Sub-30nm alignment accuracy between layered photonic nanostructures using optimized nanomagnet arrays

Anthony Nichol, George Barbastathis

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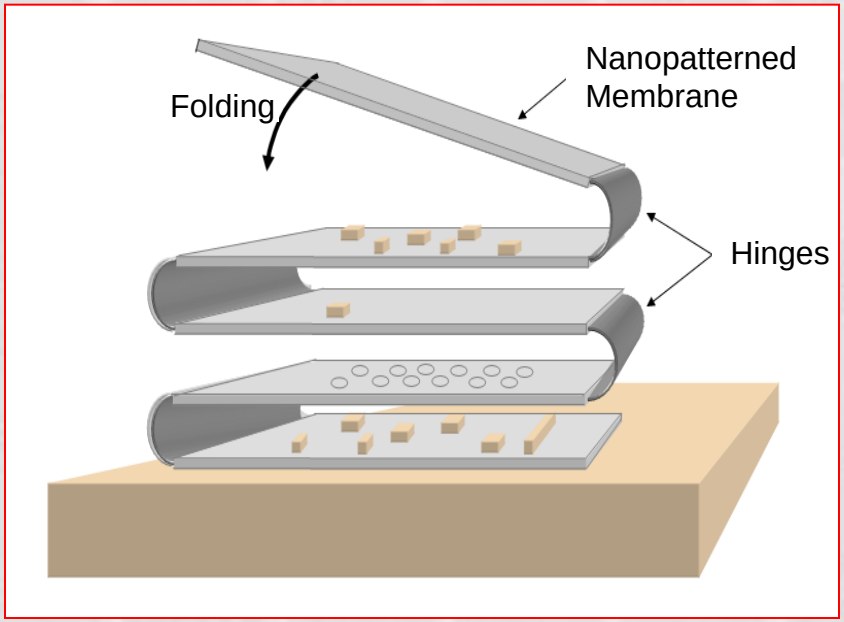
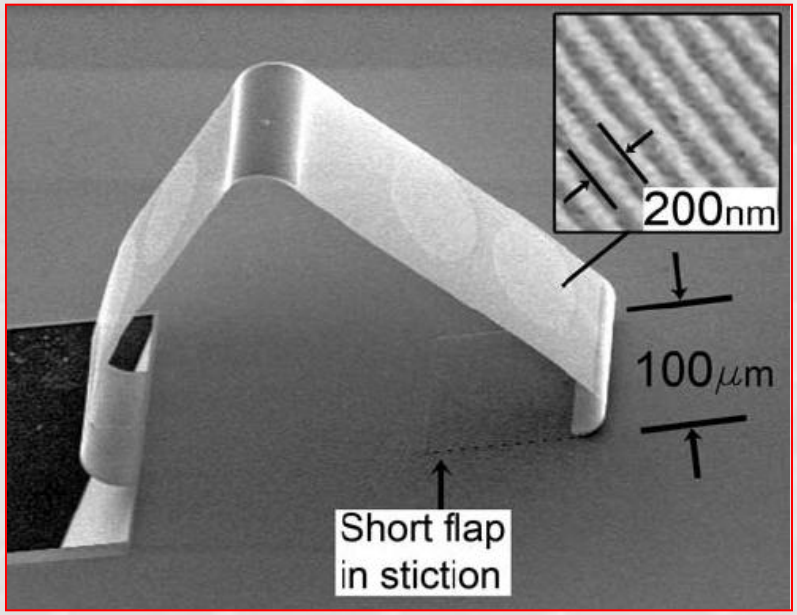
Nanostructured Origami™

Nanopattern membranes and fold into devices with 3D functionality

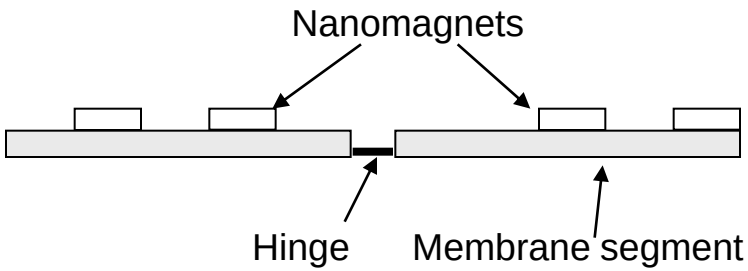
General Schematic



Example: Patterned SiN_x Bridge



Magnetic alignment overview



Pattern membrane segments, hinges and nanomagnet array

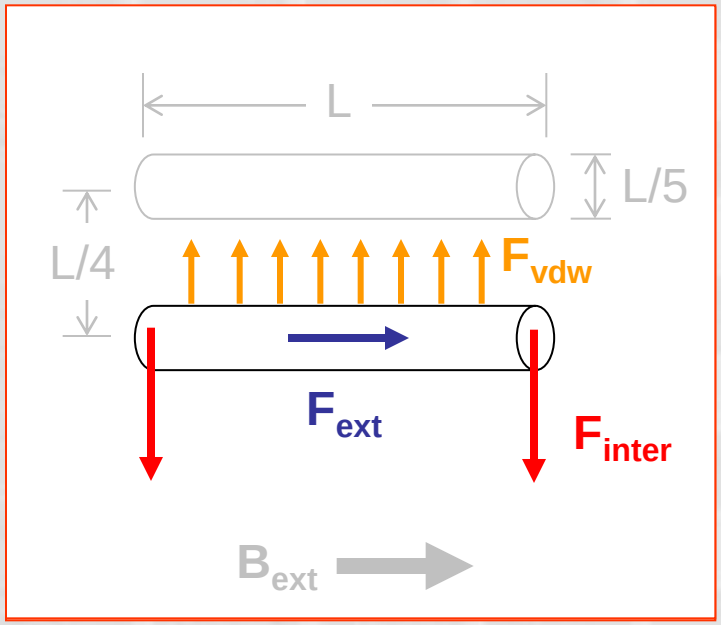
External Magnetic Field

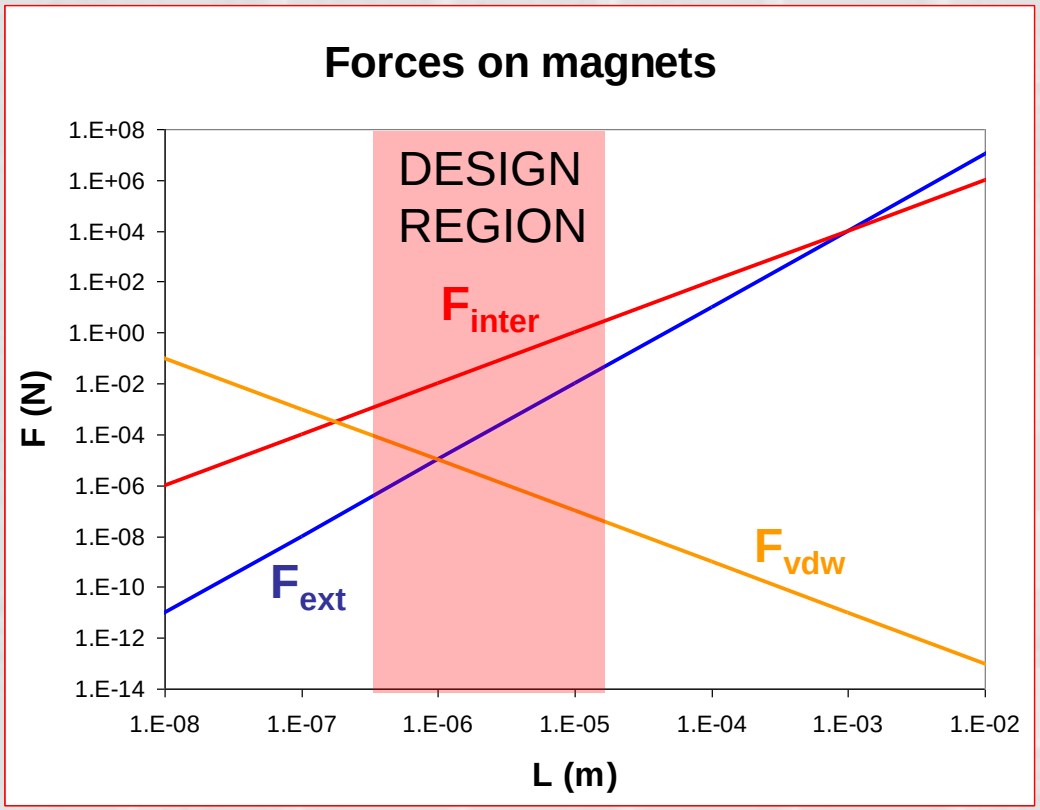
Coarse alignment using rotating magnetic field for torque on nanomagnets

Fine alignment using attractive force between arrays of nanomagnets

Forces on magnets in an external field

Two magnet schematic

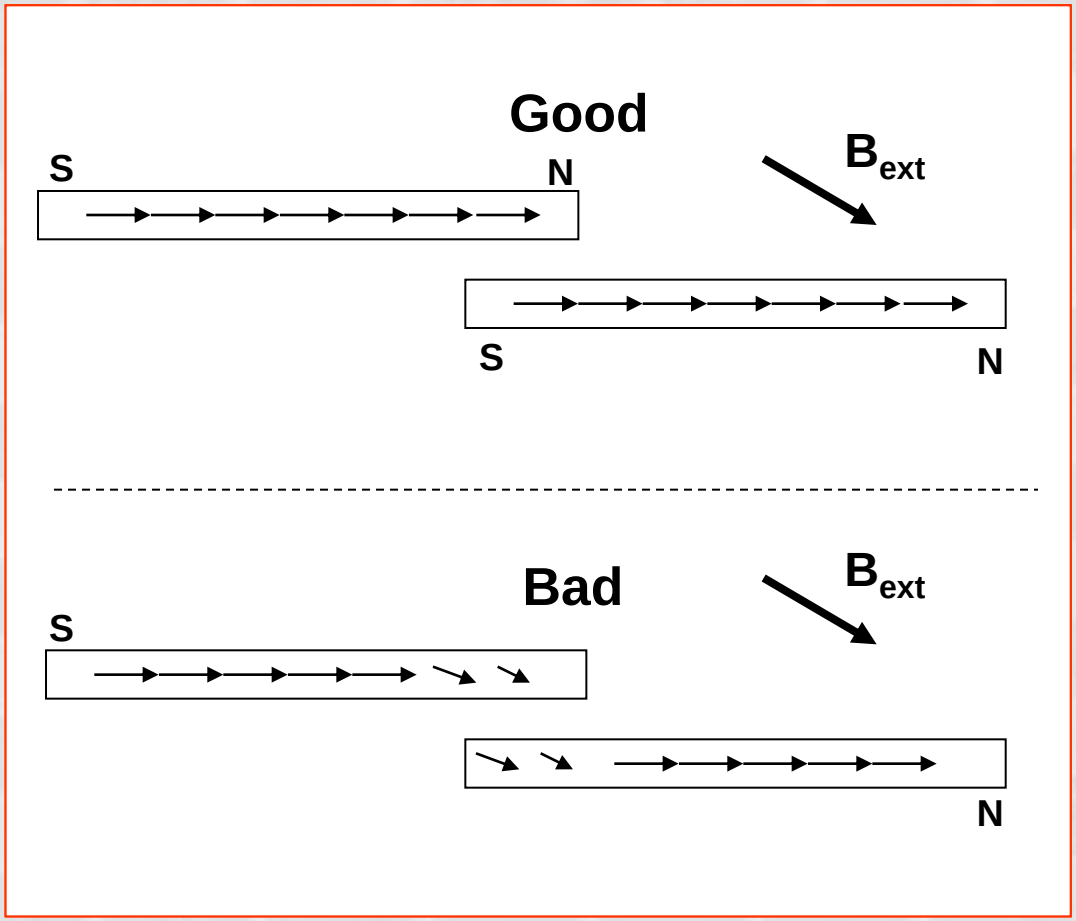




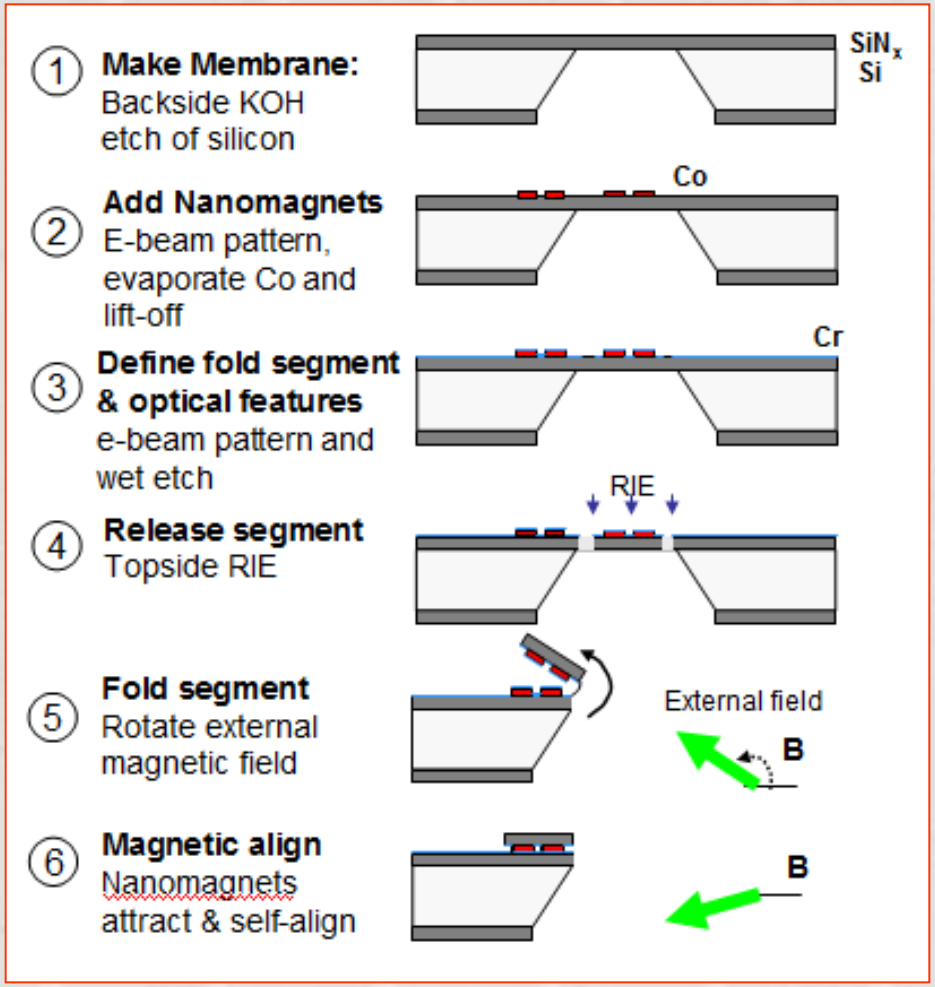
Optimization of nanomagnet array for alignment

Considerations

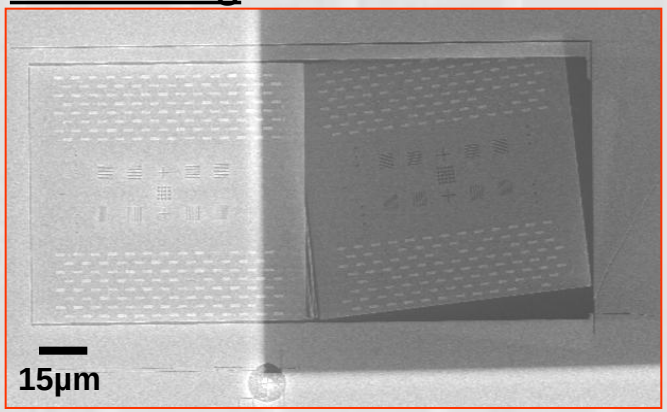
- Coarse alignment
- Error averaging
- Non-ideal dipole
- Other
  - External magnetic field
  - Membrane distortion
  - Single domain magnets
  - Flexure compliance
  - Van der Waals



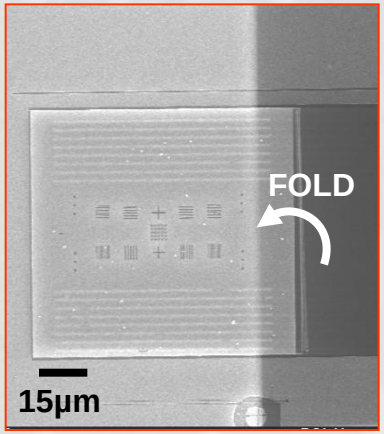
Process Flow- Integration of nanophotonic features and nanomagnets



Pre-folding



Post-folding



Parameters

Membrane:

1μm PECVD SiN_x

100 100μm

***Magnets*:**

60nm Cr/Co/Au

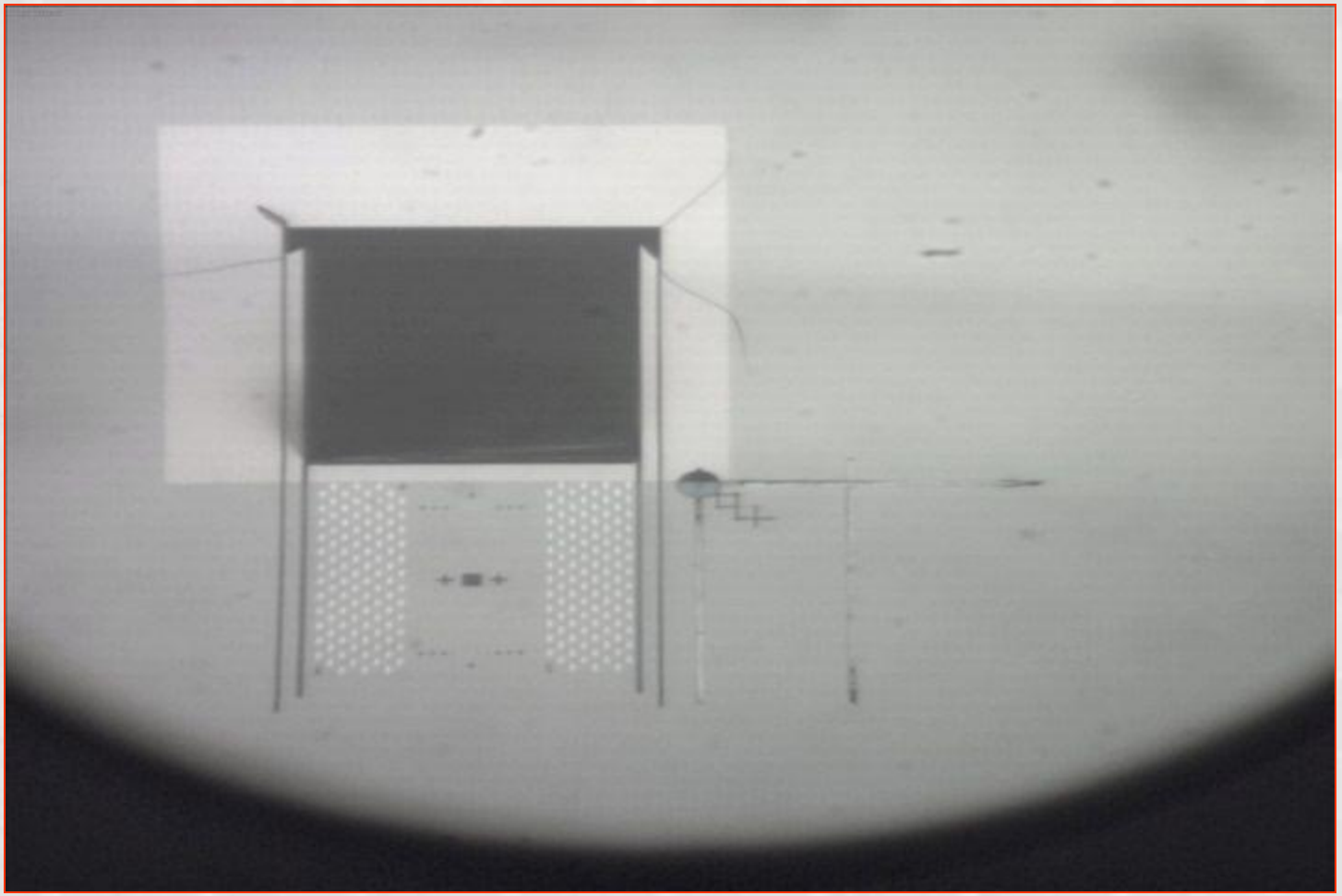
3 Sizes:

200×500nm

0.3×1μm

1×3μm

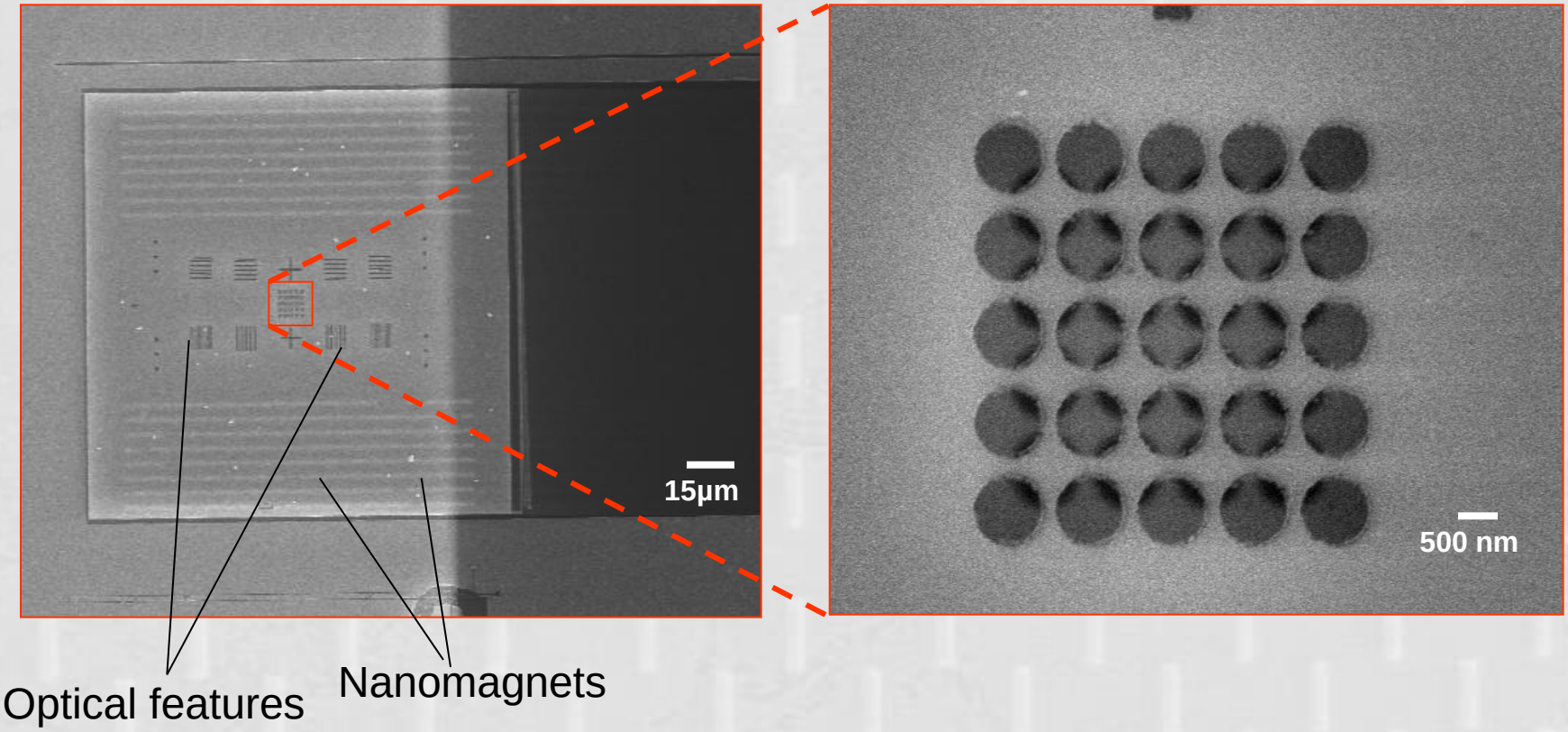
Alignment Video



Alignment Results- SEM

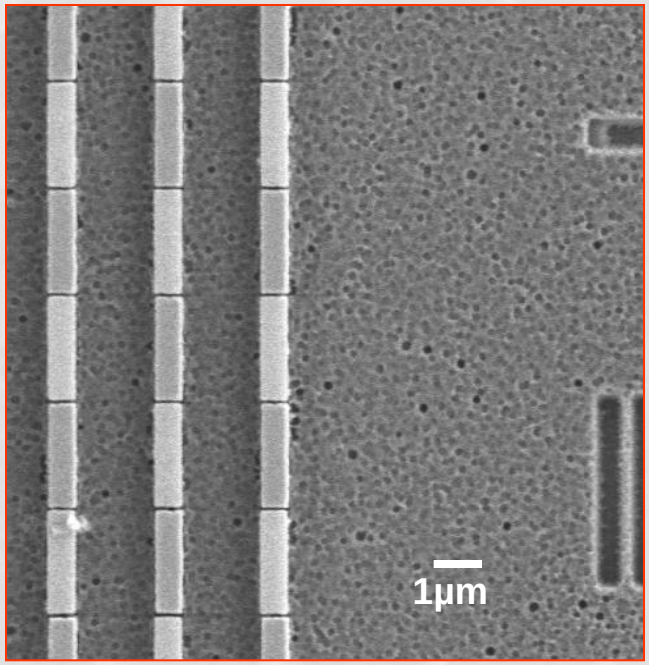
Aligned membranes

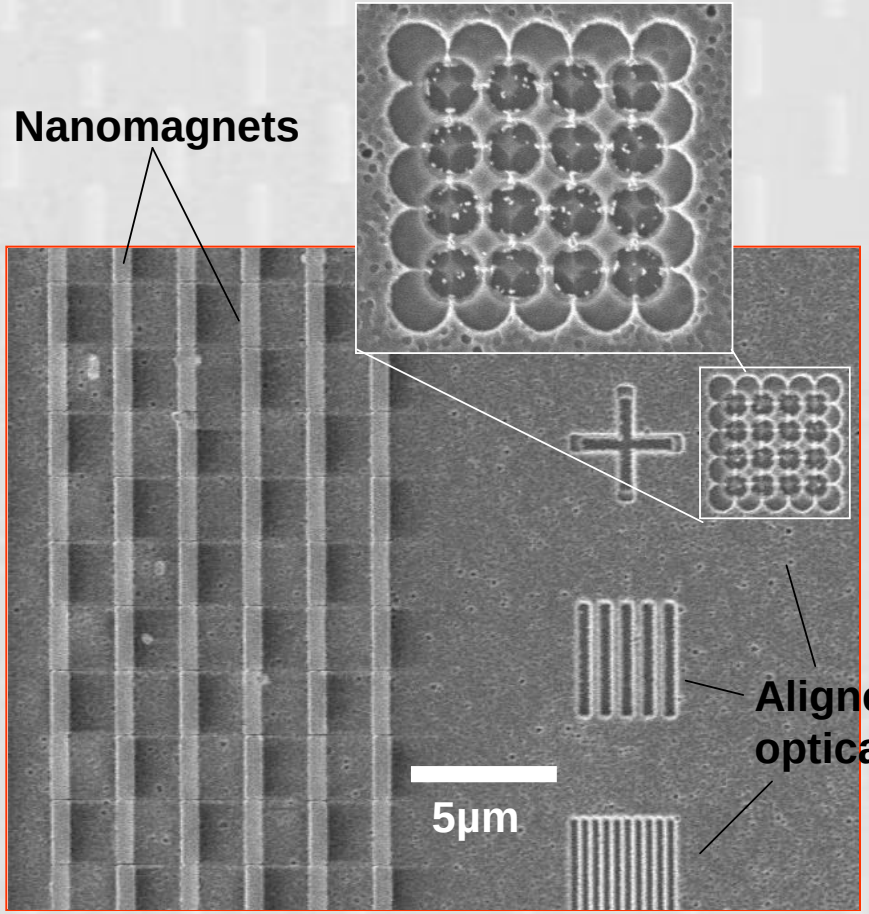
Two layers of circular voids



Results- after etching away top membrane

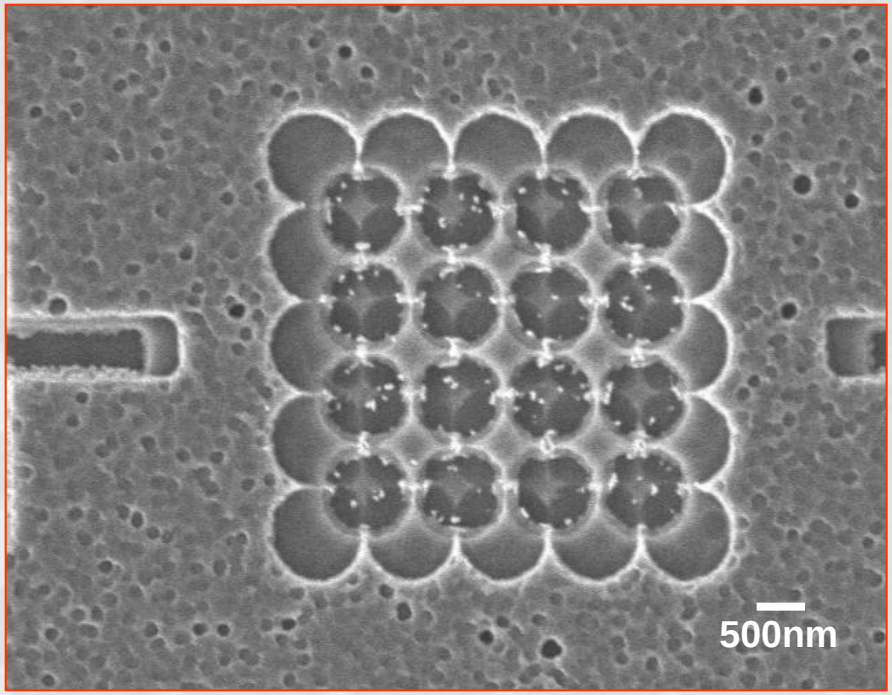
Aligned nanomagnets



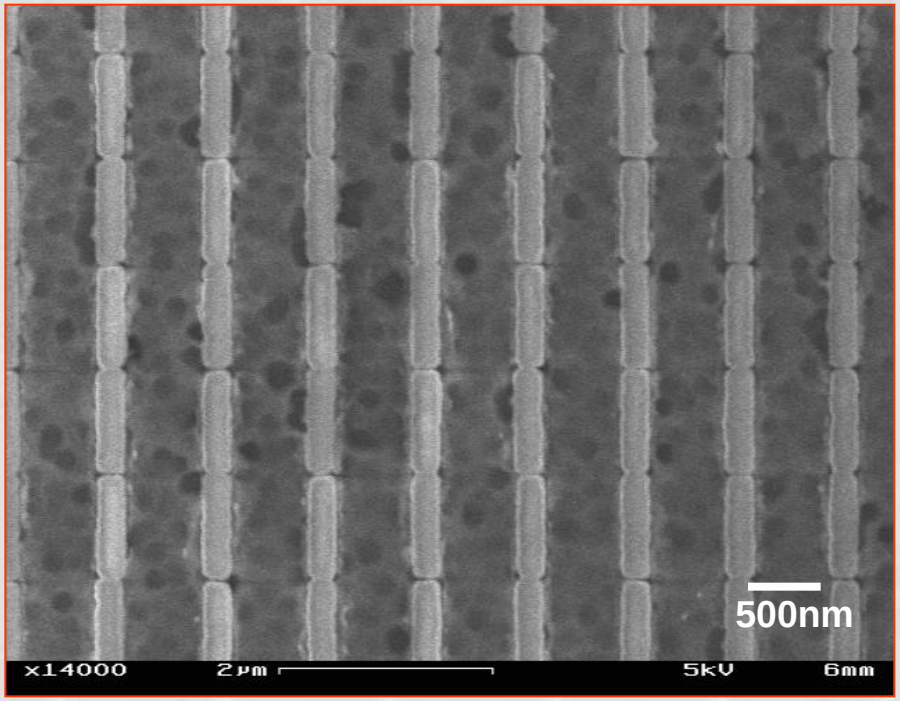


Results- after etching away top membrane

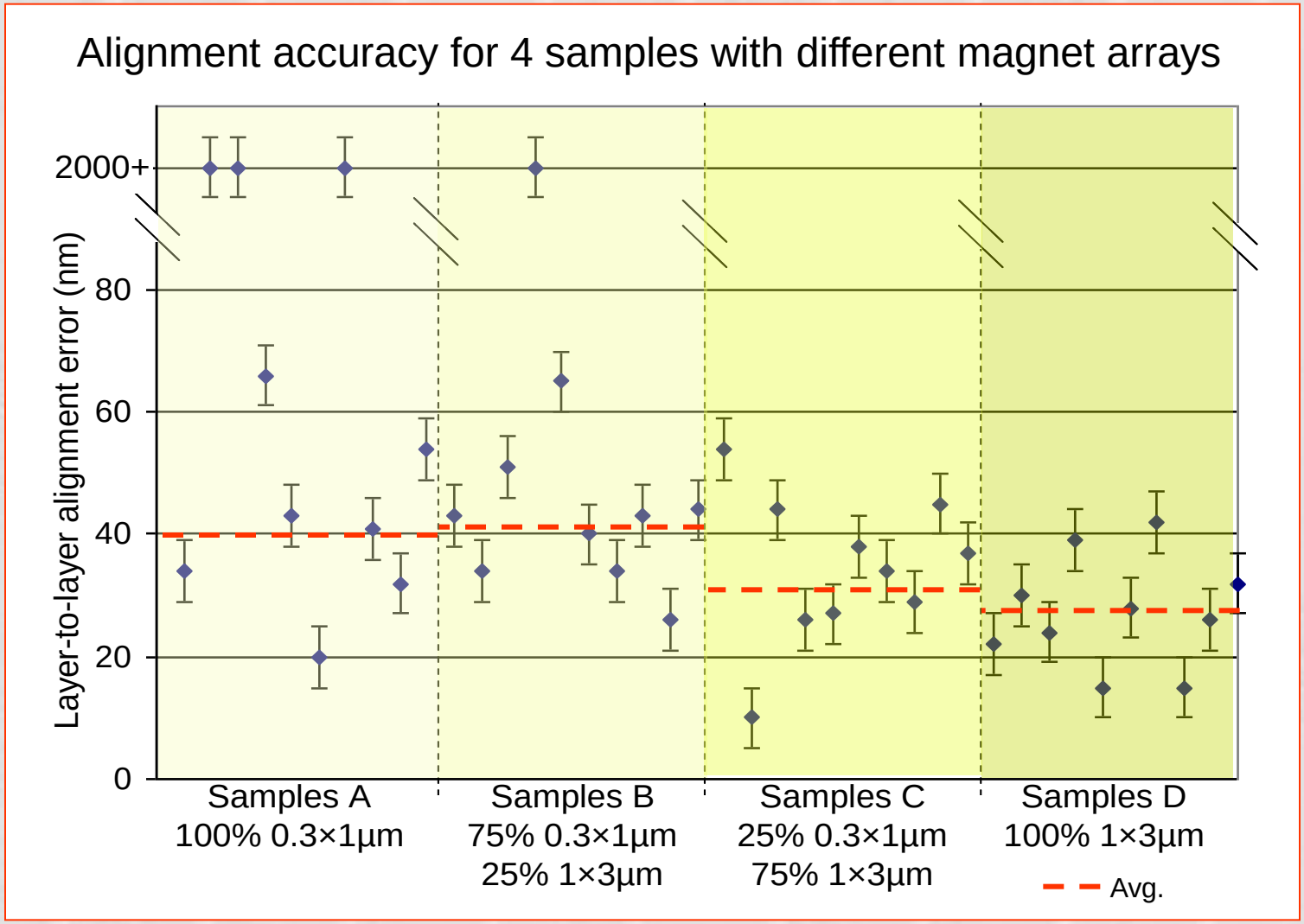
Circular voids after etch



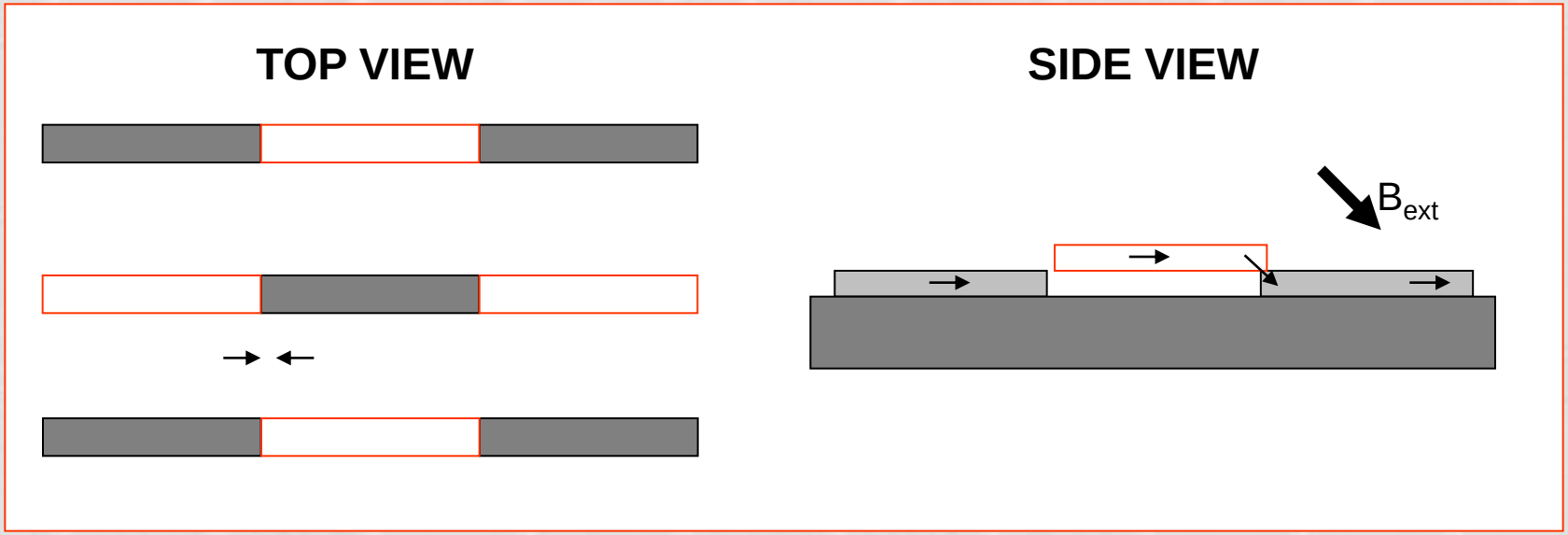
Aligned nanomagnets



Alignment results: 28nm accuracy



Further improvements/future work



- Constrain magnetization in-plane
- Pick-and-place layering method
- Multi-layer photonic structure

Thank you

Nanostructured Origami™ Researchers:
- Will Arora
- Hyun Jin In
- Satoshi Takahashi
- Nader Shaar

MIT NanoStructures Laboratory:
- Prof. Henry I. Smith
- Prof. Karl Bergren
- Jim Daley

Research funding:
- MIT Institute for Soldier Nanotechnology
- NSF Graduate Research Fellowship

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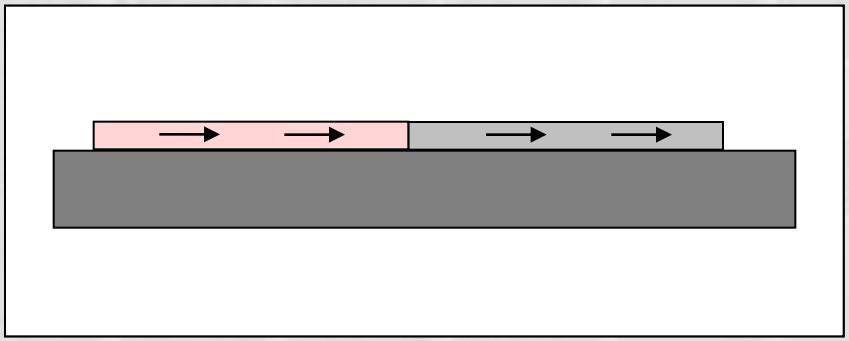
Improvements for sub-10nm alignment

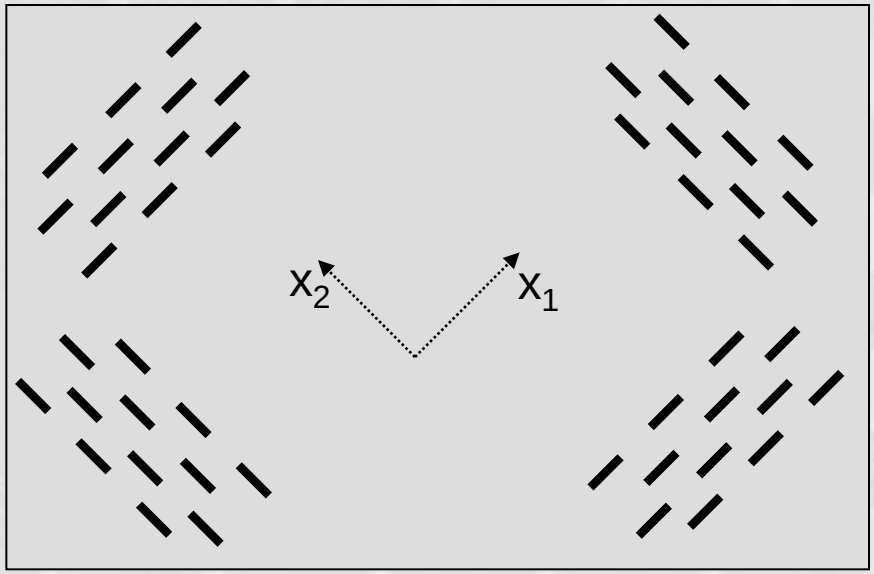
Single in-plane domain

- High external field
- Nanomagnet size & geometry



90º Layout of magnets

- High external field
- Nanomagnet size & geometry



Future work and improvements

- Single domain nanomagnets
- New membrane materials
- “Stack-n-Snap” layering method