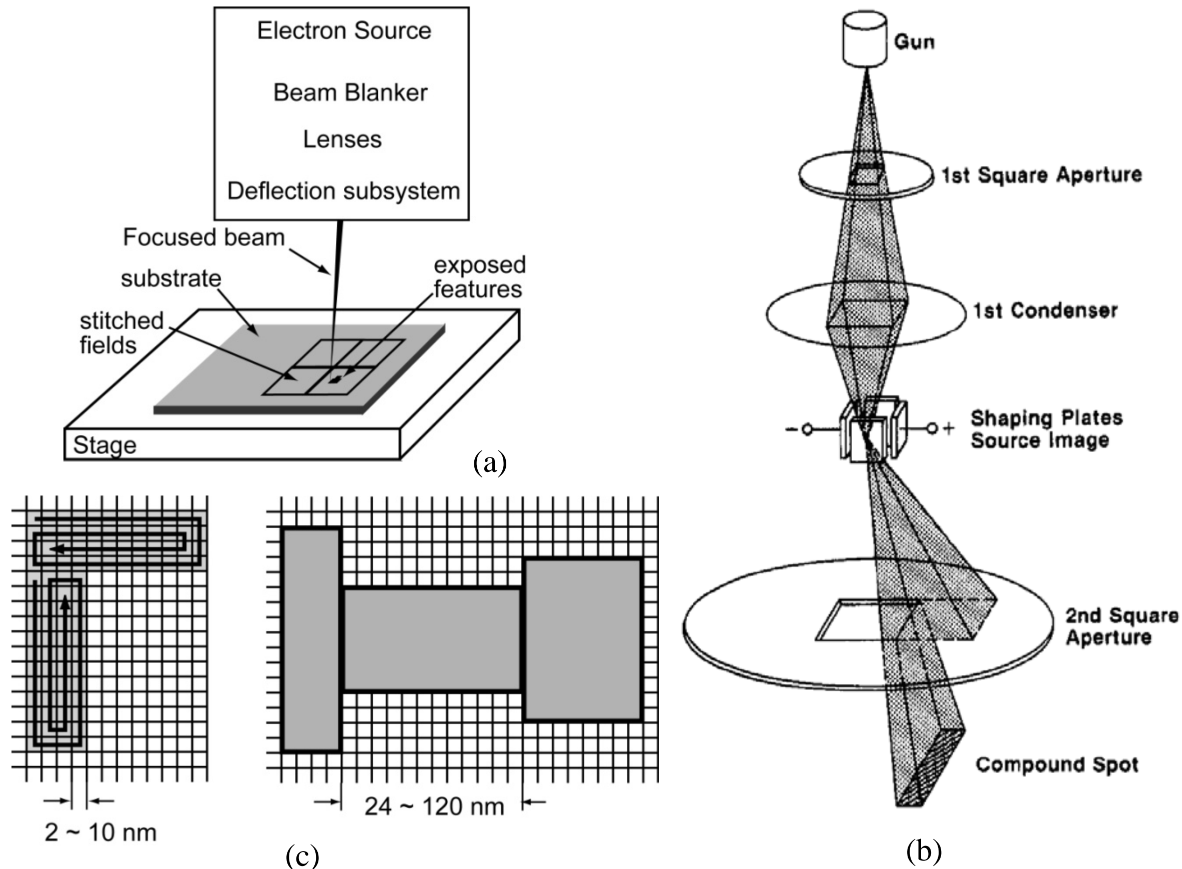
Nanometer Scale Patterning and Processing

Spring 2016

Lecture 22

Shaped-Electron-Beam Lithography

The Need for Shaped-Beam: Throughput



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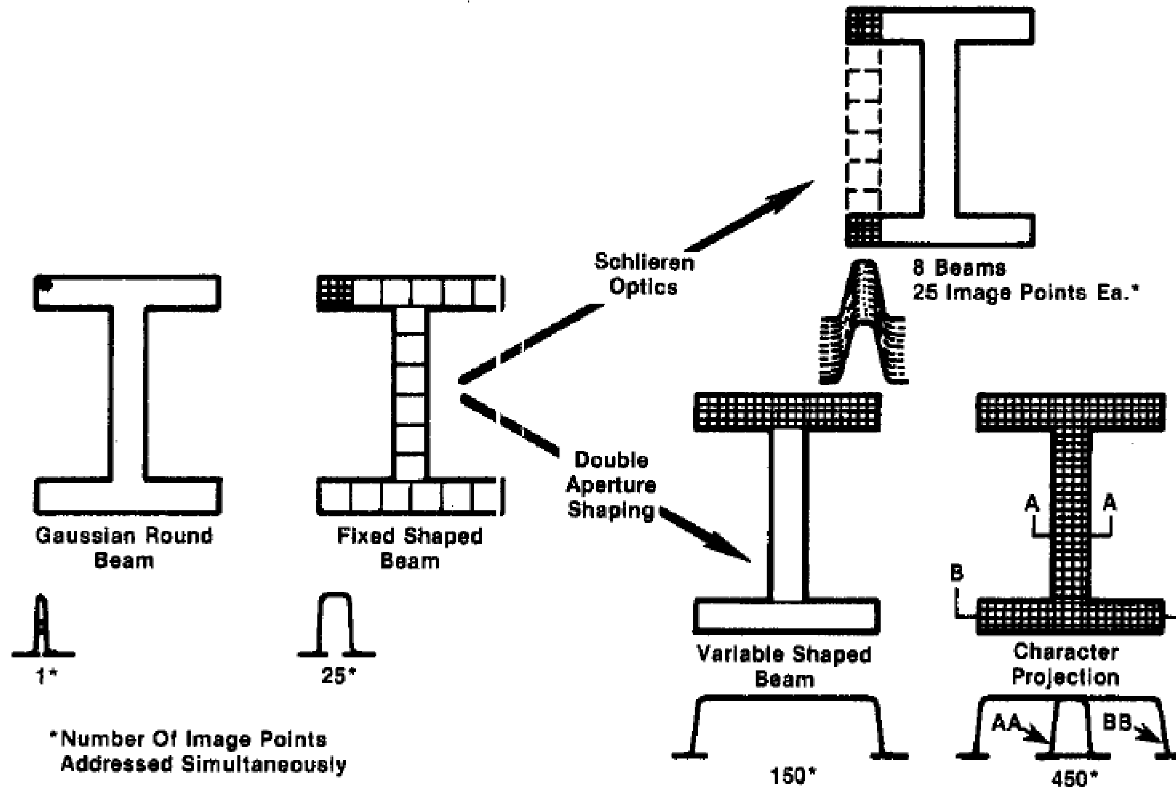
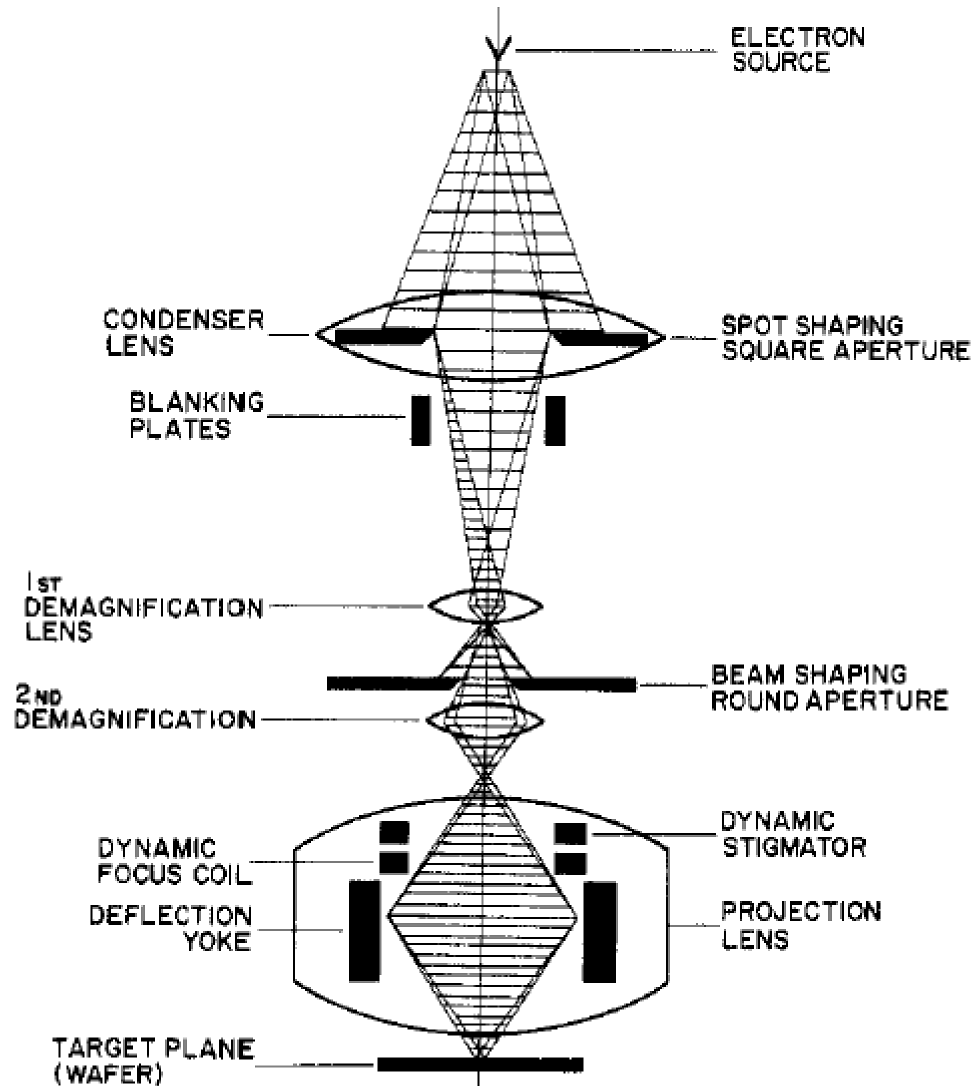
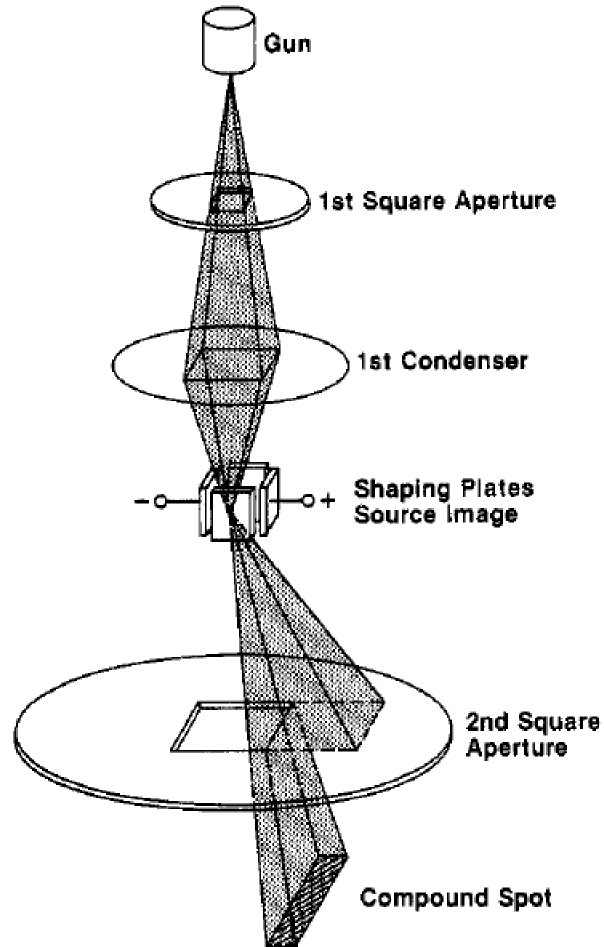
Various Beam Profiles

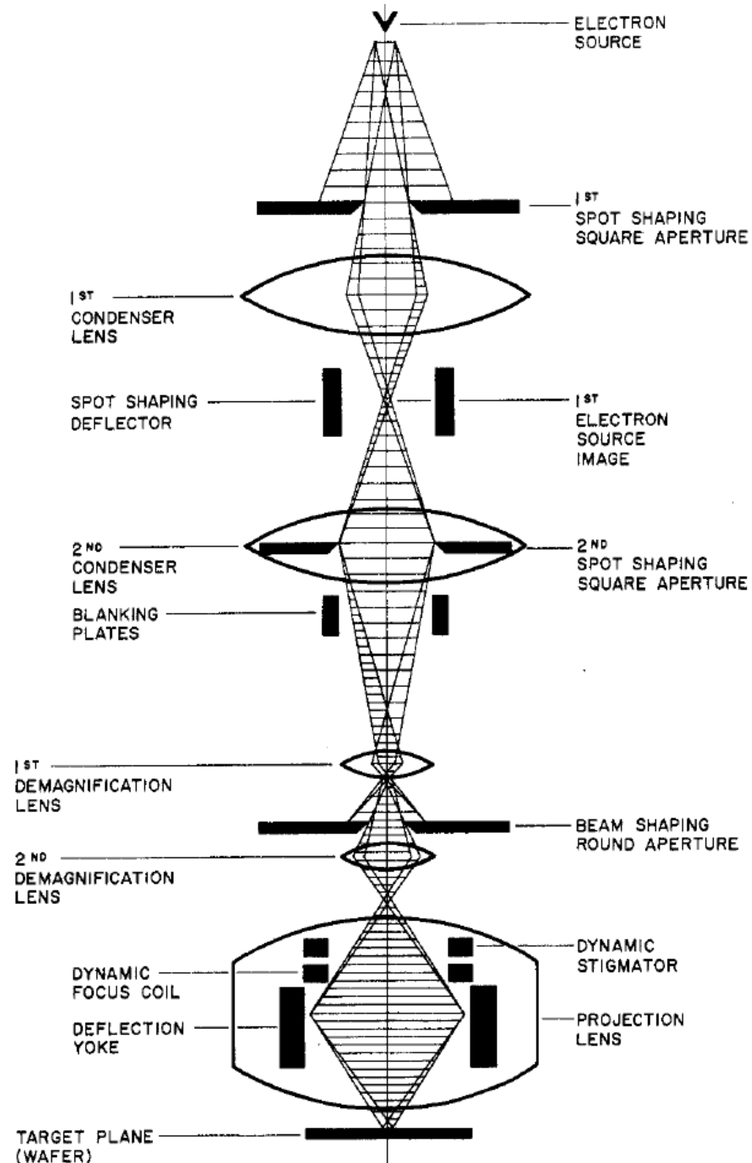


Fixed-shaped-beam imaging



Variable Shaped Beam Imaging



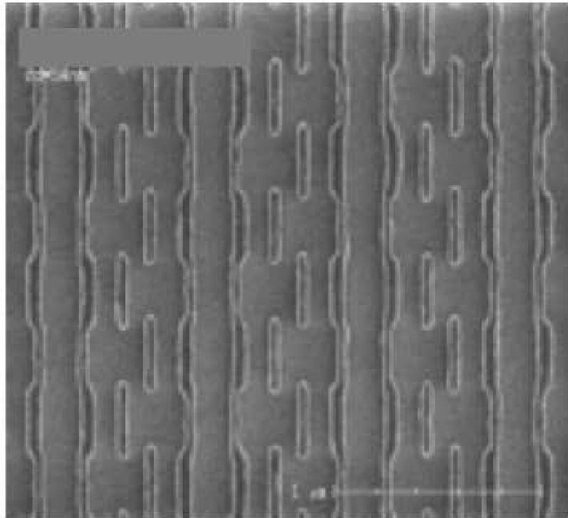


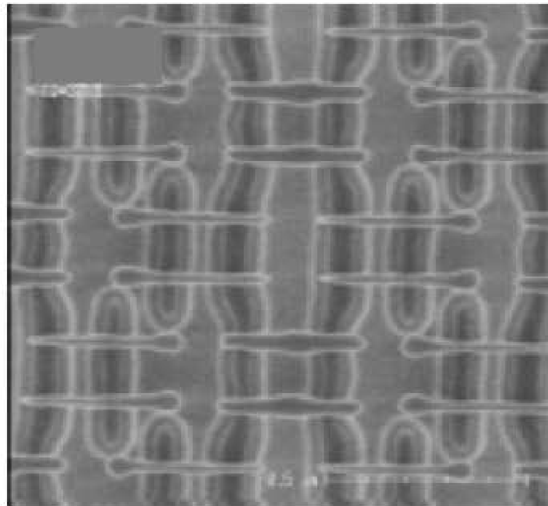
IBM's EL5 Shaped Beam System

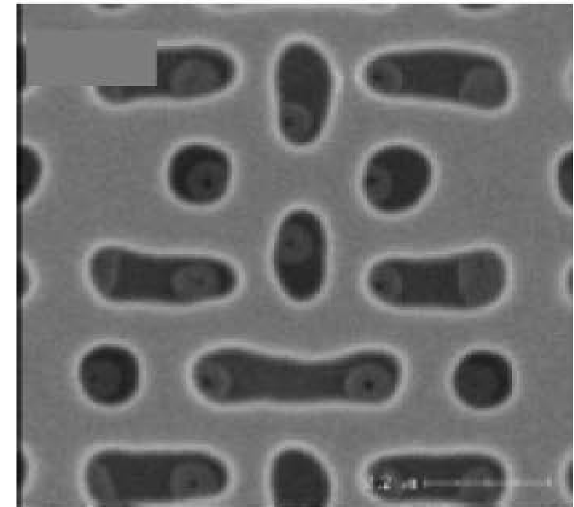
Table 1. Performance Specifications of EL5

Stage travel	300 mm+
Substrate compatibility	Carrier based – compatible with all existing mask and wafer standards
Accelerating voltage	50 kV
Current density	100 A/cm^2
Magnetic deflection range (field)	2.16 mm
Electrostatic deflection range (subfield)	24 μm
Magnetic lsb	<1 nm
Electrostatic position lsb	1 nm
Maximum spot size	2 × 2 μm
Spot shaping lsb	1 nm
Image placement	<20 nm 3 sigma
Minimum image	70 nm
Maximum effective pixel transfer rate (70 nm)	8 GHz

Performance of the Latest Variable Shaped Electron-Beam lithography tool

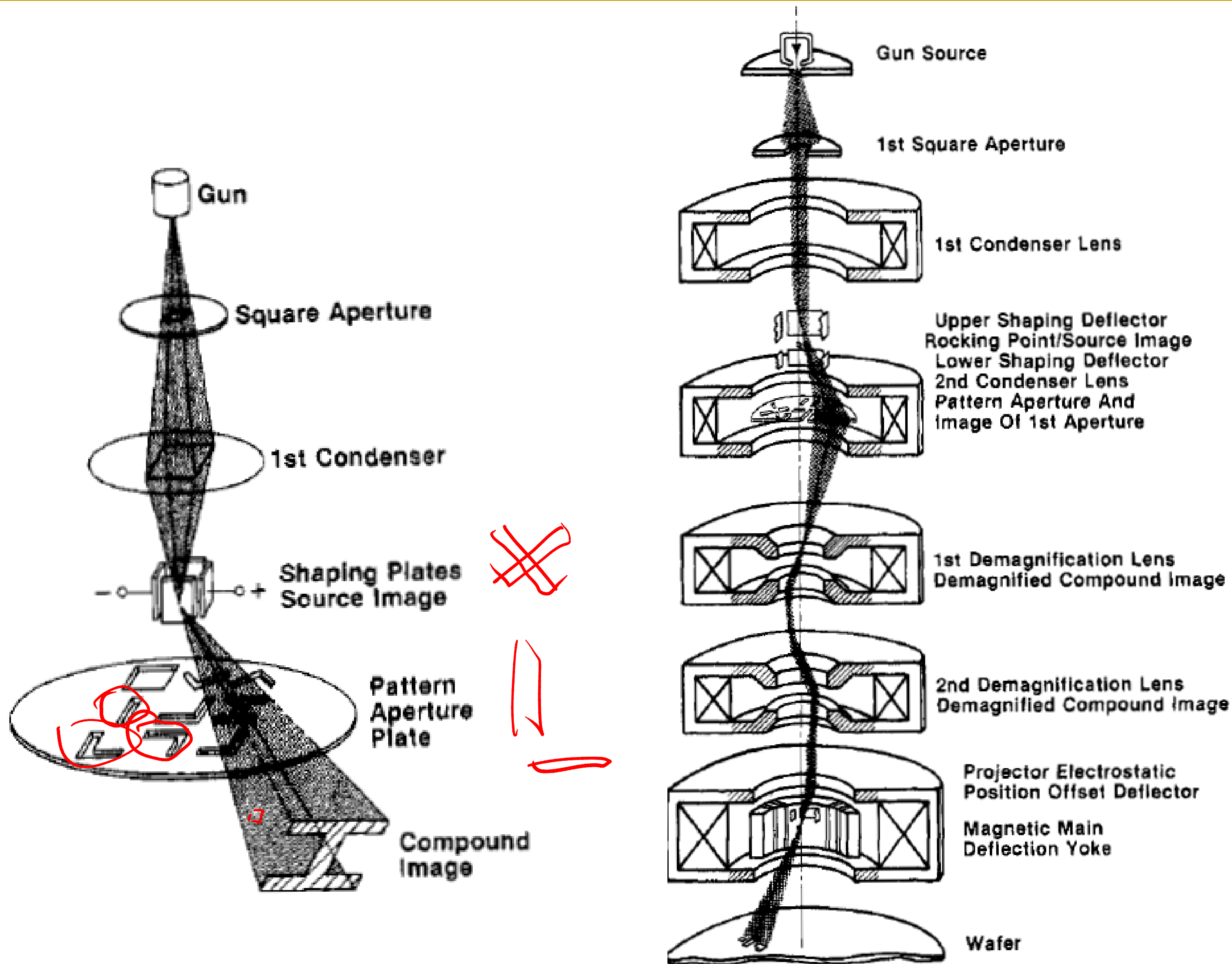

OD


Gate


Contact and Metal 1

- Vistec SB35x DW
- 45nm SRAM patterns.

Character Aperture Shaping



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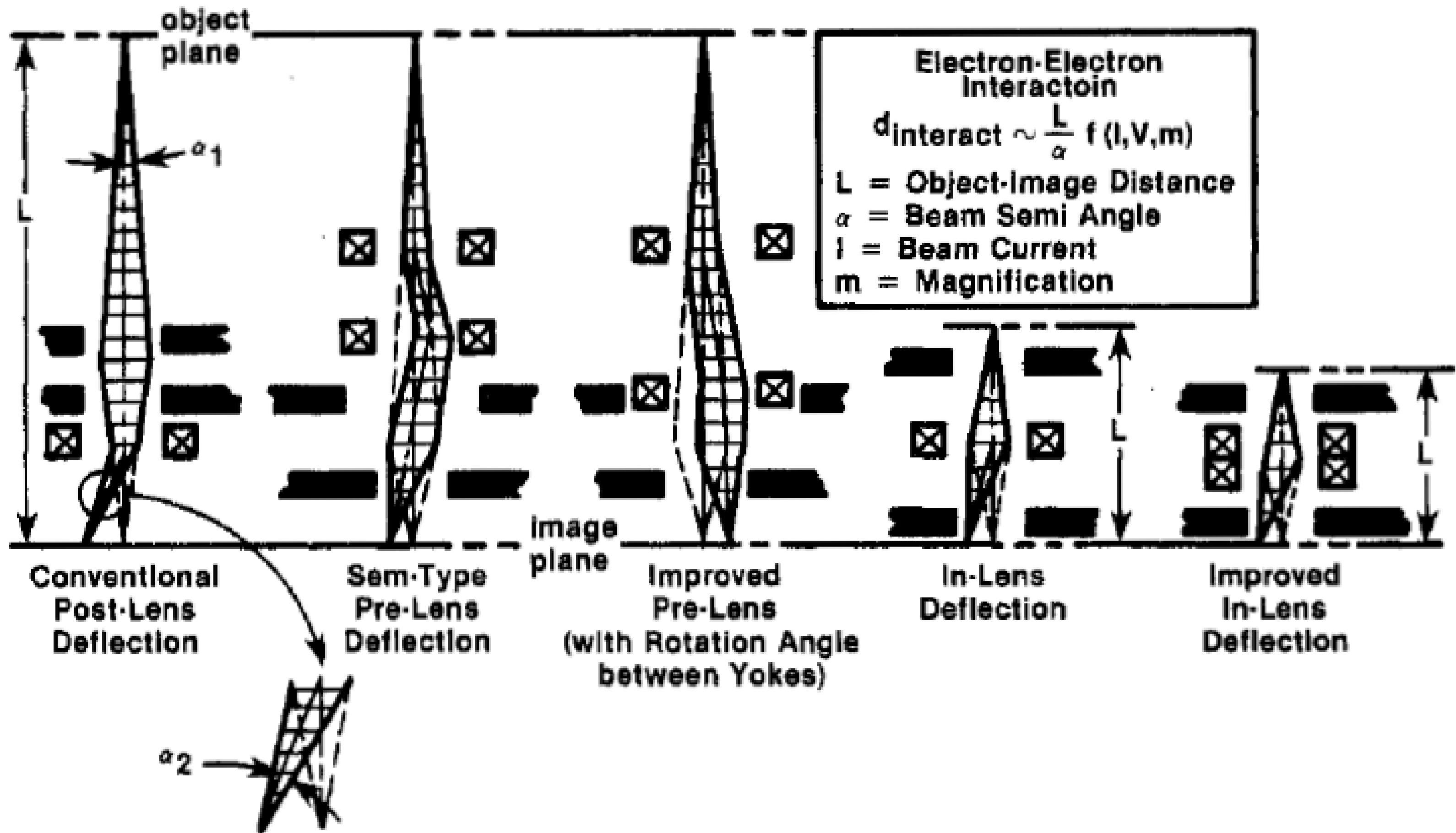
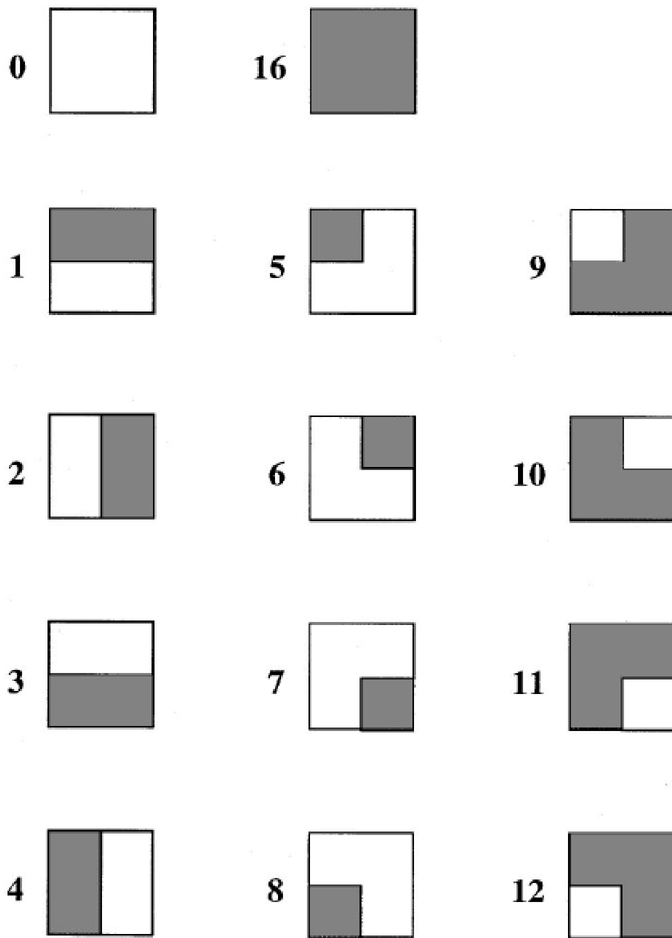
Vertical Landing of focused e-beam

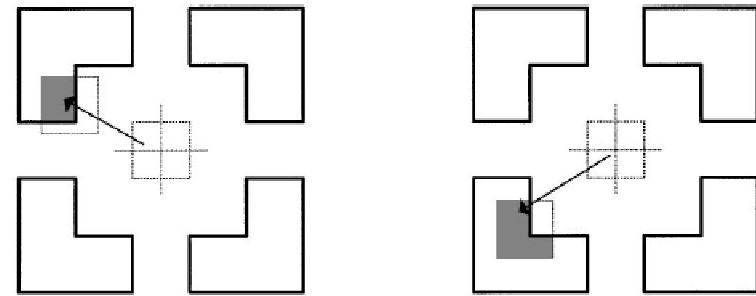


Reference: Hans C. Pfeiffer, *IEEE Transactions on Electron Devices,* ED-26, No. 4, p663, April 1979.

Raster Shaped beam pattern generation



Shape classes



Formation of the Shapes via apertures

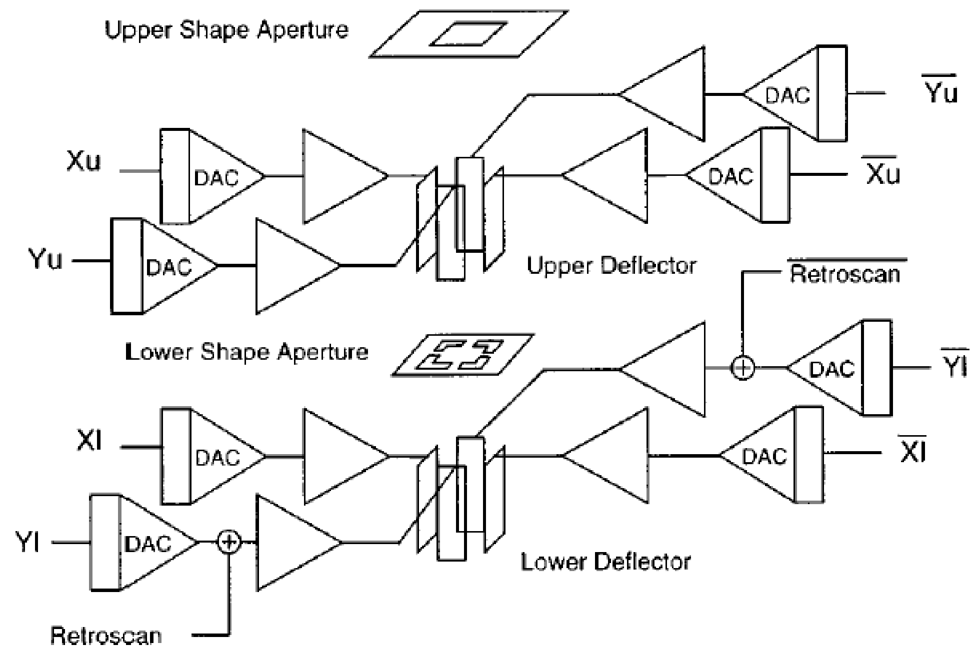
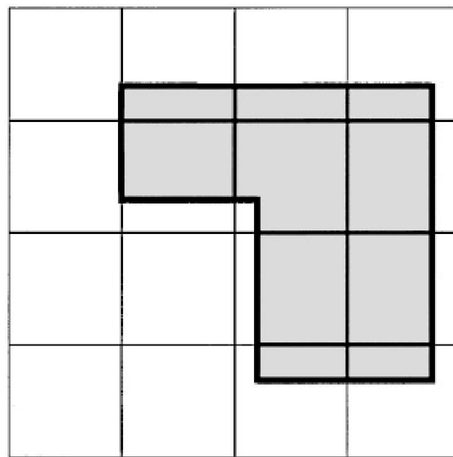
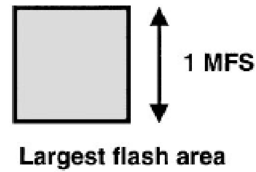
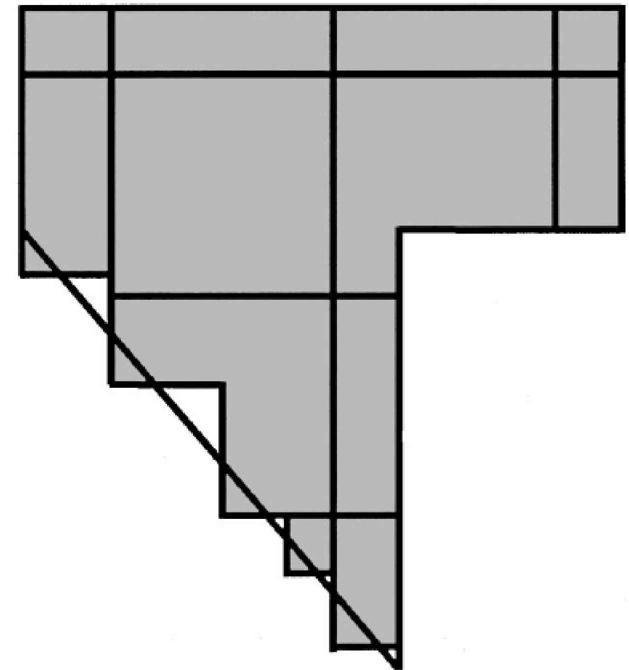


Image formation

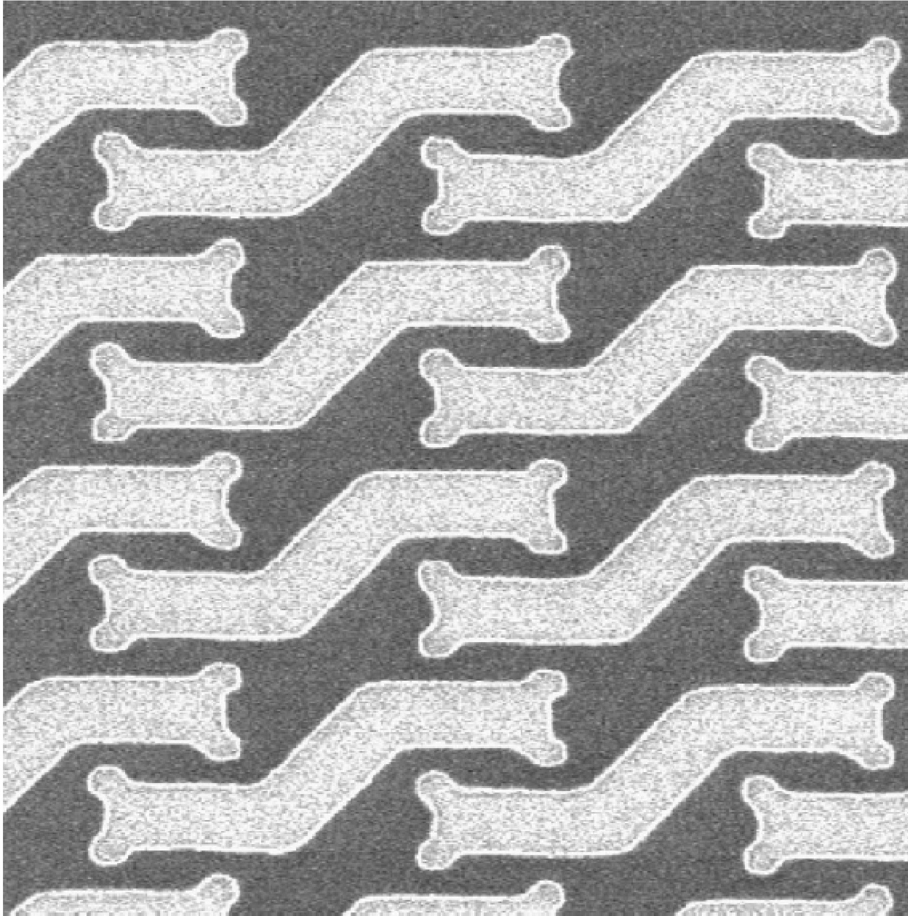






- Edges need not lie on gridlines
- Diagonal features are accommodated

Results of Raster Shaped Beam



500nm features with 200 nm OPC serifs

100 MHz flash rate

0.9 μA current,

2200 A/cm^2 current density