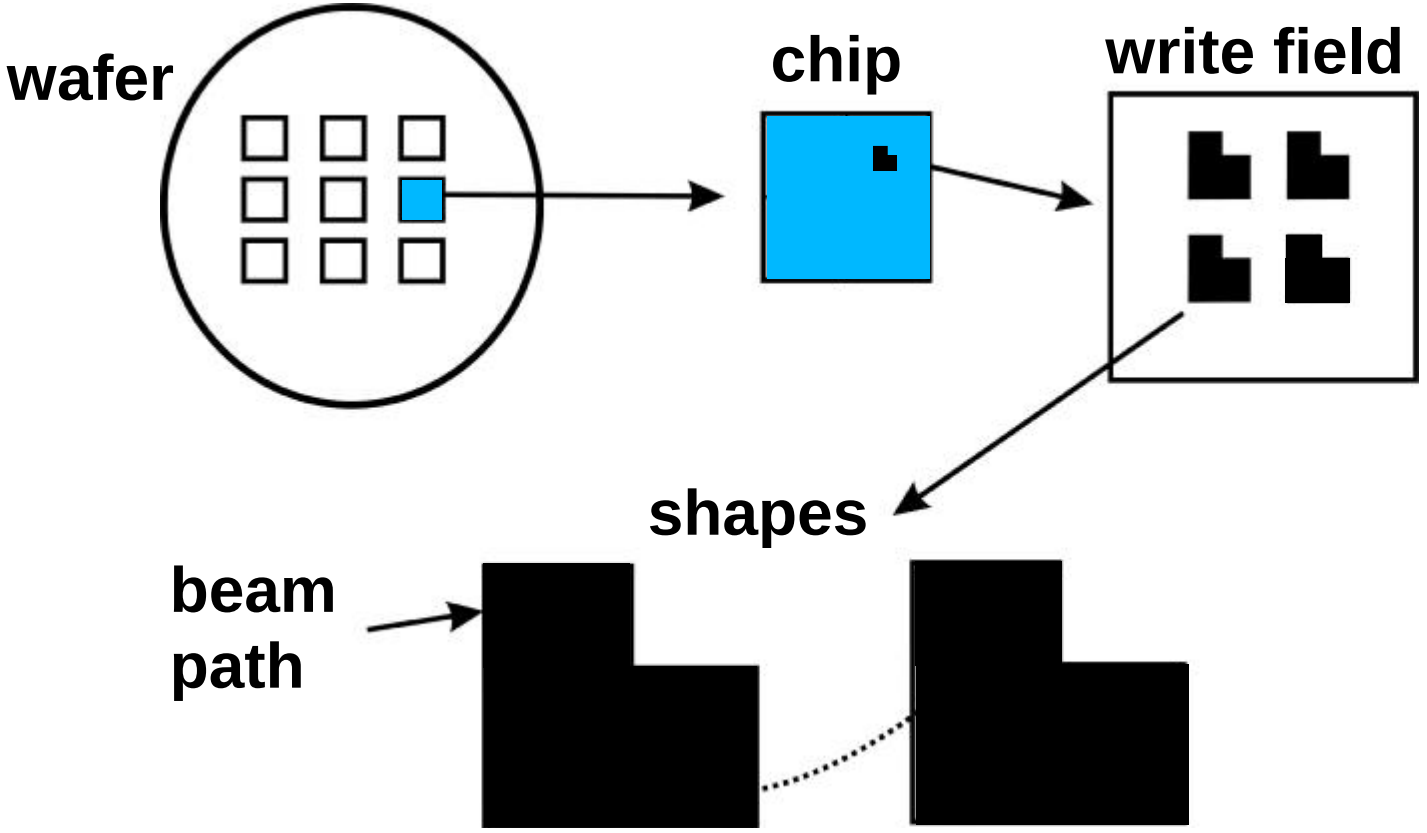
EBL Methods

strategy	beam	scan mode	stage
1 (Raith)	gaussian	vector	fixed
2 (Etec)	gaussian	raster	moving
3 (Leica)	shaped		fixed

1st Strategy (Raith)

EBL Methods

gaussian beam, vector scan, fixed stage

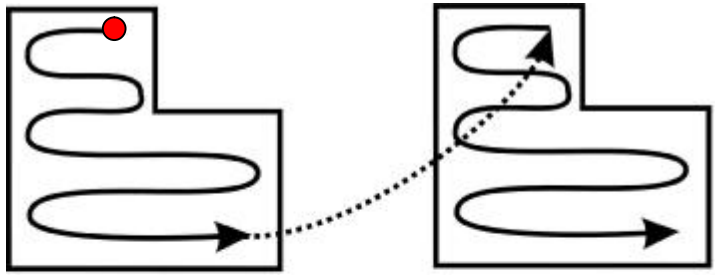


1st Strategy (Raith)

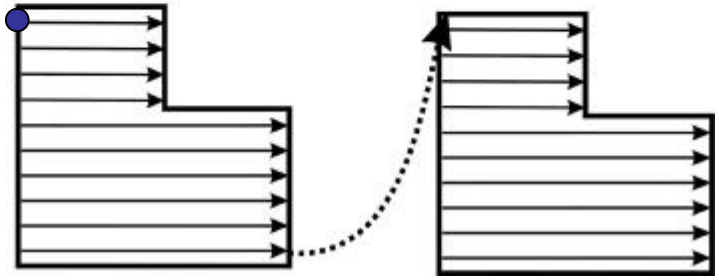
EBL Methods

gaussian beam, vector scan, fixed stage

meander mode



line mode



1st Strategy (Raith)

EBL Methods

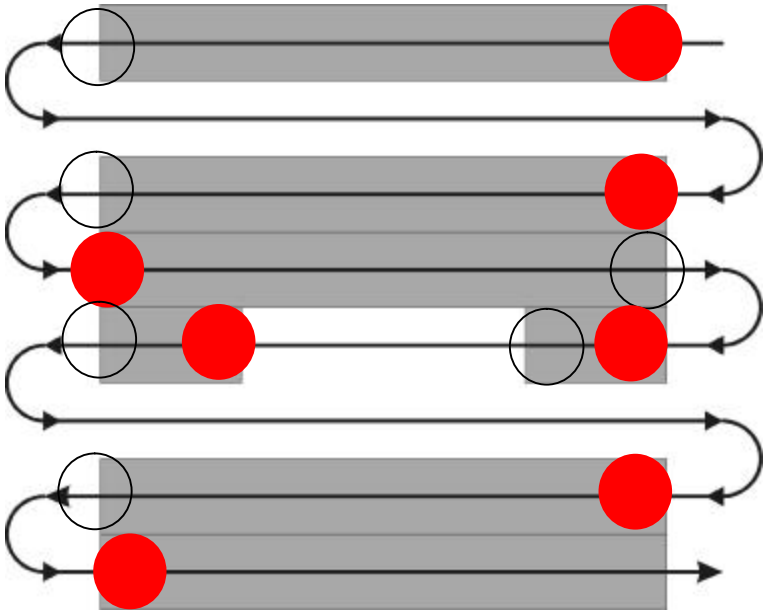
gaussian beam, vector scan, fixed stage

+ fast writing of sparse patterns
(unwritten areas are skipped)
+ easy dose variation from shape to shape
– settling time and hysteresis
have to be calibrated
– overhead time caused by
increased stage settling time

→ Applications: nano lithography, R&D, …

2nd Strategy (Etec)

gaussian beam, raster scan, moving stage



stage motion

beam motion

(e.g. used by MEBES (Etec Systems Inc.))

2nd Strategy (Etec)

gaussian beam, raster scan, moving stage

+ very simple

+ very repeatable ⟶ calibration possible

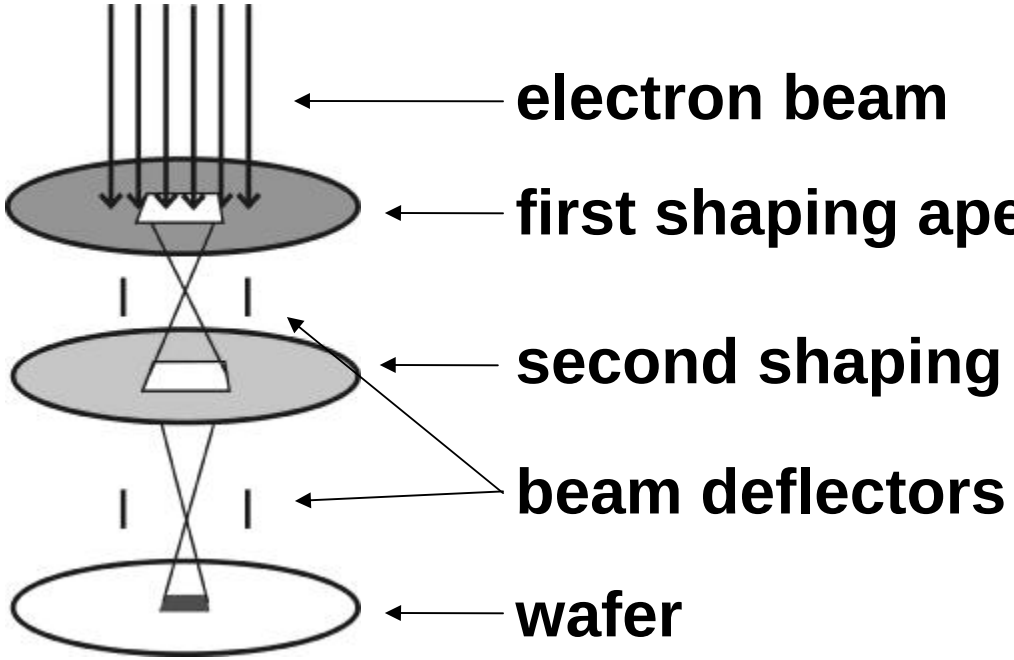
– sparse patterns take as long as dense patterns

– difficult to adjust dose during writing

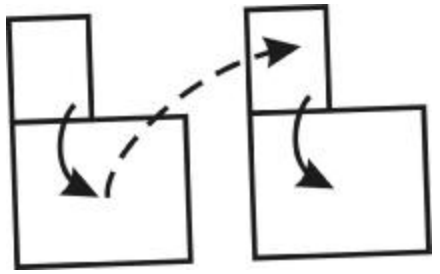
Applications: mask making, R&D, …

3rd Strategy (Leica)

shaped beam, moving stage



two fields



3rd Strategy (Leica)

shaped beam, moving stage

+ » 10 x faster than equivalent gaussian beam machines

– extremely complex electron optical column

– complicated calibration routines

– resolution and focus varies with shape size

Applications: mask making,
advanced chip development

Extension: Cell projection
(one of the square apertures is replaced by a more complex shape such as a DRAM cell.

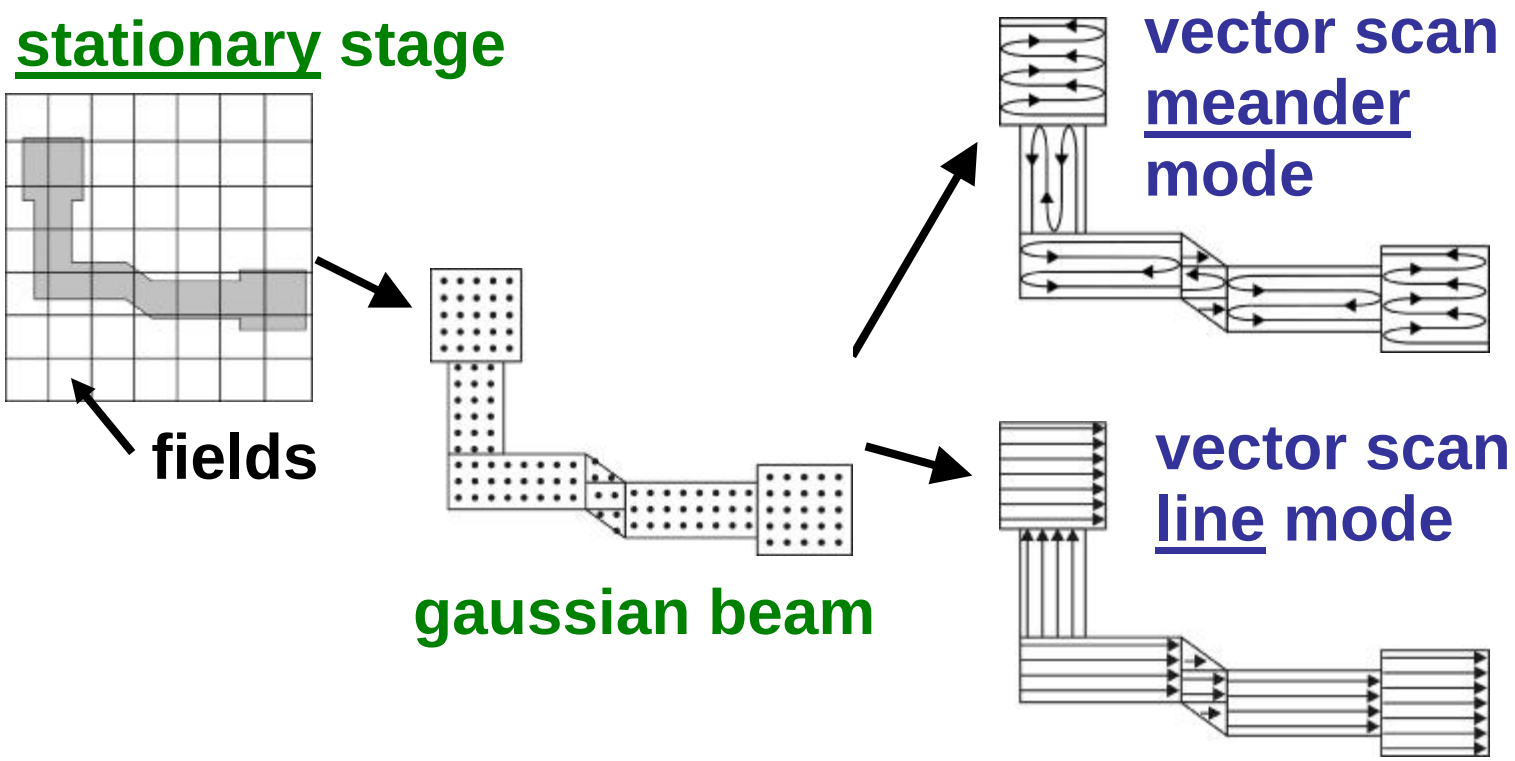
Summary: 3 Strategies

EBL Methods

strategy	beam	scan mode	stage
1 (Raith)	gaussian	vector	fixed
2 (Etec)	gaussian	raster	moving
3 (Leica)	shaped		fixed

Summary: Strategy used by Raith

EBL Methods



Applications:

Nano device fabrication, R&D