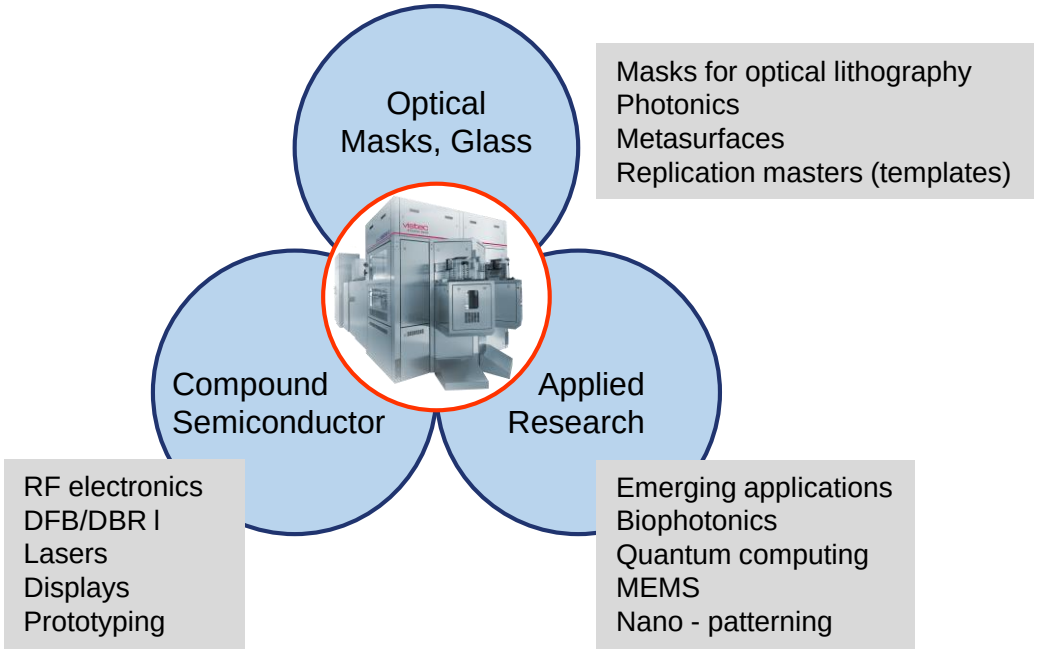
vistec
Electron Beam

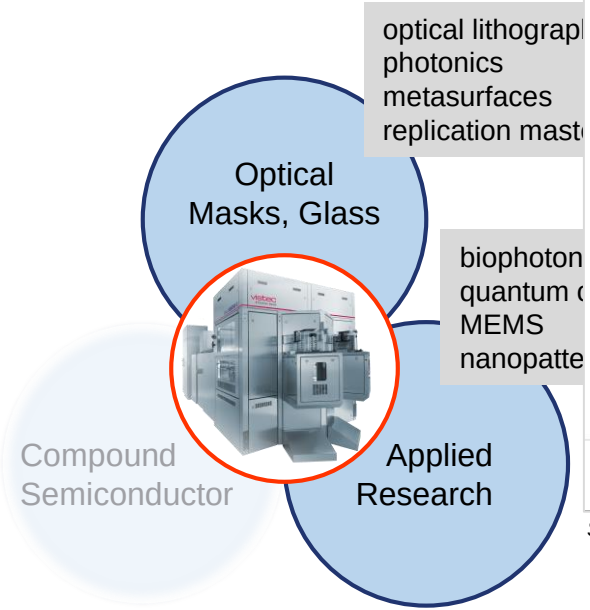
Versatile nanopatterning for optics and photonics by Variable Shaped Beam Lithography

Mathias Hädrich, Ines Stolberg, Eike Linn, Ulf Weidenmüller

Variable Shaped Beam (VSB) - Markets and Application examples

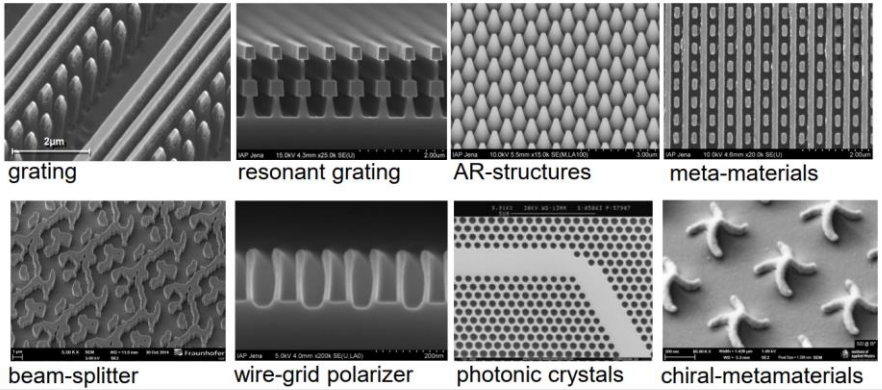


Vistec VSB writers have been adapted to optical requirements and non-Manhattan features



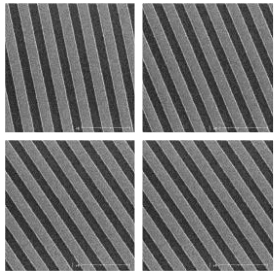
Variety of Nano Optical Pattern

- **sub-wavelength resolution**
- high **positioning accuracy** over **very large distances**
- **large areas** to become application relevant
- **repetitive / periodic**

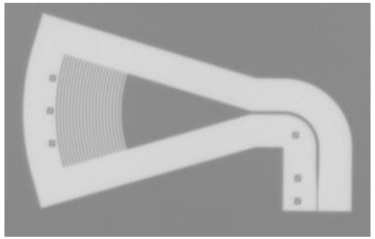


Source: U. Zeitner (Fraunhofer IOF, Germany); SPIE AL2023

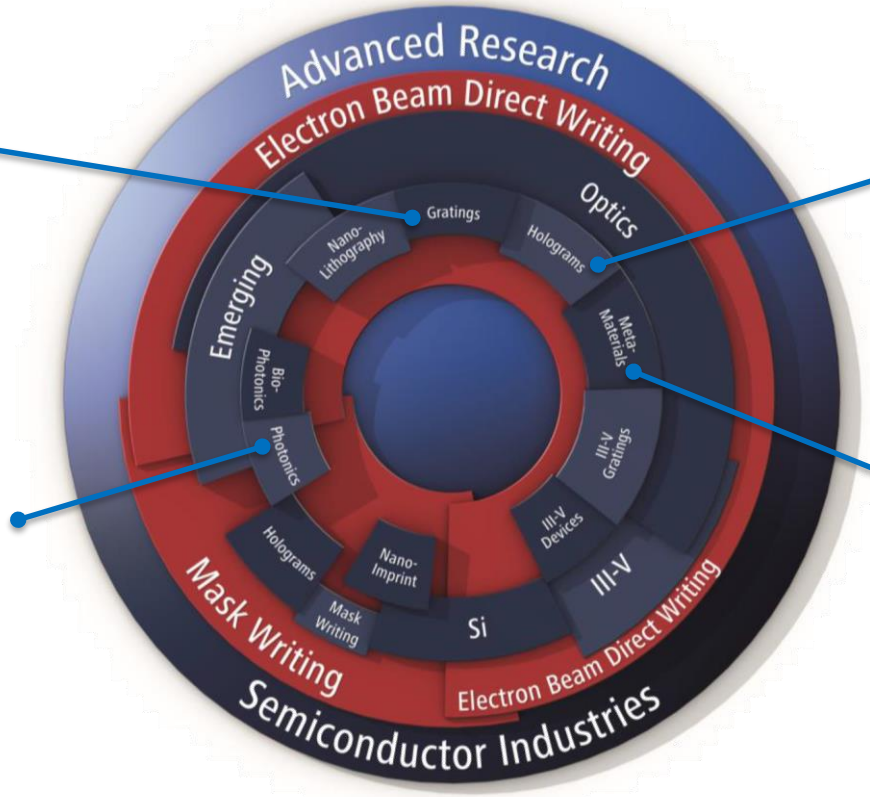
Available solutions for optical applications on Vistec E-Beam Writers

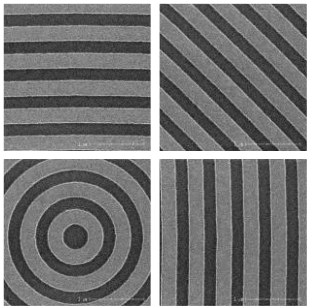


Any-angle gratings

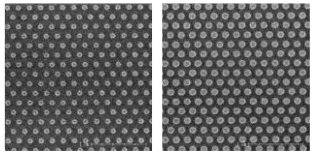


Photonic waveguides





Diffractive optical elements



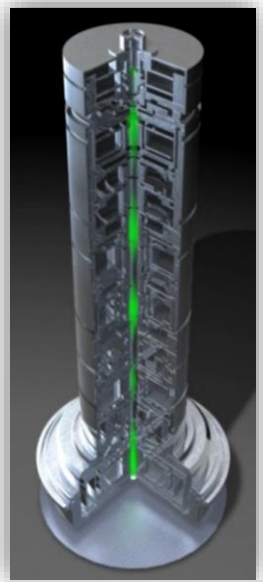
Nanophotonics

Source: Vistec Electron Beam GmbH.

E-beam lithography – well concerted system of e-beam writer, resist & data prep

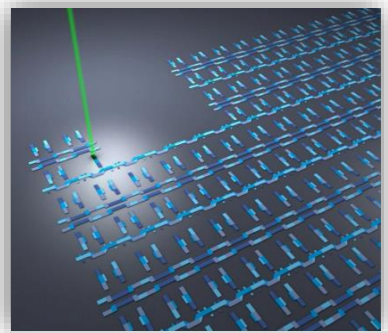
Vistec SB254

substrate on vacuum stage



electron-optical column

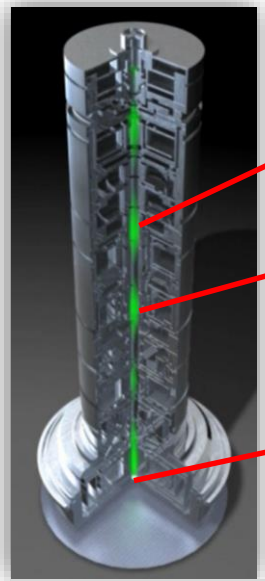
Data - preparation



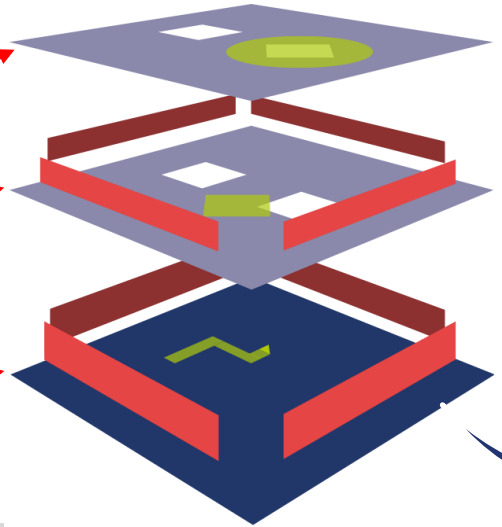
pattern writing (exposure)

Source: Vistec Electron Beam GmbH

Pattern writing with Variable Shaped Beam (VSB)



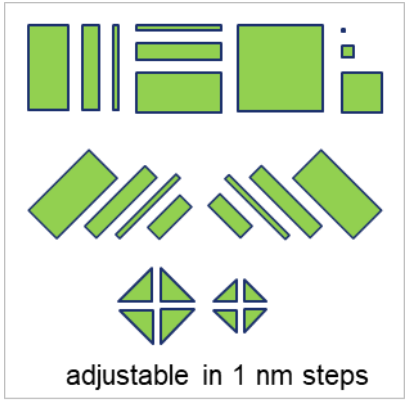
electron-optical column

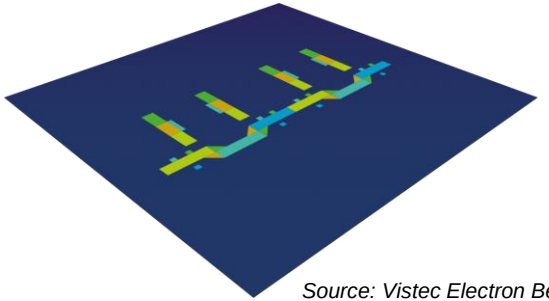


upper shaping aperture

lower shaping aperture

substrate





Source: Vistec Electron Beam GmbH

Pattern writing with Cell Projection (CP) – Enhanced productivity, seamless combination with VSB

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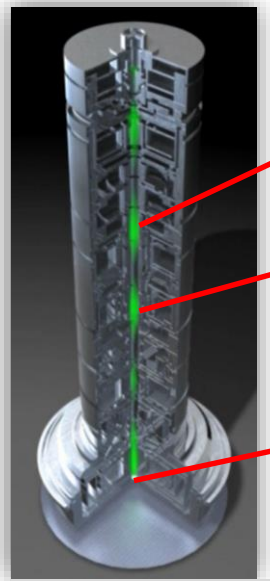
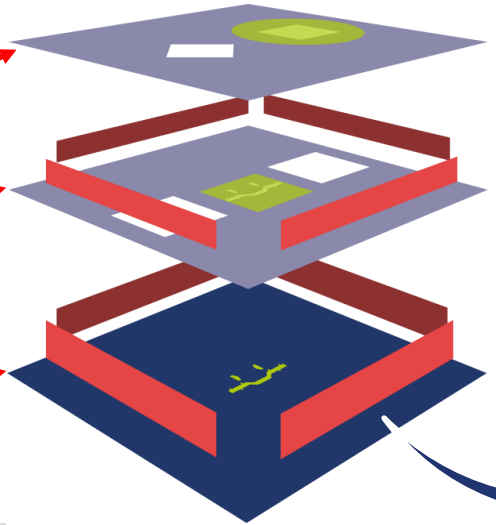


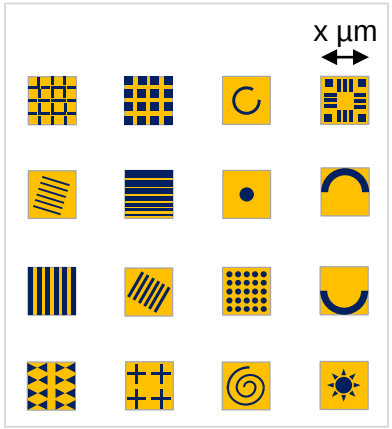
electron-optical column



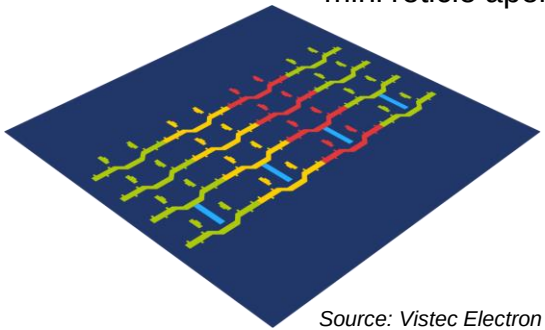
upper multi stencil chip

lower multi stencil chip

substrate



mini reticle apertures



Source: Vistec Electron Beam GmbH

Patterning of dense nano-structures on a 300 mm wafer for a metasurface master is feasible with VSB & CP e-beam writers

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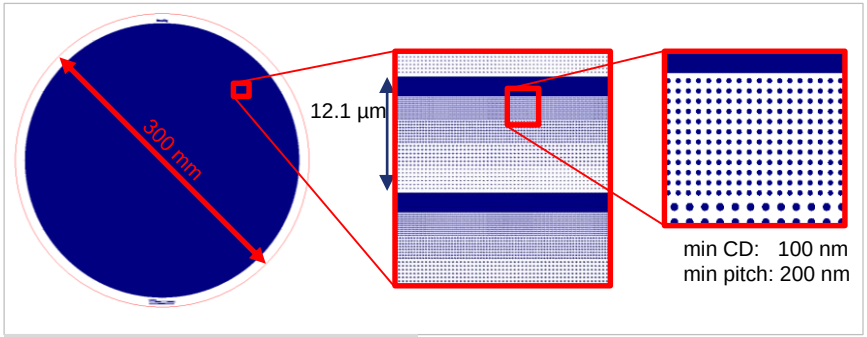
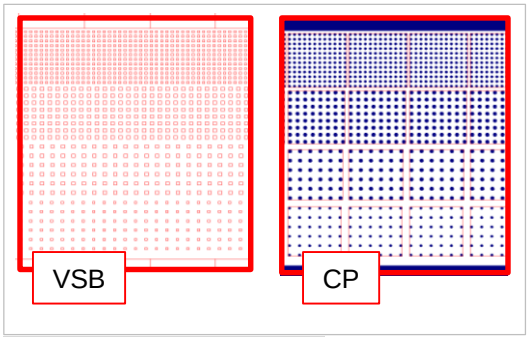
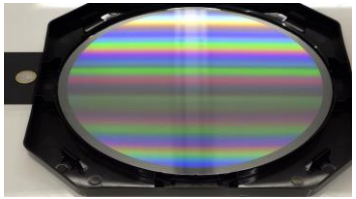


effective medium blazed grating

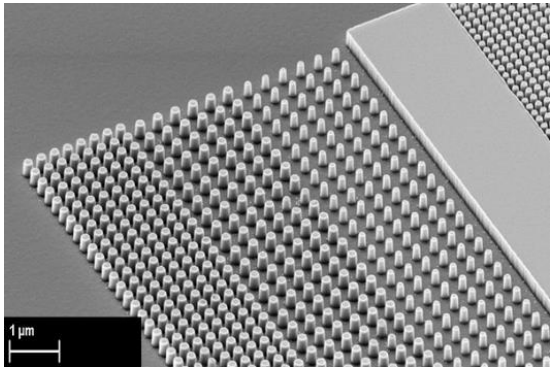


exposure layout (detail)



	VSB / squares	CP / dots arrays
shot count	596 billion	11 billion
write time estimate	74 d 20 h	1 d 12 h
write time	-	1 d 12 h

Writing this pattern is approx. 50 x faster with CP



Resist: EN038, FujiFilm; 55µC/cm²

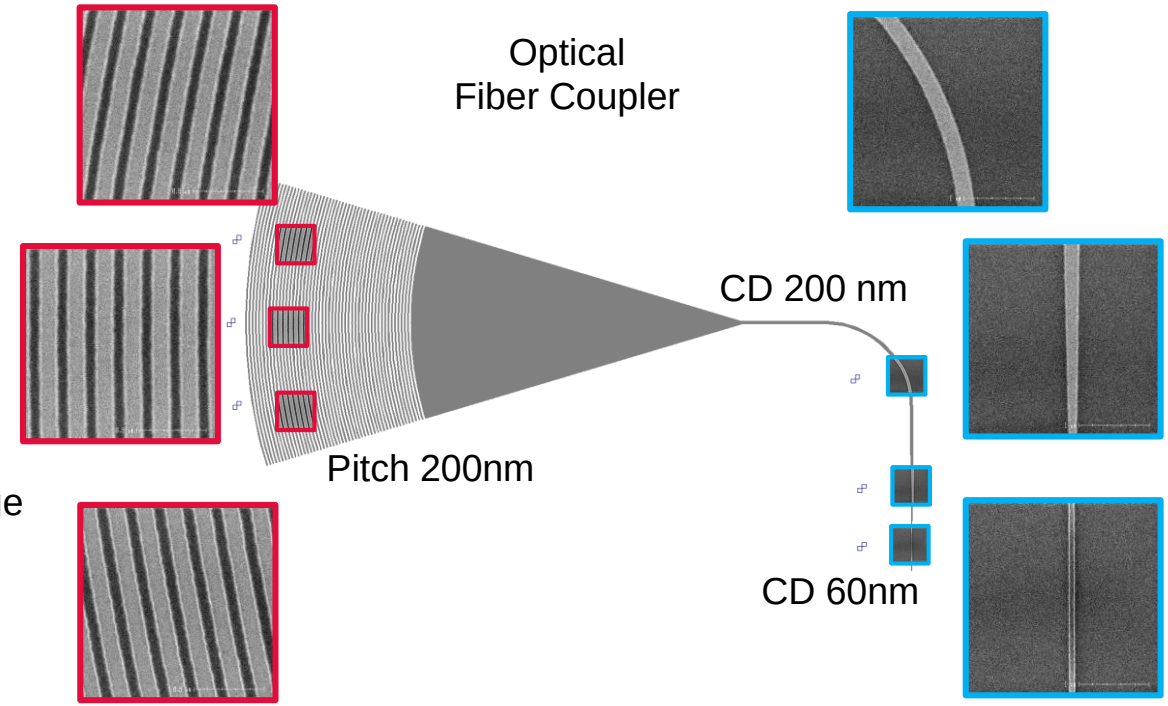
Source: Fraunhofer IOF, Jena / Germany

Key Requirements for Optical Applications demand high e-beam patterning performance & fast writing

Angle-independent characteristics
High diffraction efficiency

High pattern fidelity
Low scattering

→ Accurate edge location
→ Low and angle-independent edge roughness



: CD-SEM marks

JES – Approximation enables fracturing with respect to the resist edge and not to the pattern edge

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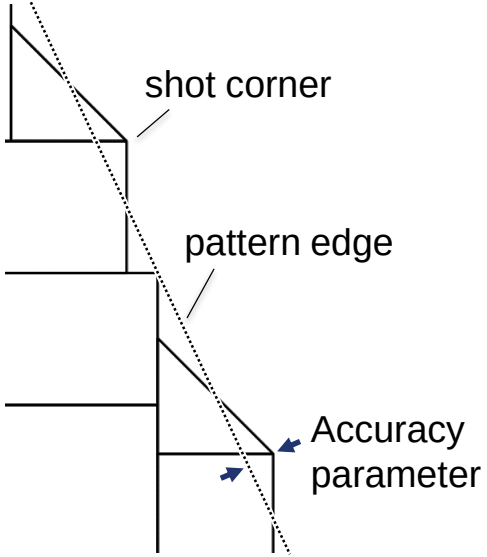
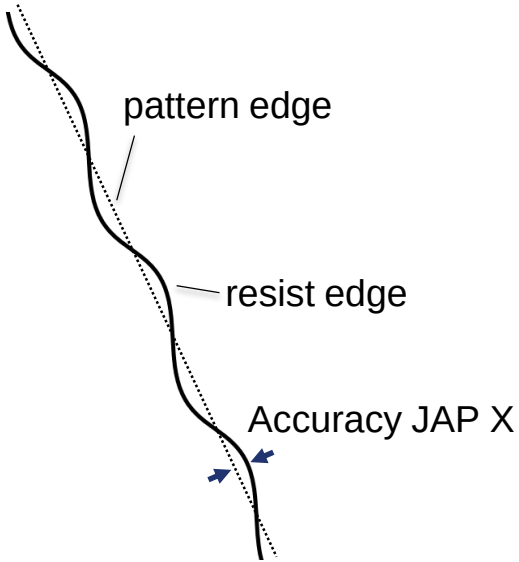
Border Approximation



Common mode

JES-Approximation



New mode

JAP enables accurate edge location, low and angle-independent edge roughness – BUT only MIA avoids vertices

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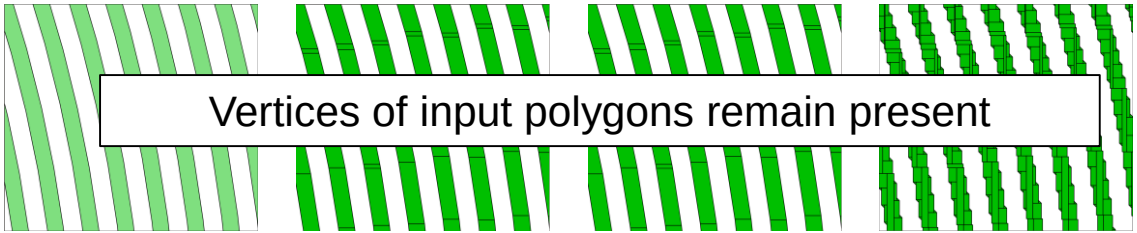
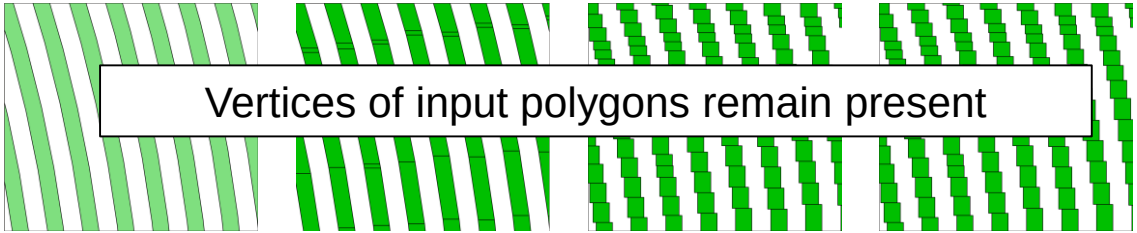
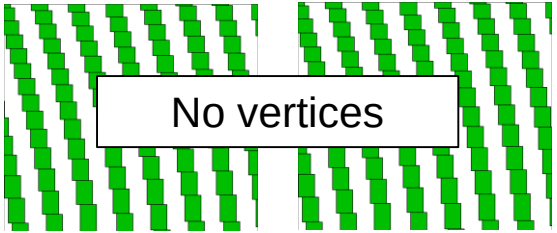
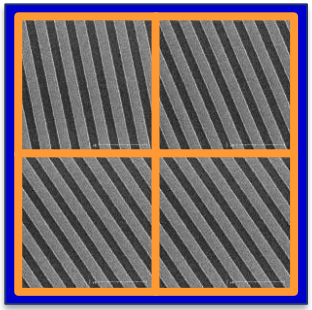
	Starting point	Input	Trapezoids	JES-data	Shots
Border-Approximation (BAP)	 Polygonal data				
JES-Approximation (JAP)	 Polygonal data				
Mathematical Input Approximation (MIA)	$n \cdot \text{pitch} = r(x,y) = \sqrt{x^2 + y^2}$ Exact function for axicon				

Vertices of input polygons remain present

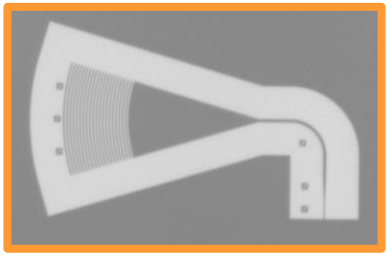
Vertices of input polygons remain present

No vertices

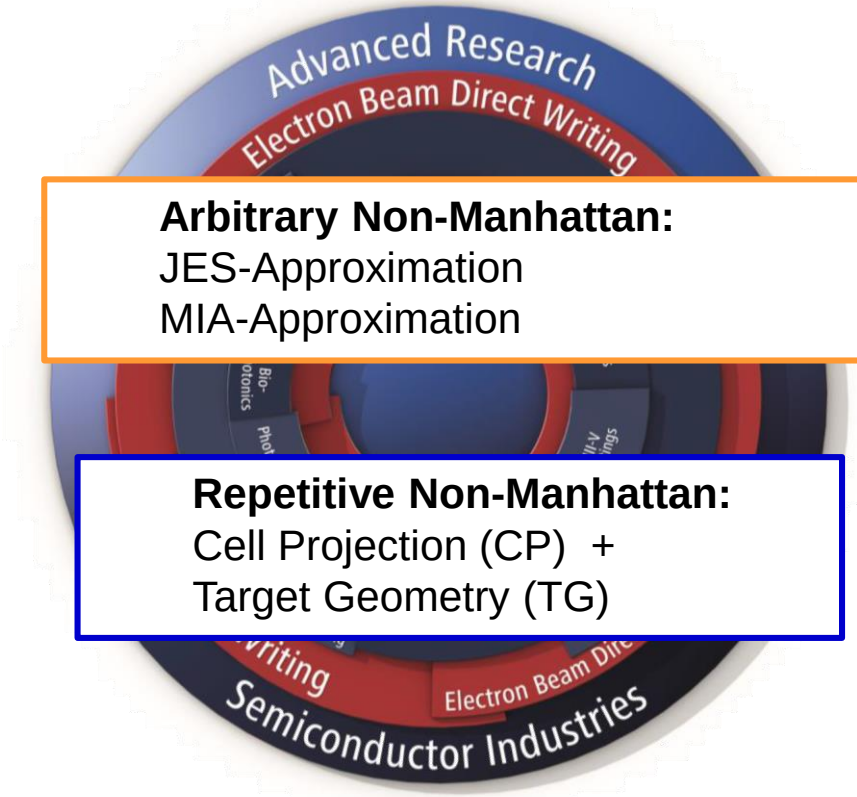
Available solutions for optical applications on Vistec E-Beam Writers



Any-angle gratings

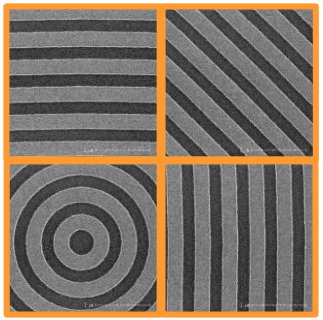


Photonic waveguides

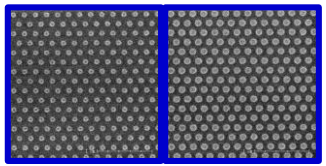


Arbitrary Non-Manhattan:
JES-Approximation
MIA-Approximation

Repetitive Non-Manhattan:
Cell Projection (CP) +
Target Geometry (TG)



Diffractive optical elements



Nanophotonics

Source: Vistec Electron Beam GmbH

Thank you for your attention!

www.vistec-semi.com

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Publisher

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