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Automated alignment procedure for stitching with a focused ion beam

Marie Verbist

17 June 2010

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nano

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nanophotonics

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nanophotonics

very very small photonic chips

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nanophotonics

very very small photonic chips
fabricated with **nanometer** precision

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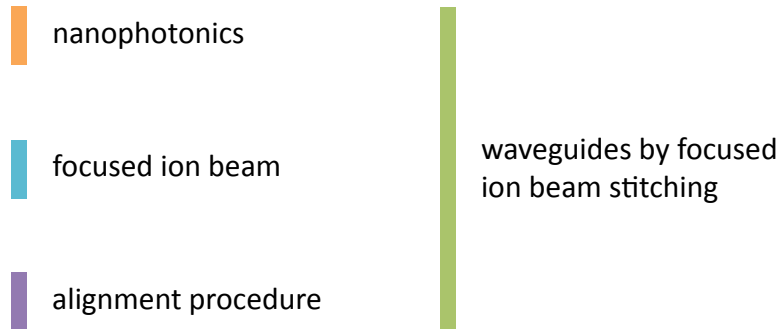
Automated alignment procedure for stitching with a focused ion beam

-  nanophotonics
-  focused ion beam
-  alignment procedure

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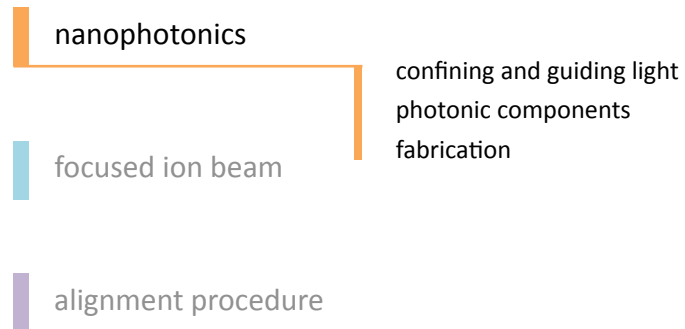
Automated alignment procedure for stitching with a focused ion beam



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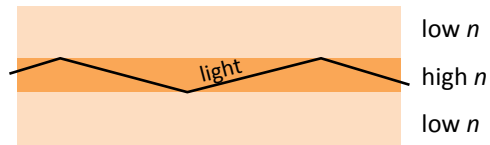
Automated alignment procedure for stitching with a focused ion beam



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Light can be confined by
refractive index contrast

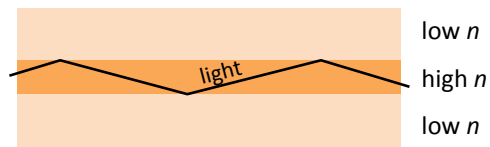


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Light can be confined by refractive index contrast

layer sandwich of materials with different refractive index (n)



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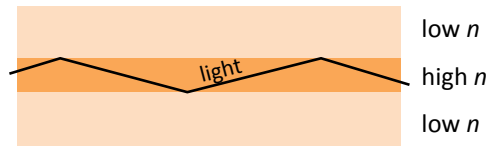
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Light can be confined by refractive index contrast

layer sandwich of materials with different refractive index (n)

total internal reflection

light stays in the core with higher n



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Light can be confined by refractive index contrast

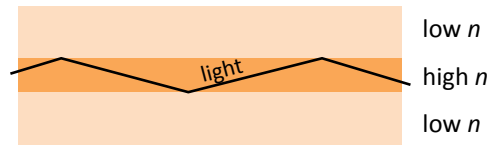
layer sandwich of materials with different refractive index (n)

total internal reflection

light stays in the core with higher n

higher index contrast

smaller core and sharper bends

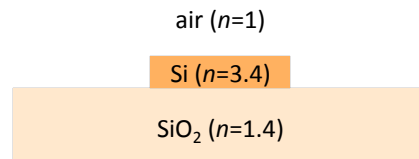


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Waveguides are the basis of many nanophotonic components

cross-section



top view

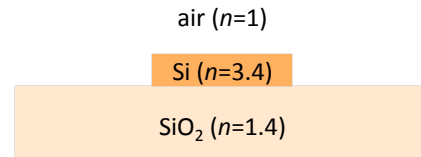


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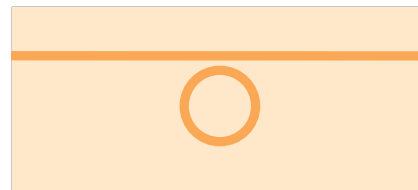
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Waveguides are the basis of many nanophotonic components

cross-section



top view



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CMOS technology is not ideal for prototyping

CMOS fabrication tools
ideal for industry

??
ideal for research

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CMOS technology is not ideal for prototyping

CMOS fabrication tools
ideal for industry

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ideal for research

mass fabrication

long development cycle

not all materials

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CMOS technology is not ideal for prototyping

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ideal for research

mass fabrication

prototype fabrication

long development cycle

short development cycle

not all materials

all materials

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CMOS technology is not ideal for prototyping

CMOS fabrication tools
ideal for industry

mass fabrication

long development cycle

not all materials

Focused Ion Beam tool
ideal for research

prototype fabrication

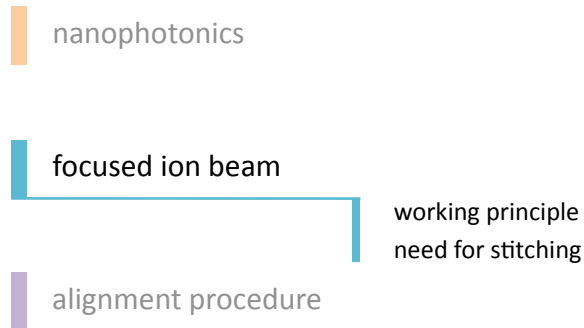
short development cycle

all materials

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Automated alignment procedure for stitching with a focused ion beam



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A focused ion beam tool enables milling and imaging

An ion beam is focused
 scanned
 blanked

Ga⁺ beam



target

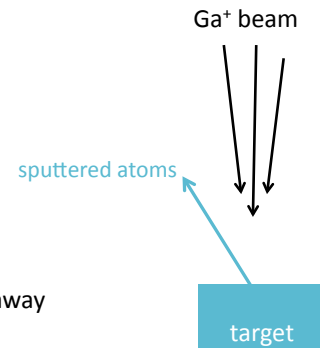
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A focused ion beam tool enables milling and imaging

An ion beam is focused
 scanned
 blanked

Impact causes atoms to be sputtered away



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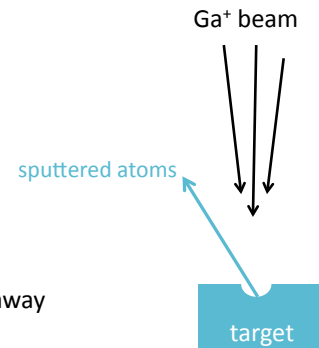
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A focused ion beam tool enables milling and imaging

An ion beam is focused
 scanned
 blanked

Impact causes atoms to be sputtered away

This allows for milling holes



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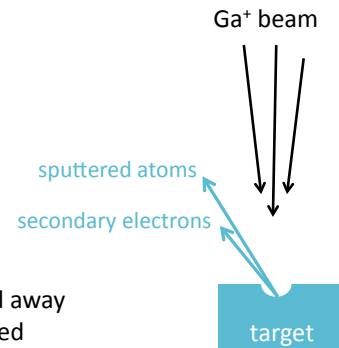
Watch this presentation on www.scitable.com

A focused ion beam tool enables milling and imaging

An ion beam is focused
 scanned
 blanked

Impact causes atoms to be sputtered away
 electrons to be released

This allows for milling holes



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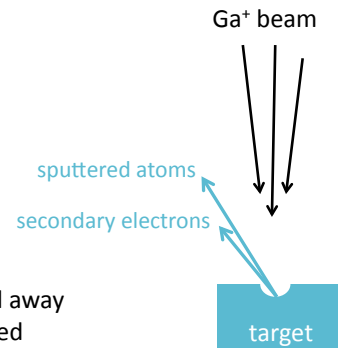
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A focused ion beam tool enables milling and imaging

An ion beam is focused
scanned
blanked

Impact causes atoms to be sputtered away
electrons to be released

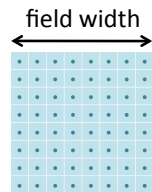
This allows for milling holes
imaging (through electron detection)



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Large structures need to be stitched

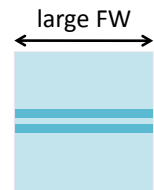


same number of pixels for any field width

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Large structures need to be stitched



low resolution



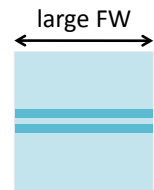
high resolution

same number of pixels for any field width
for a certain required scan resolution, the FW is limited

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Large structures need to be stitched



low resolution



high resolution

same number of pixels for any field width

for a certain required scan resolution, the FW is limited

structures larger than the field width have to be stitched

i.e. etch part of the structure, move stage, etch next part, ...

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Automated alignment procedure for stitching with a focused ion beam



nanophotonics



focused ion beam



alignment procedure

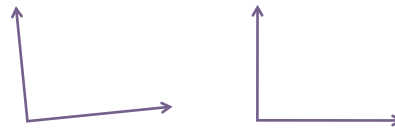
adjusting the beam rotation
adjusting the beam shift

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Problem 1 : misalignment of beam and stage axes

Beam axes and stage axes are slightly misaligned

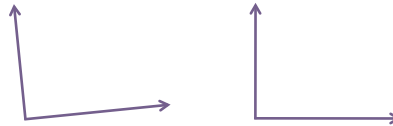


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Problem 1 : misalignment of beam and stage axes

Beam axes and stage axes are slightly misaligned

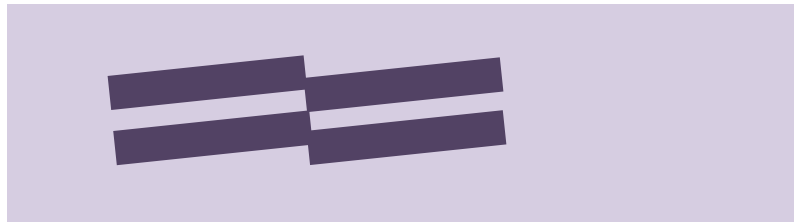
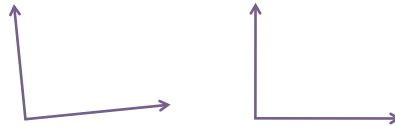


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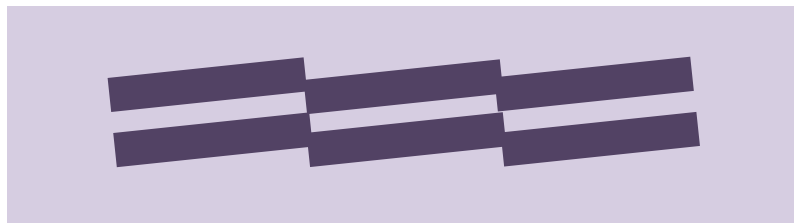
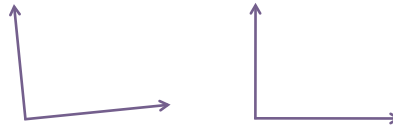


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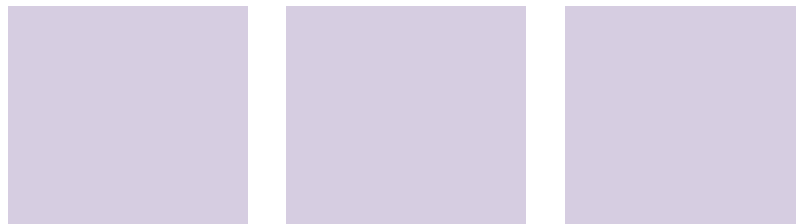


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Solution 1 : adjust beam rotation

Determine angle between stage and beam axes
move stage to the corners of a square
mill alignment markers in each corner and image
calculate angle from rotated square



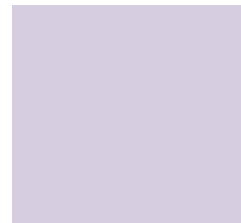
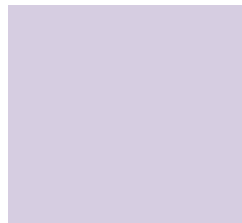
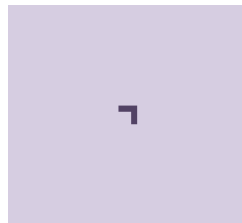
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Solution 1 : adjust beam rotation

Determine angle between stage and beam axes
move stage to the corners of a square
mill alignment markers in each corner and image
calculate angle from rotated square

mill & image

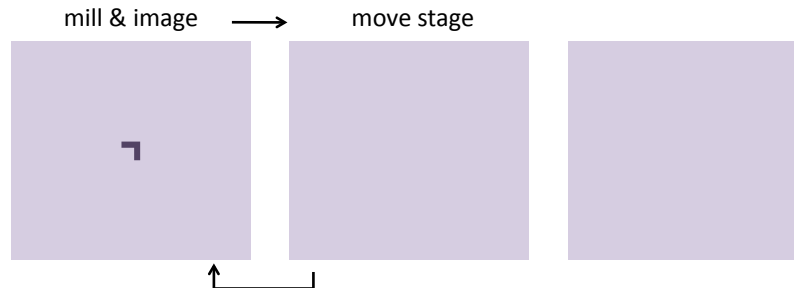


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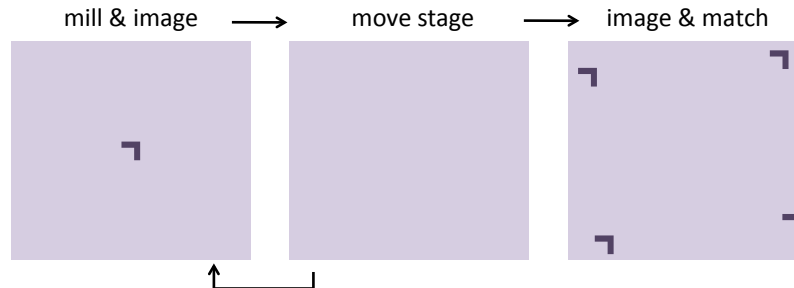


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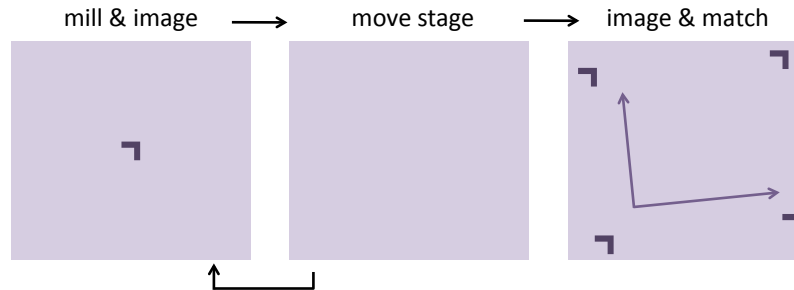


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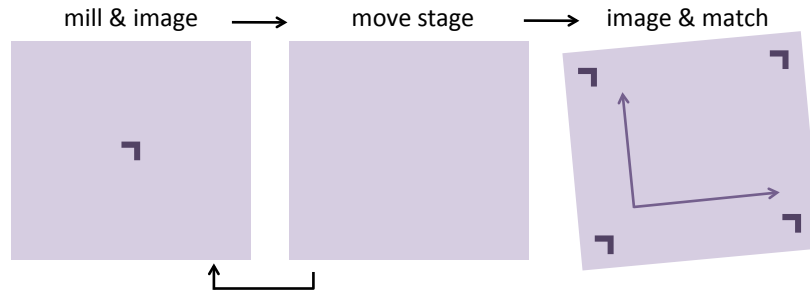


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Determine angle between stage and beam axes
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Problem 2 : inaccuracy of stage moves

Stage moves are too inaccurate
causing overlap or space between the several milled parts

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Stage moves are too inaccurate
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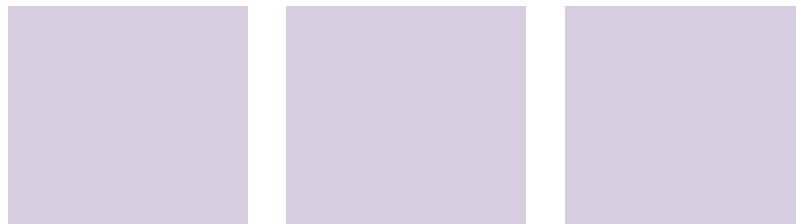


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Solution 2 : adjust beam shift

Determine beam shift to compensate for stage inaccuracy
based on image recognition of markers



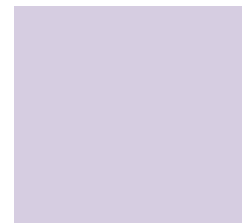
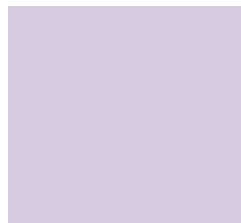
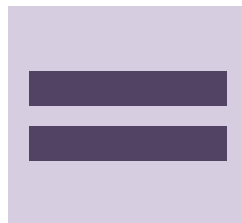
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Solution 2 : adjust beam shift

Determine beam shift to compensate for stage inaccuracy
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mill & image



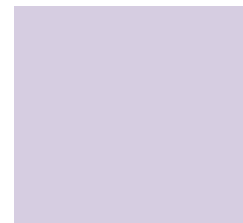
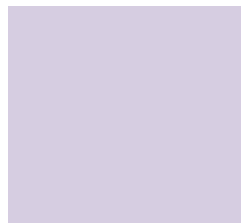
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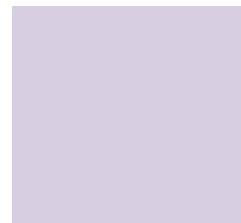
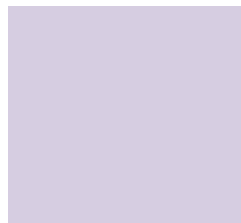
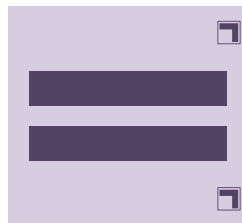
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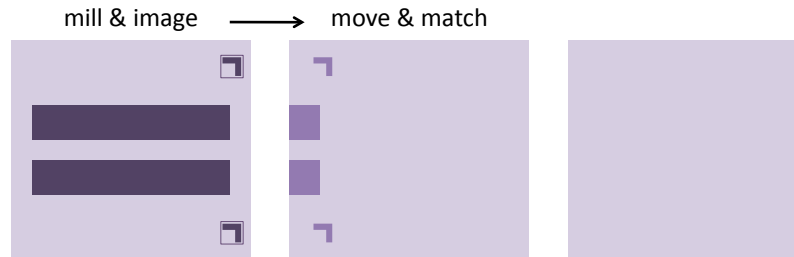


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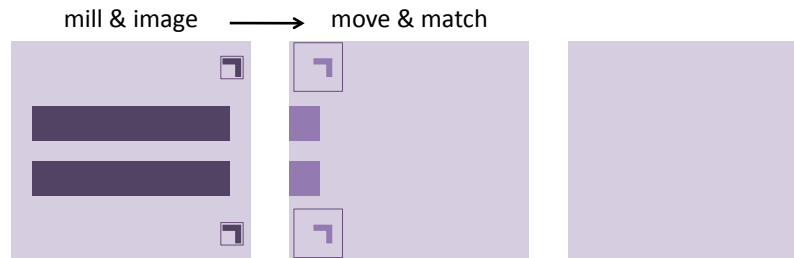


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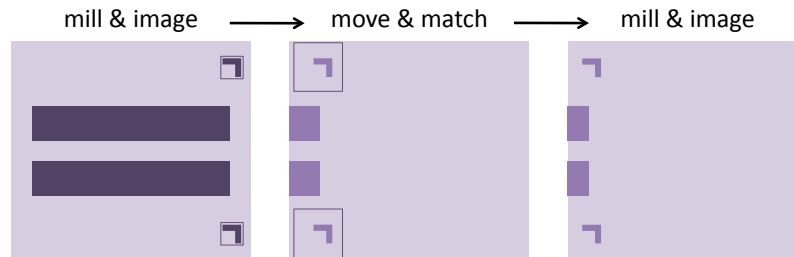


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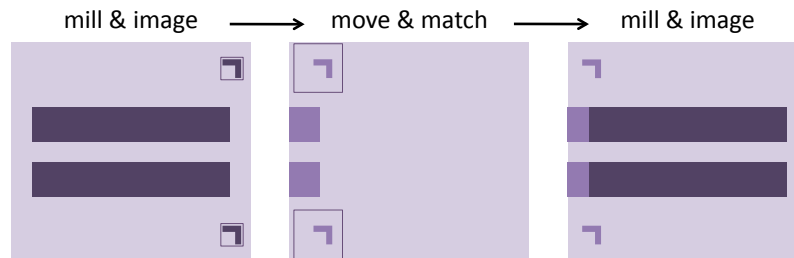


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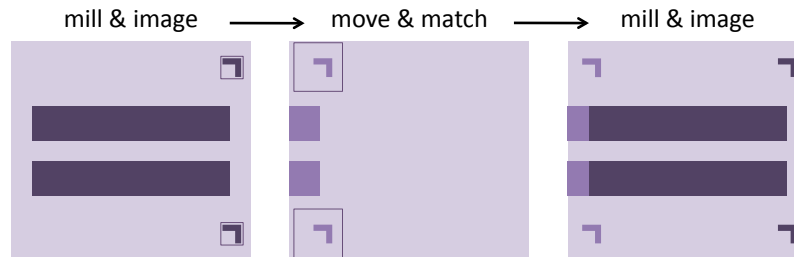


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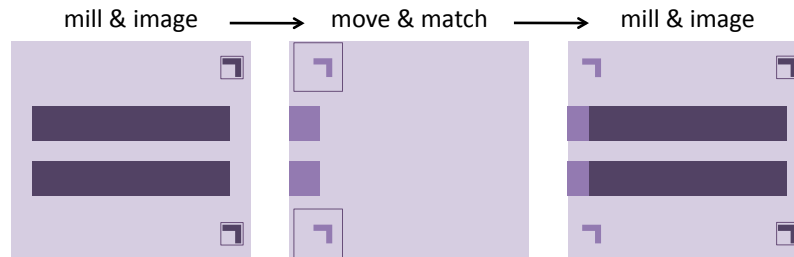


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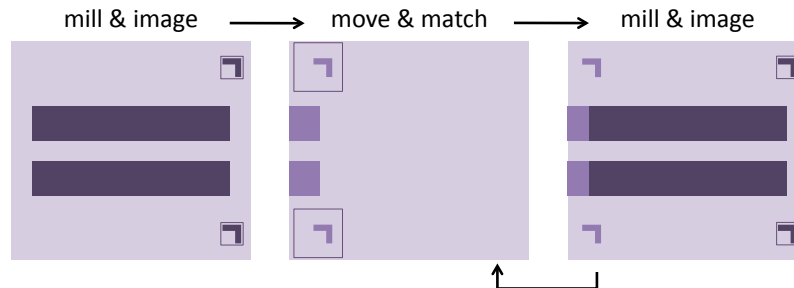


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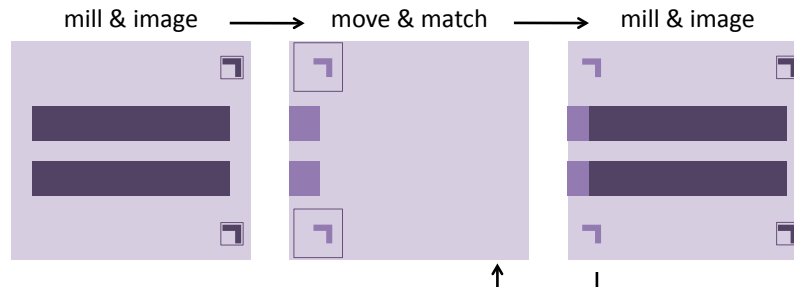
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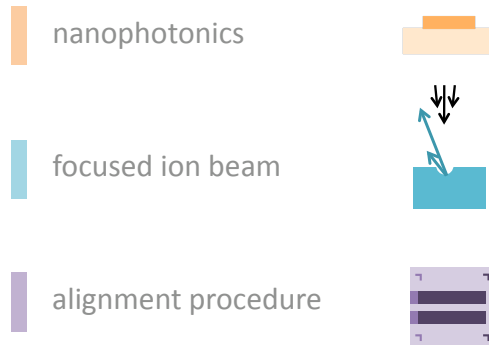
The waveguide itself is never imaged to avoid damage/losses



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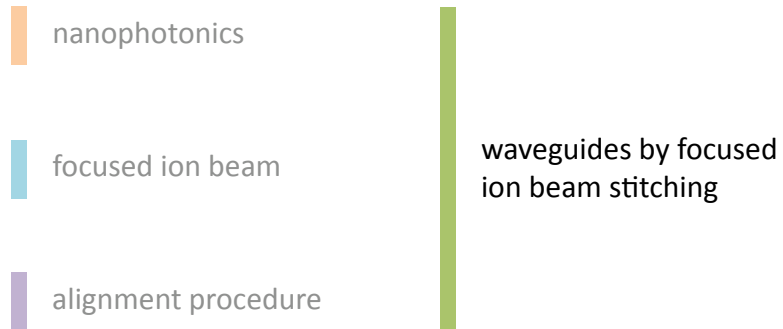
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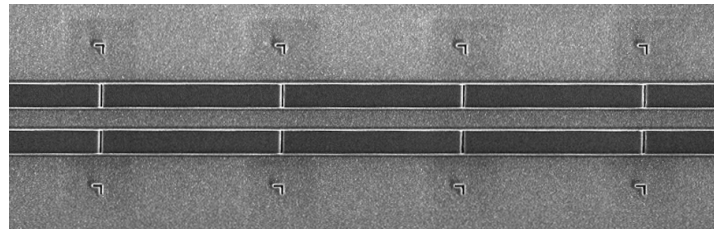
Automated alignment procedure for stitching with a focused ion beam



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Long waveguides could be stitched

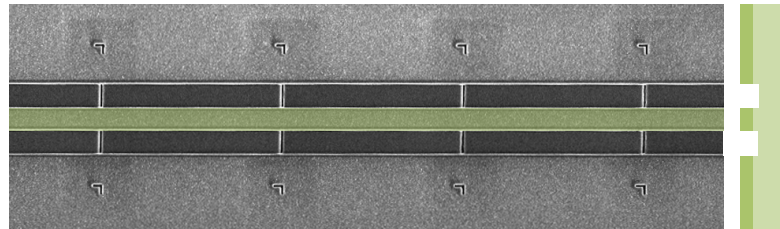


80 μm

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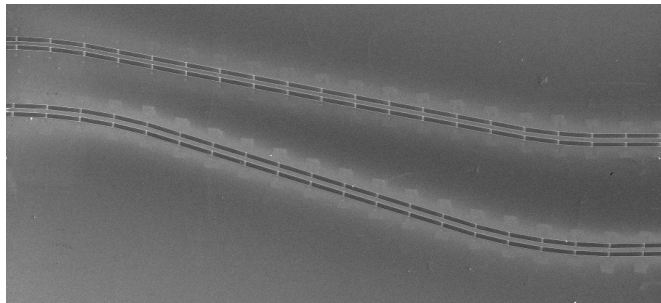


80 μm

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Structures are unlimited in size

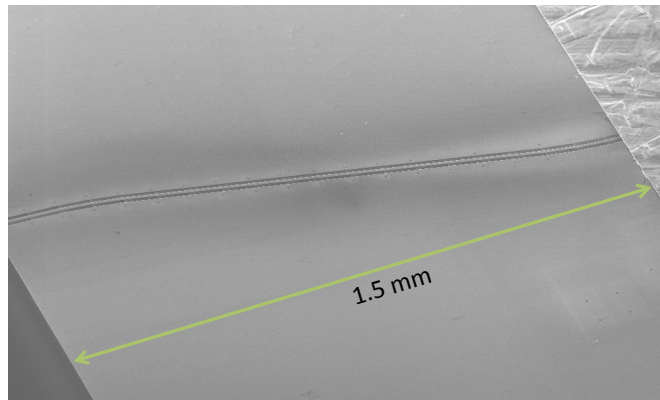


1.5 mm

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Structures are unlimited in size
except by the size of the sample



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nanophotonics as large as we want



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