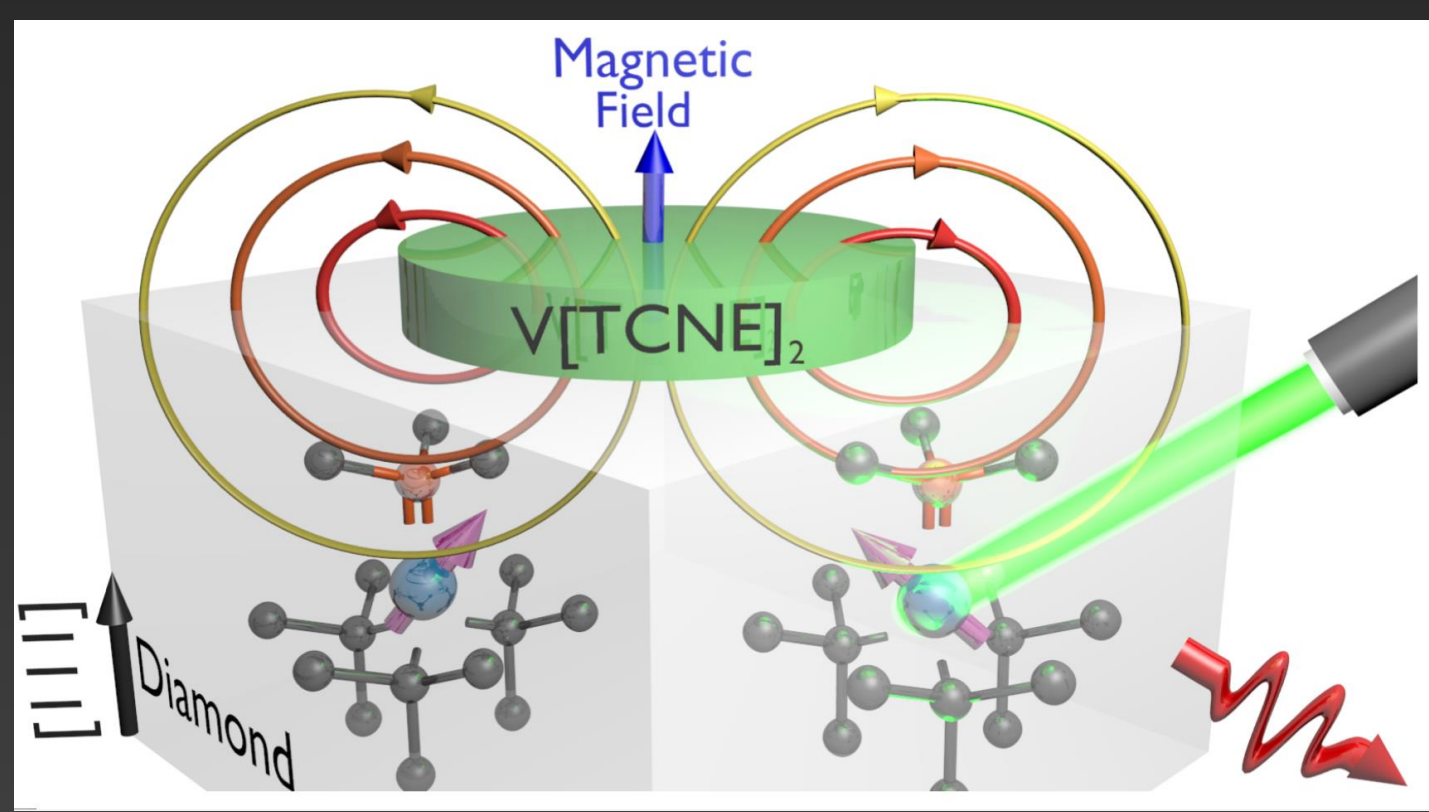


# J-H GROUP

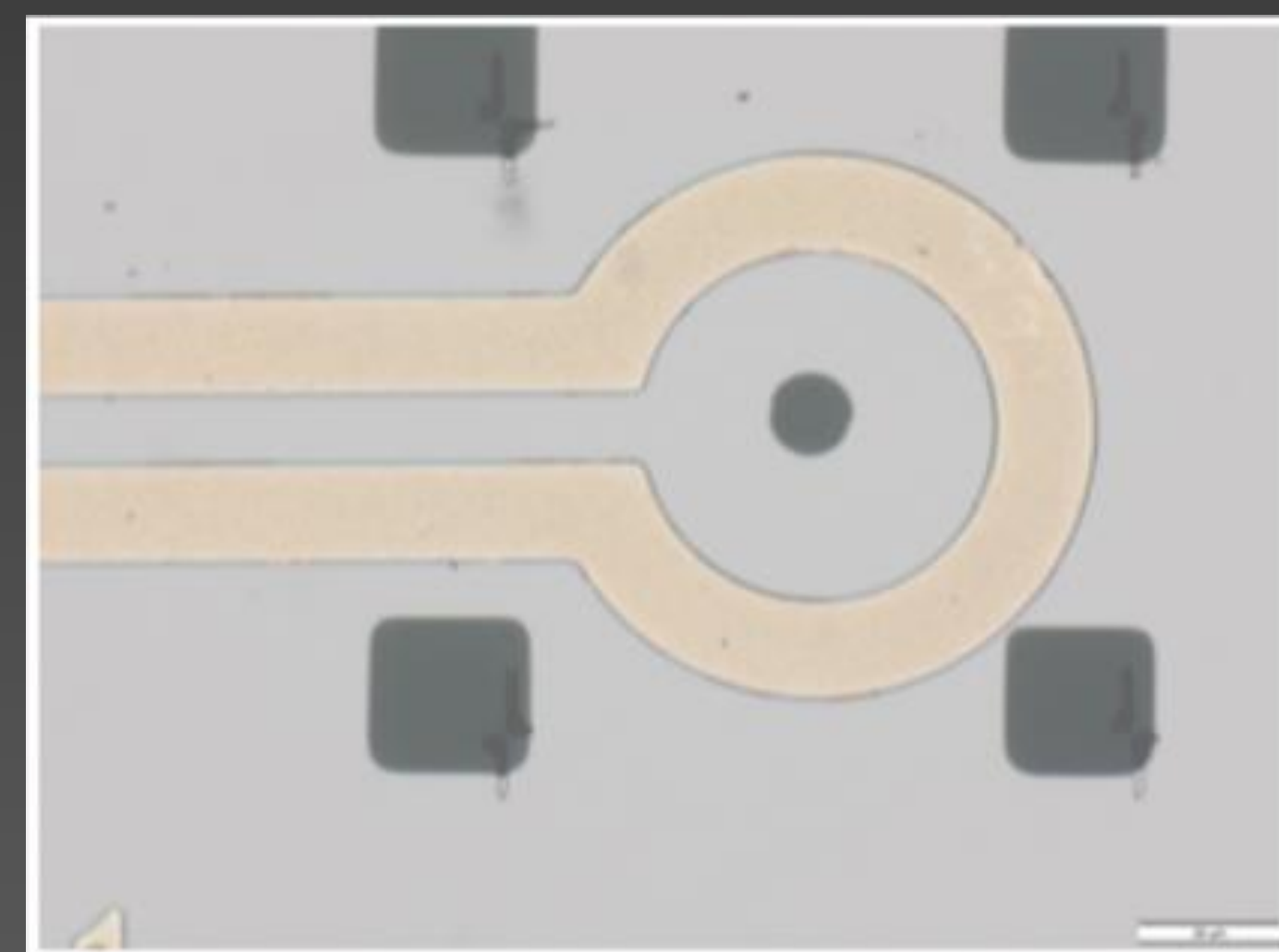
## Quantum Information

Using the quantum state of a system for information transfer and processing



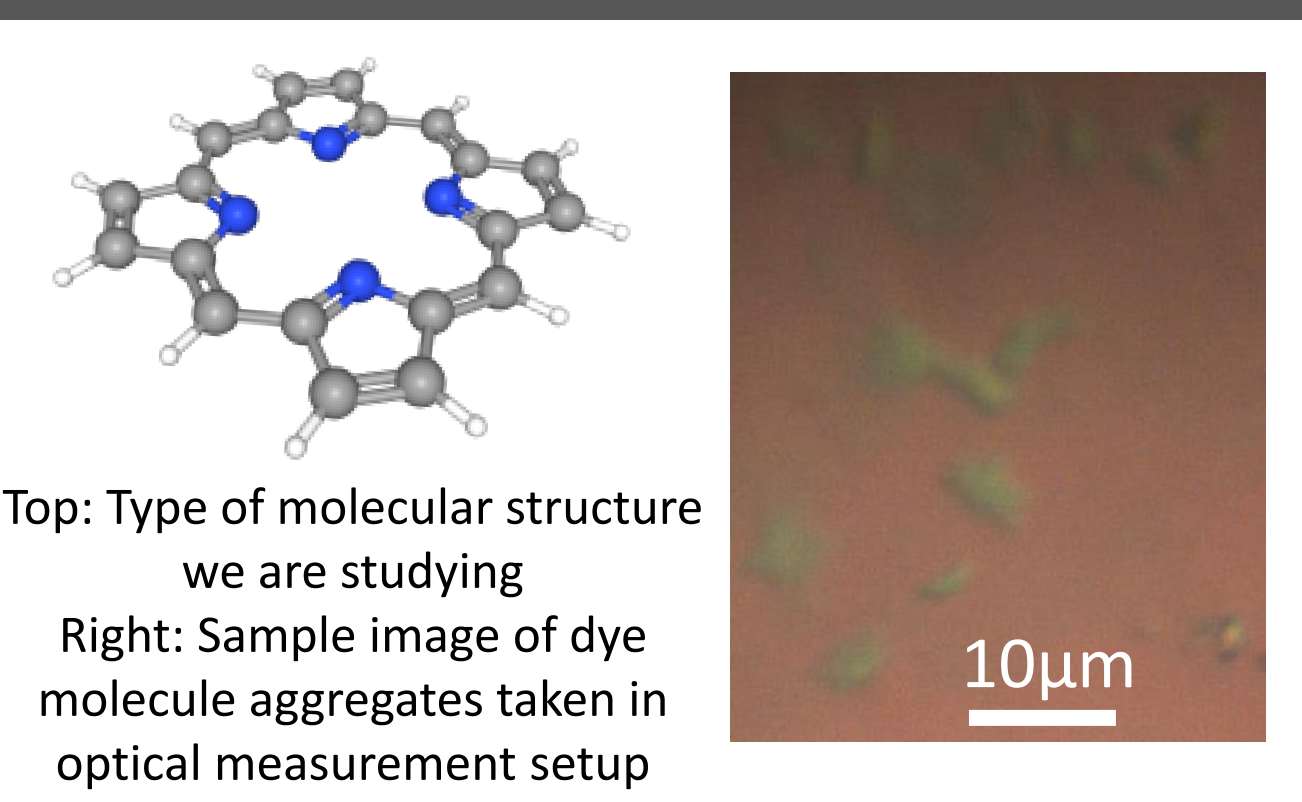
### Magnon - Spin Qubit Coupling

- Magnon modes in a  $V[TCNE]_{x \sim 2}$  disc can be used to coherently couple remote spin qubits
- Scalable quantum transduction over micron length scales



### On-chip $V[TCNE]_{x \sim 2}$ Integration

- First ever on-chip integration of  $V[TCNE]_x$  with diamond microwave device!
- Lift-off patterning using e-beam lithography
- No increase of damping on patterning (see Coherent Magnonics)

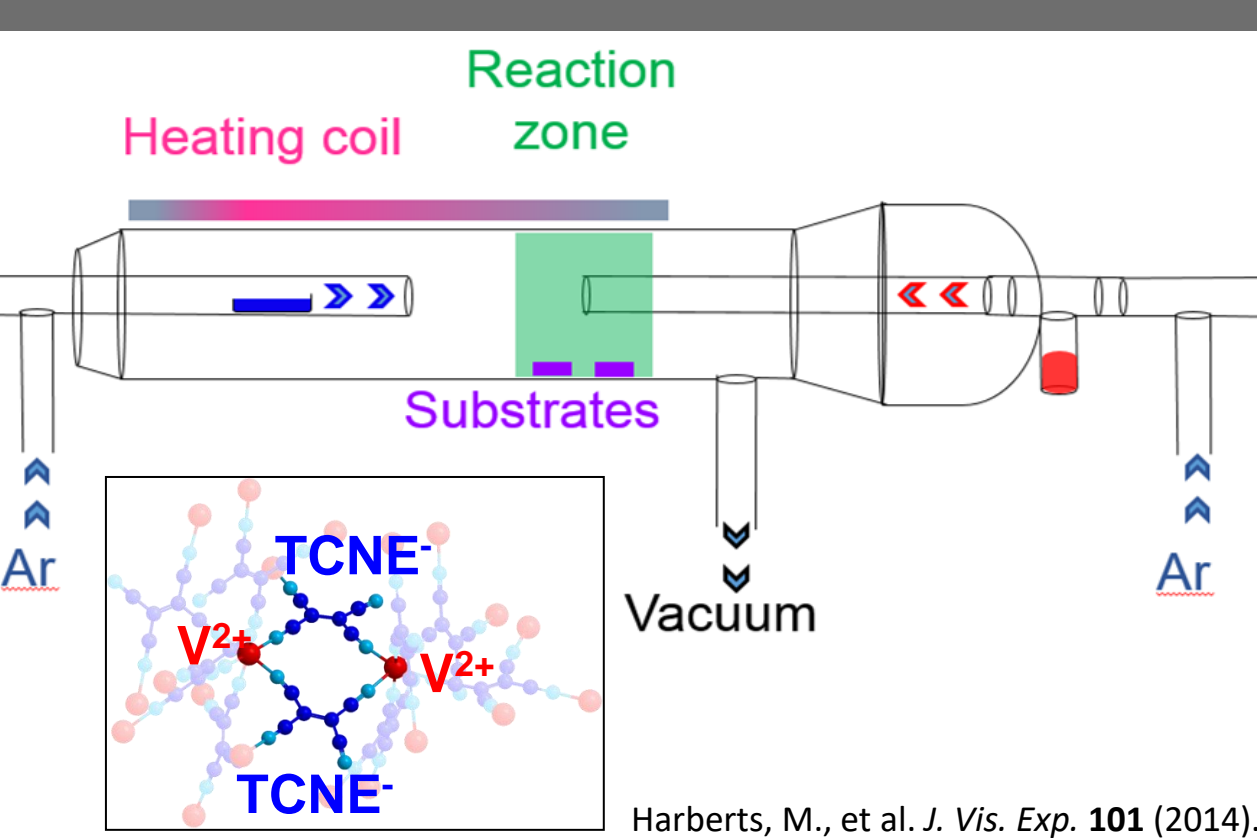


### Molecular Qubits

- Deposit candidate molecular qubit systems on surfaces and incorporate into solid state devices
- Optical (left) and electrical measurements of spin resonance

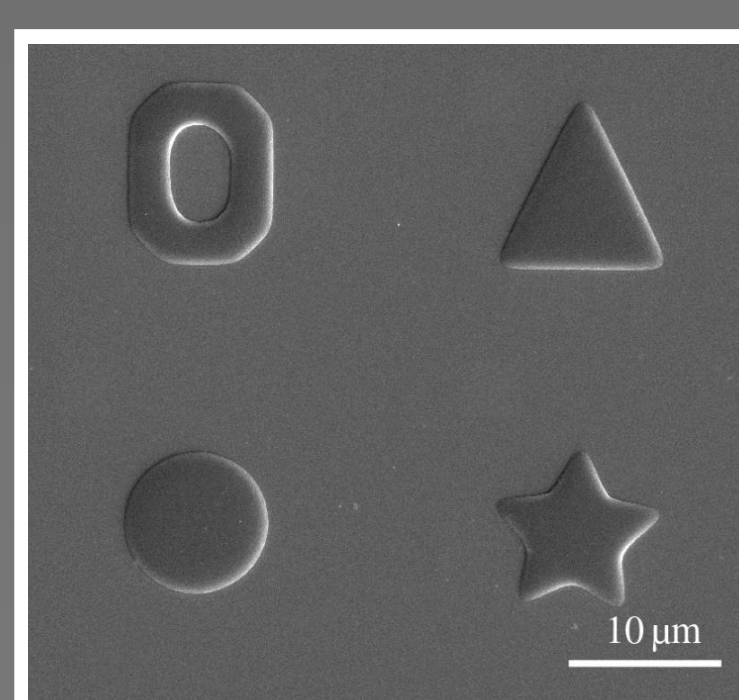
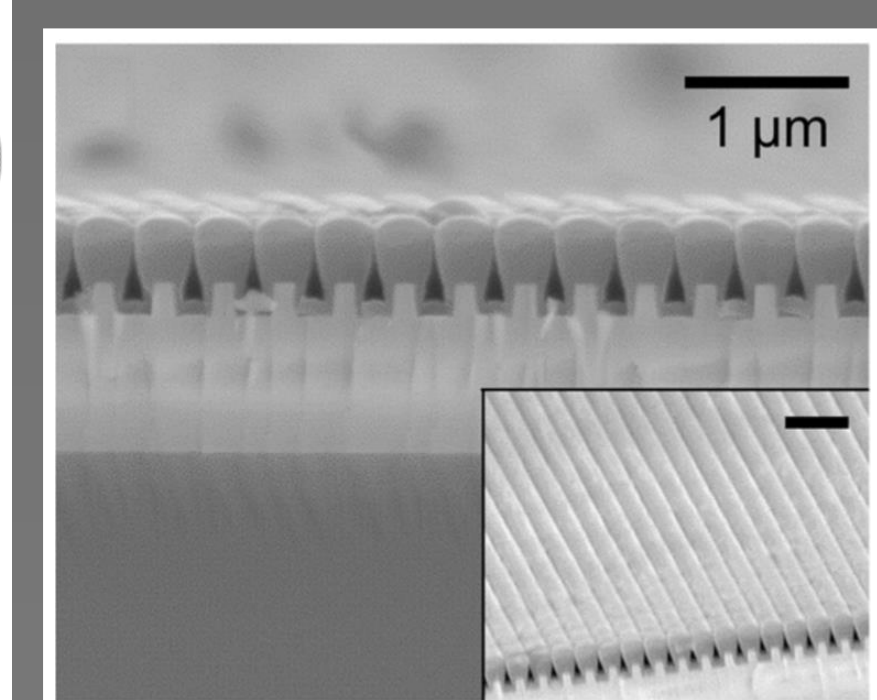
## Coherent Magnonics

### Magnetism in $V[TCNE]_{x \sim 2}$



Templated Patterning

Lithography



- Robust room temperature ferrimagnetic semiconductor
- World class linewidth ( $< 1$  G) and Gilbert damping ( $\sim 4 \times 10^{-5}$ )
- Low saturation magnetization ( $4\pi M_s \sim 75$  G)
- Deposits well on many substrates via chemical vapor deposition

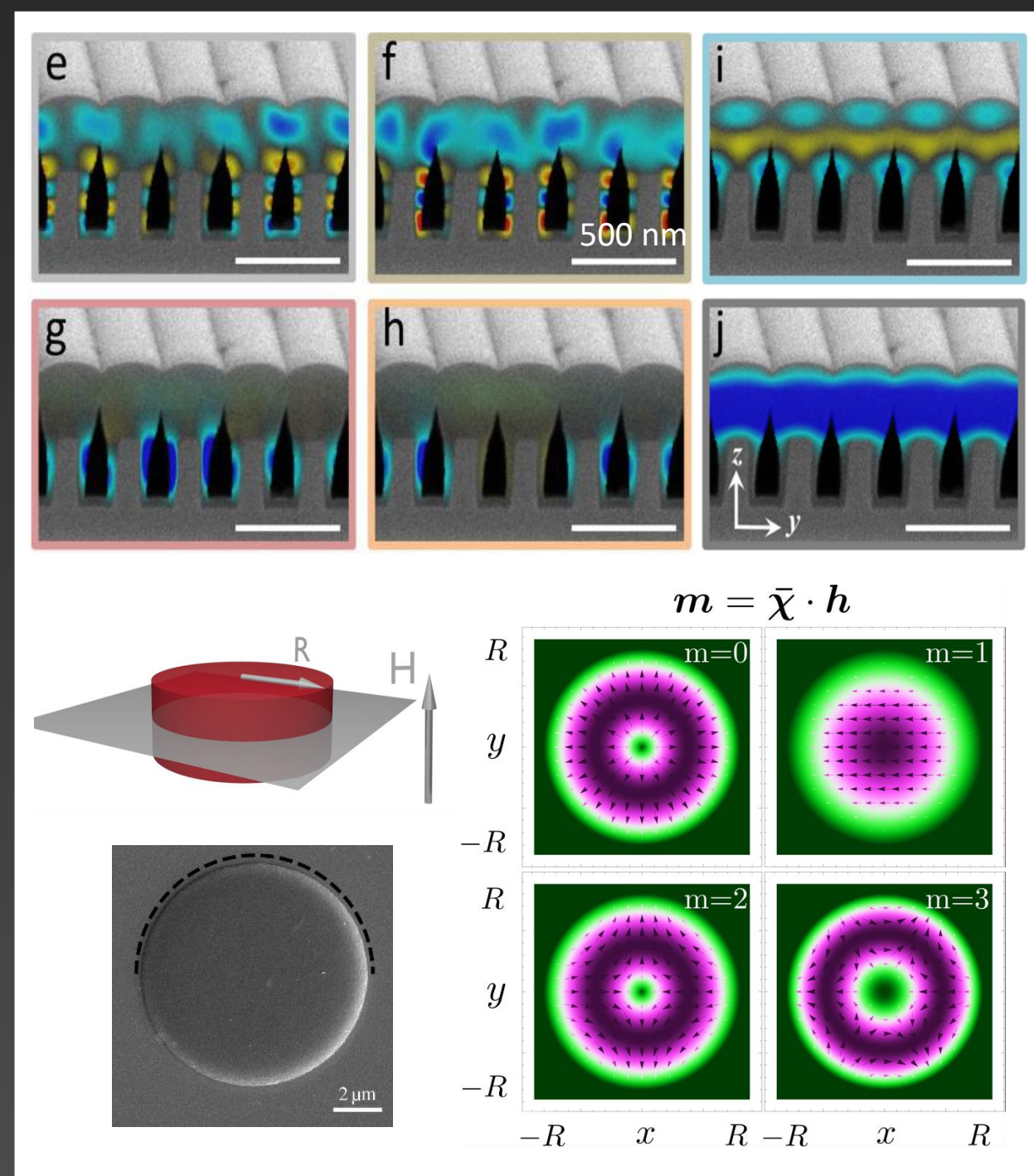
## Principal Investigator: Ezekiel Johnston-Halperin

Group Members: Andrew Franson, Ethel Perez-Hoyos, Michael Swartz, Prerna Kabtiyal, Huma Yusuf, Seth Kurfman, Donley Cormode, Benjamin Hillman, Ellie Holmgren, Zoe Phillips

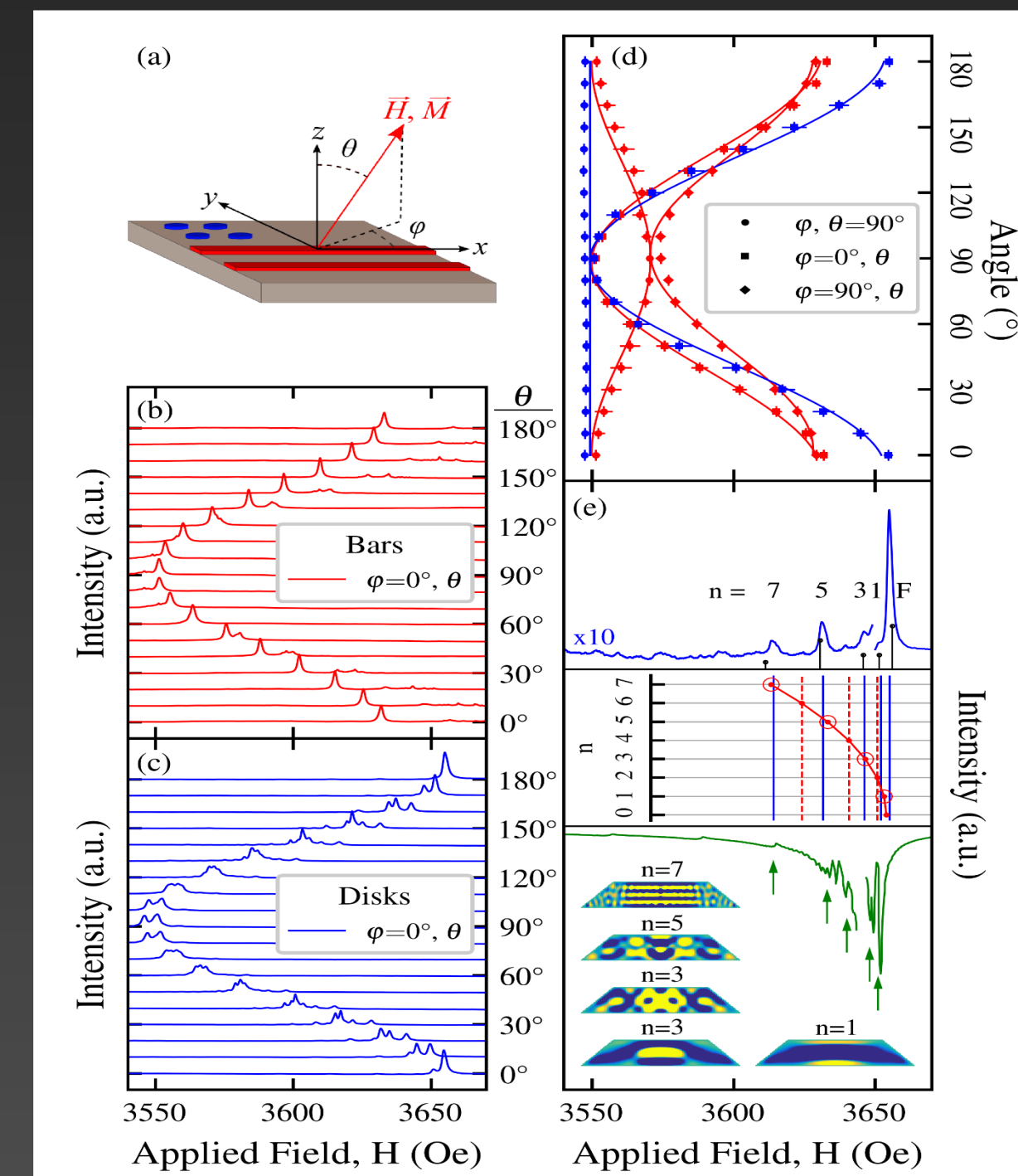
## Coherent Magnonics (cont.)

### $V[TCNE]_{x \sim 2}$ Patterning

#### Magnon Modes in $V[TCNE]_x$



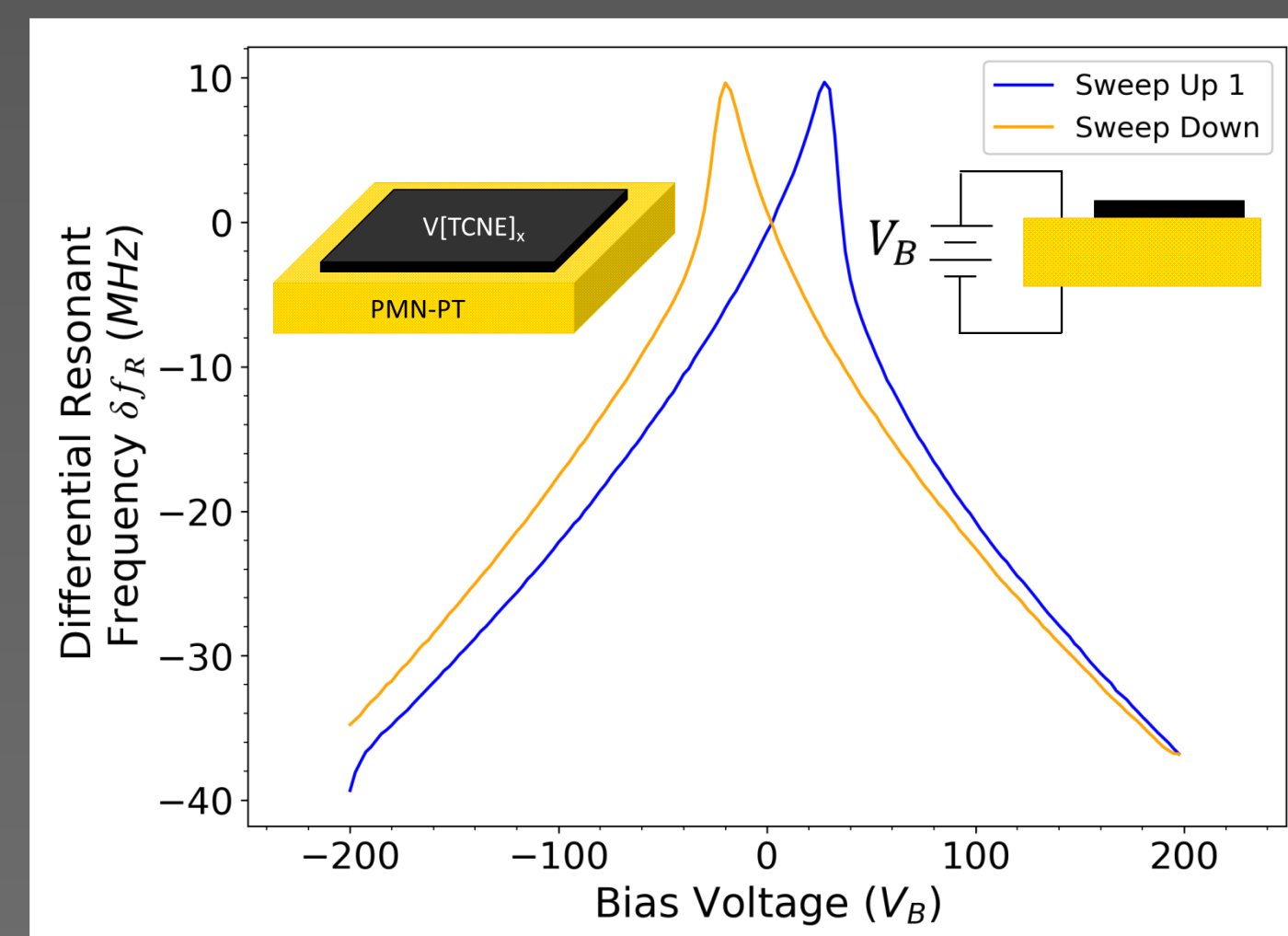
#### High-Q Magnon Cavities



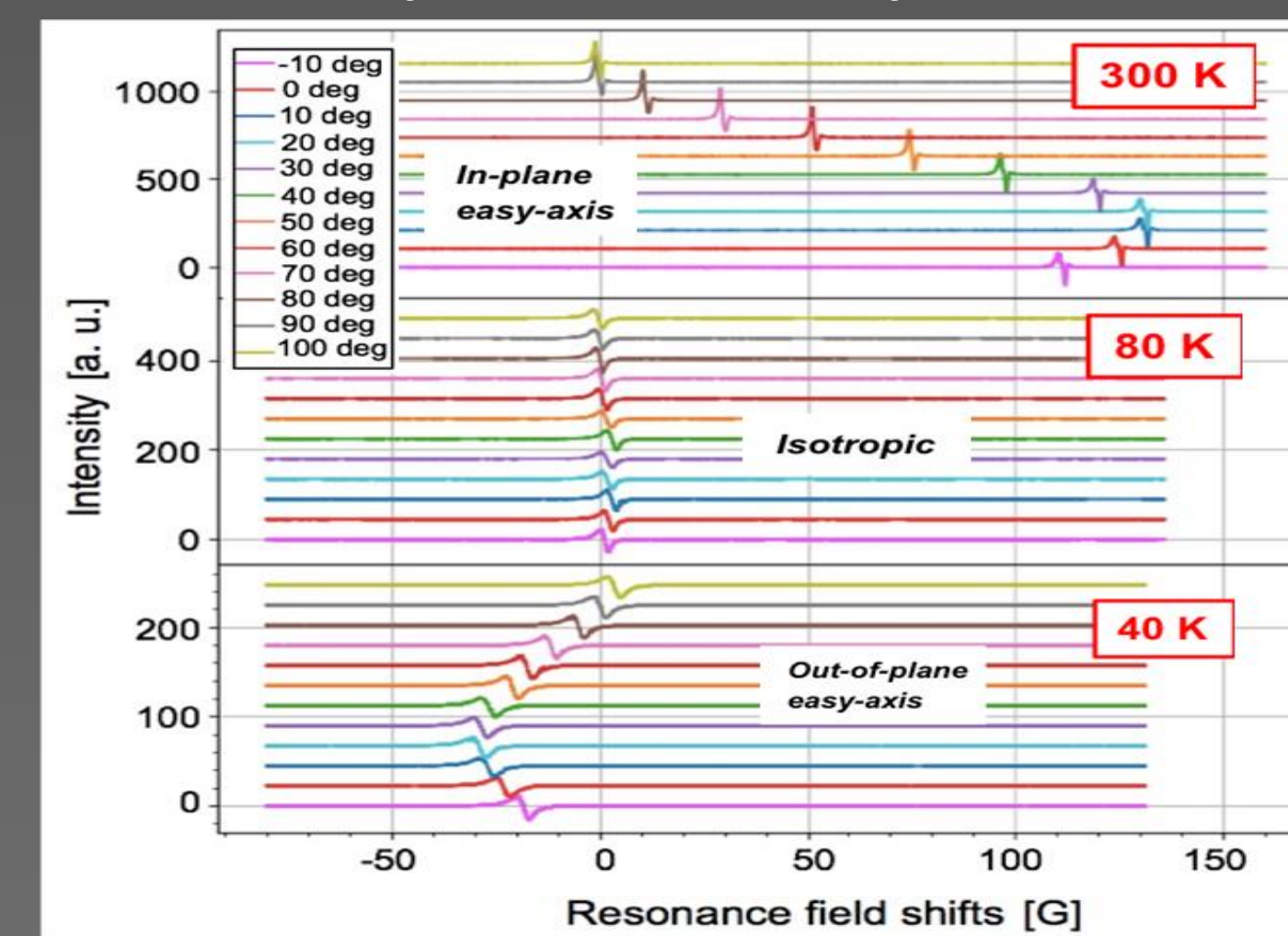
- Extending standard lithographic techniques allows for patterning of this unique magnetic material and facile on-chip integration of  $V[TCNE]_x$
- Negligible increase in damping allows for highly coherent magnon cavities

### Strain-Tuning of Magnetism in $V[TCNE]_{x \sim 2}$

#### Electric-Field Control

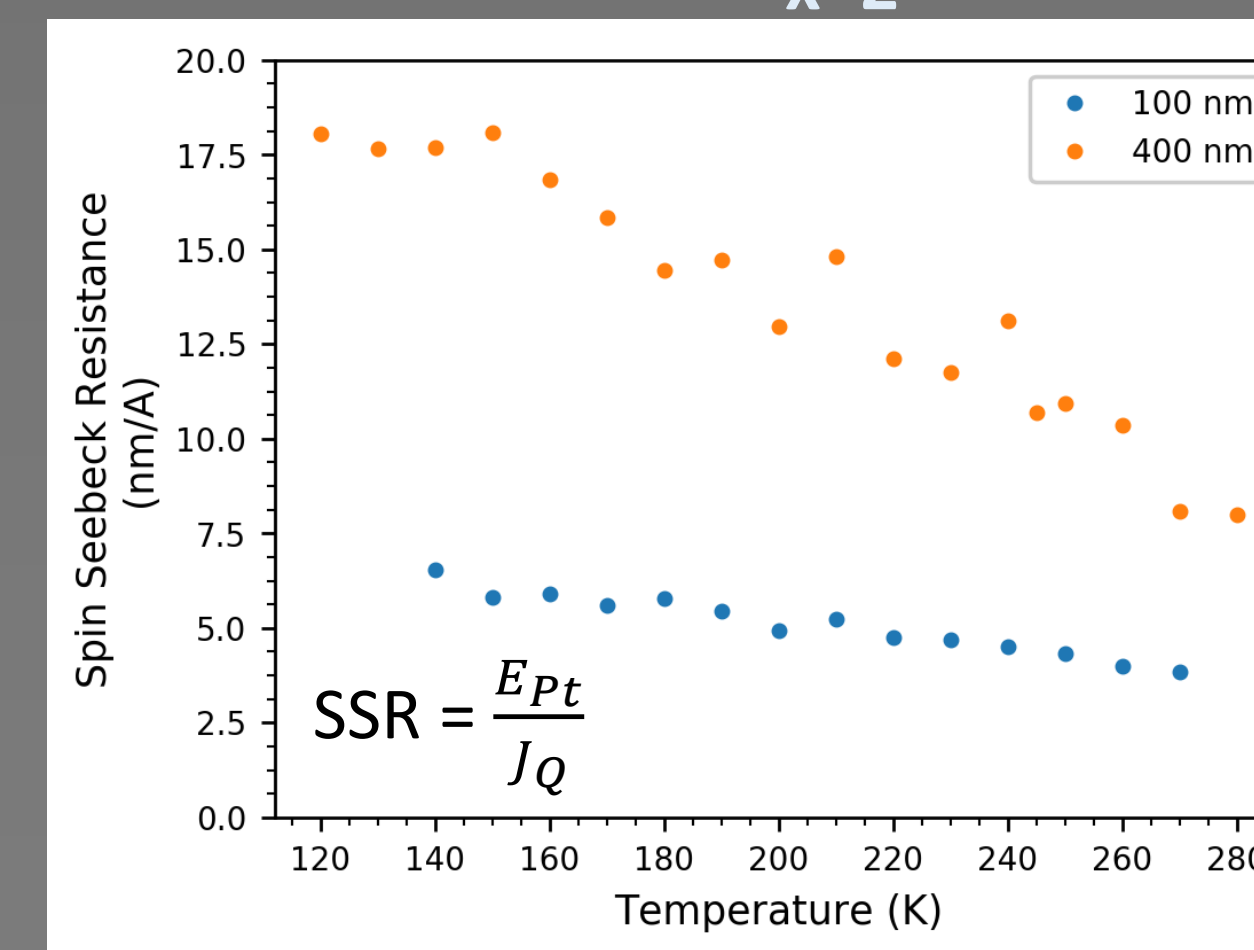
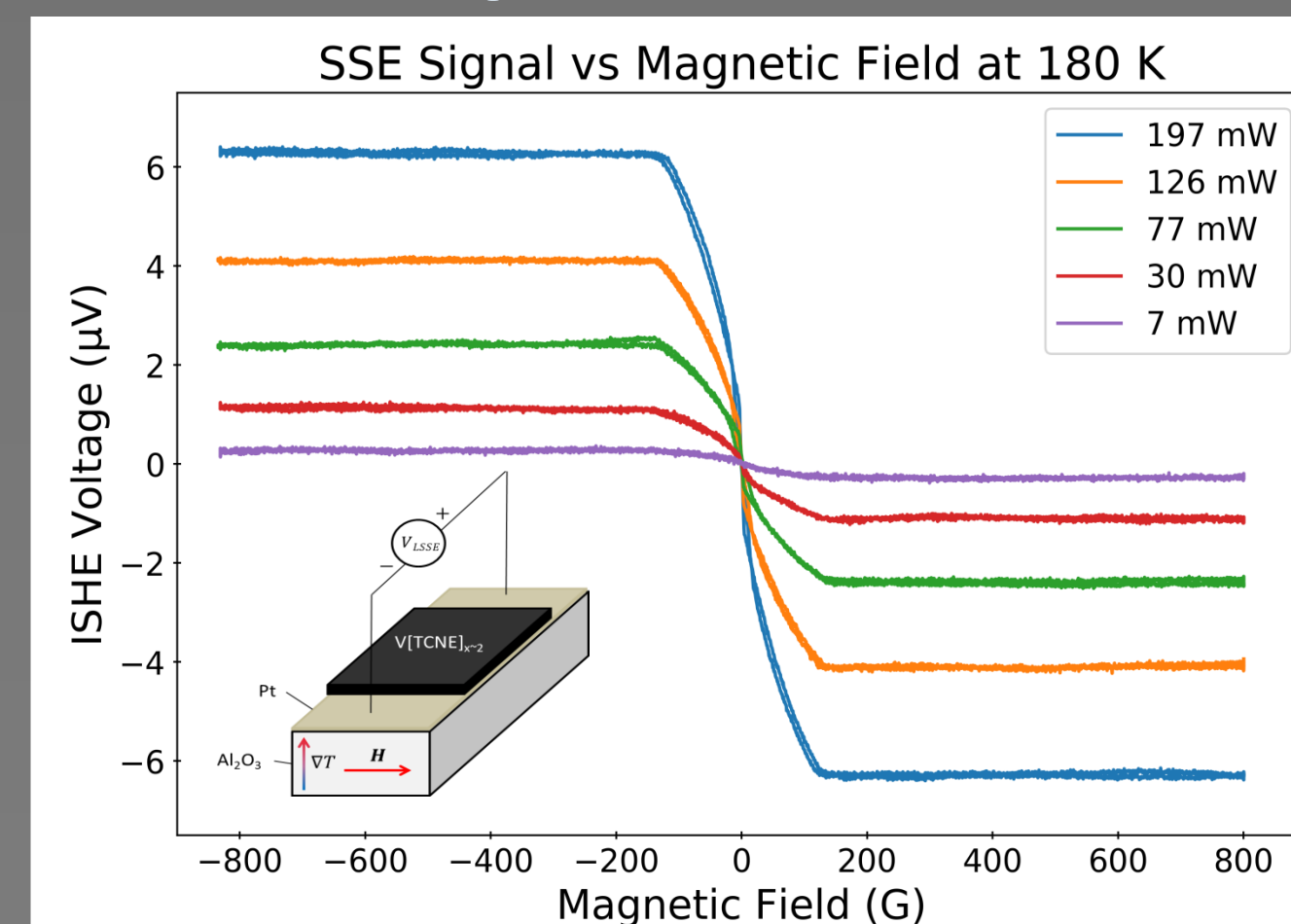


#### Temperature-Dependent



- Electric-field control of strain in piezoelectric substrate propagates into  $V[TCNE]_x$  to tune FMR resonance frequency
- Differential thermal expansion between  $V[TCNE]_x$  and substrate induces strain that changes magnetic anisotropy from in-plane to out-of-plane

### Spin-Thermal Phenomena in $V[TCNE]_{x \sim 2}$



- Spin Seebeck effect – excitation of magnon spin current  $J_S$  with  $\nabla T$
- Spin Seebeck resistance – normalizes SSE voltage to heat flux  $J_Q$  to allow for direct comparison between SSE in magnetic materials

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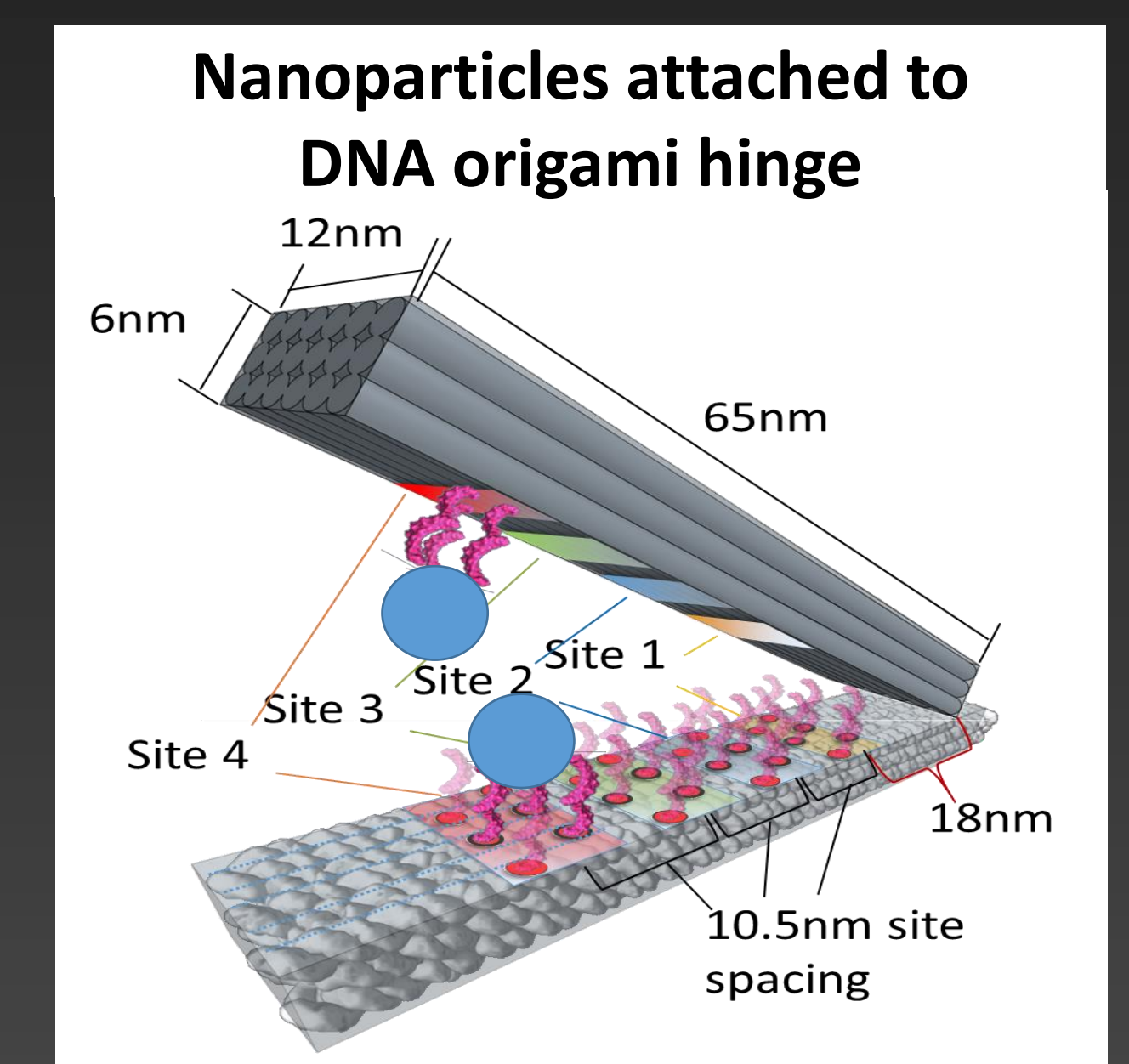
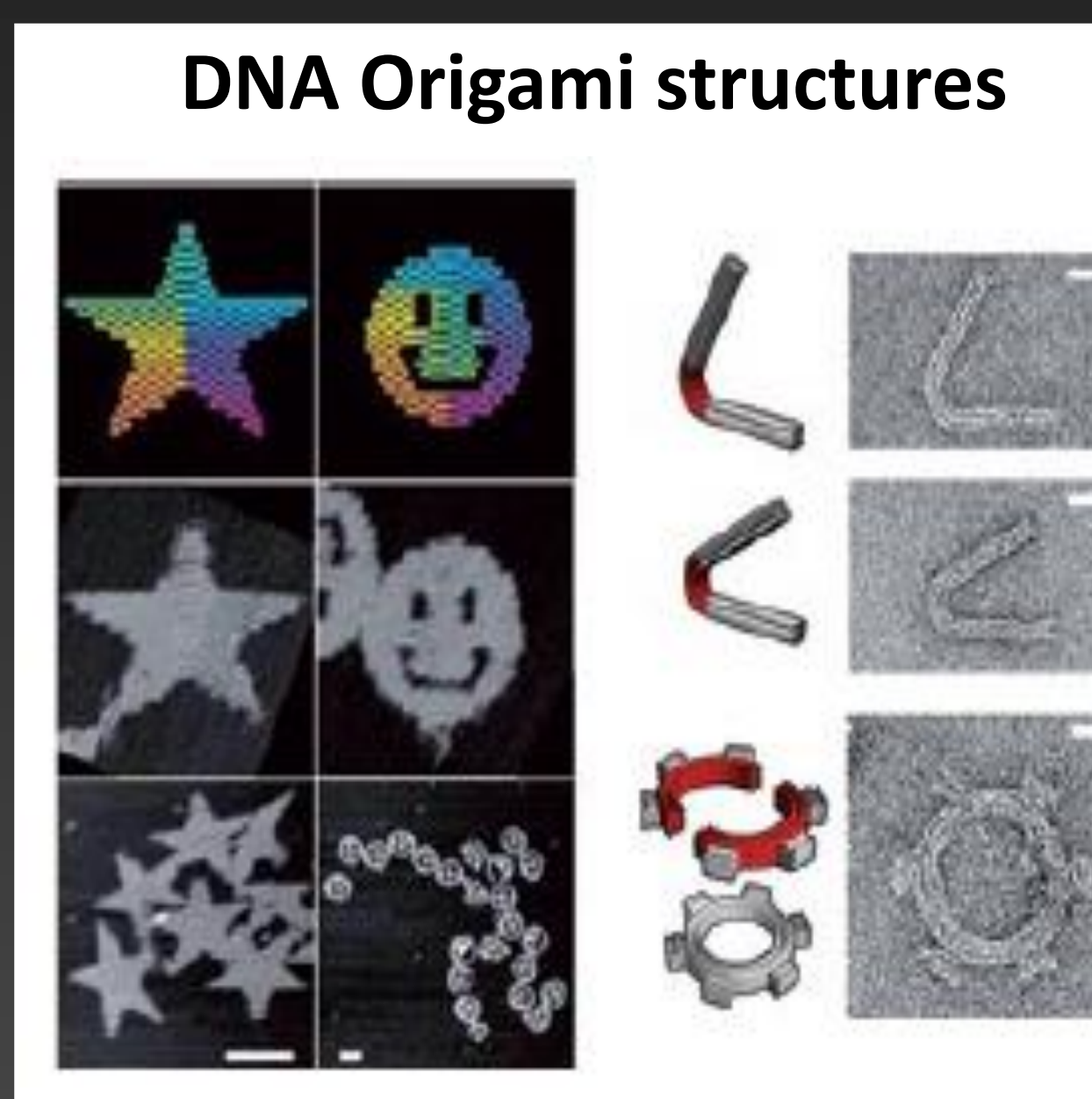
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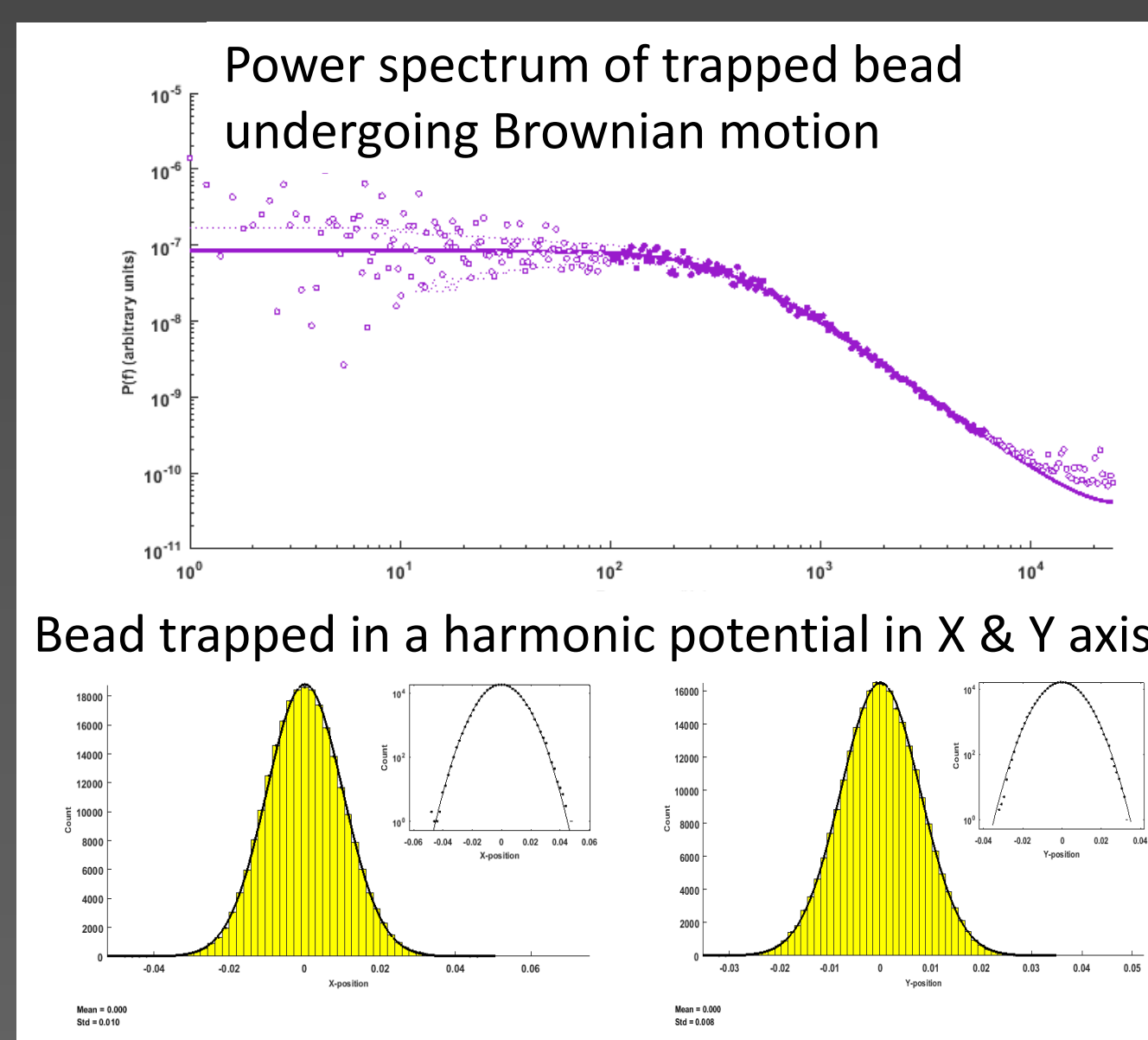
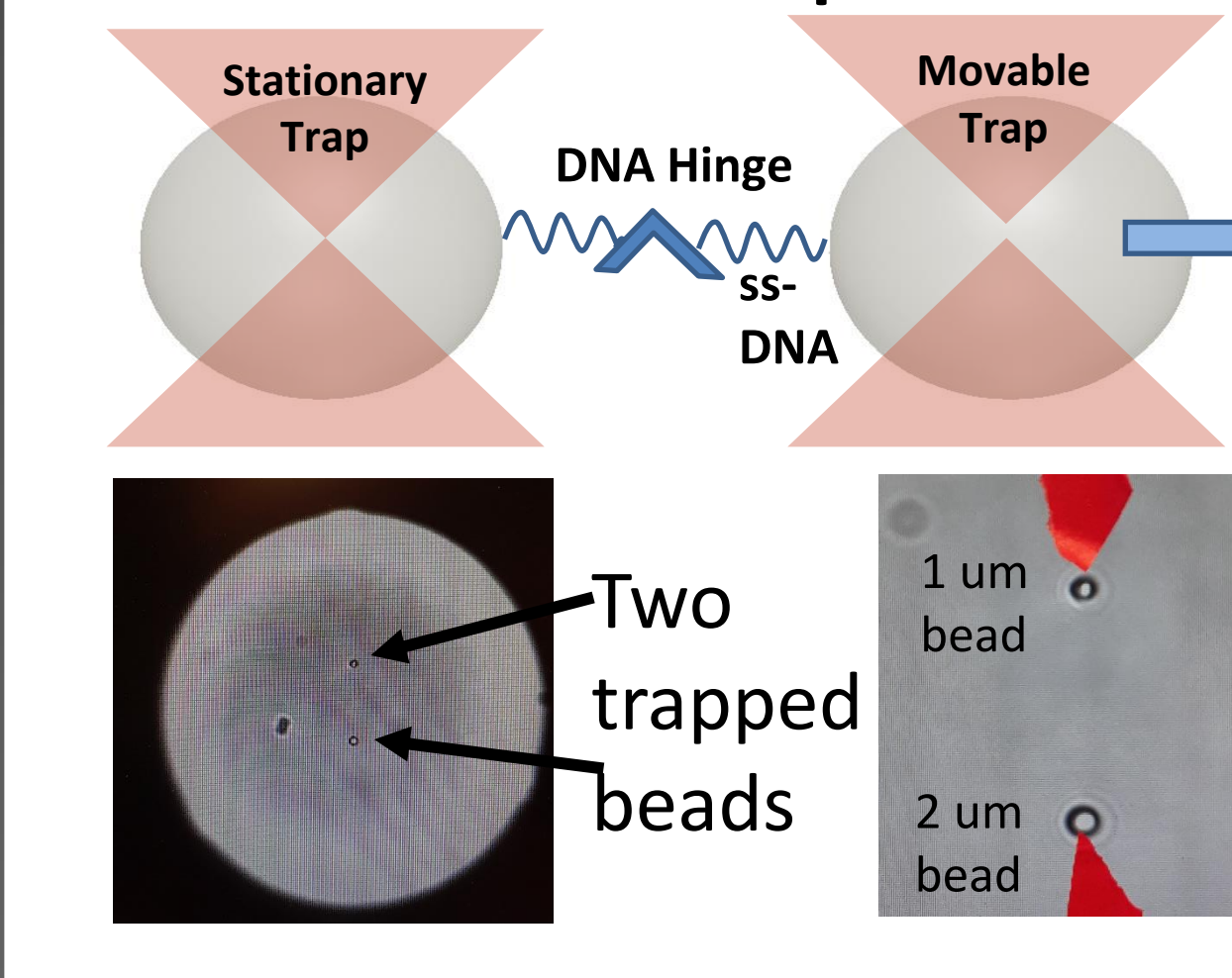
## DNA Origami

### Dynamics of DNA Hinge-Nanoparticle Structures



- DNA strands are manipulated to engineer machine-like structures

### Two beads held and manipulated with the traps



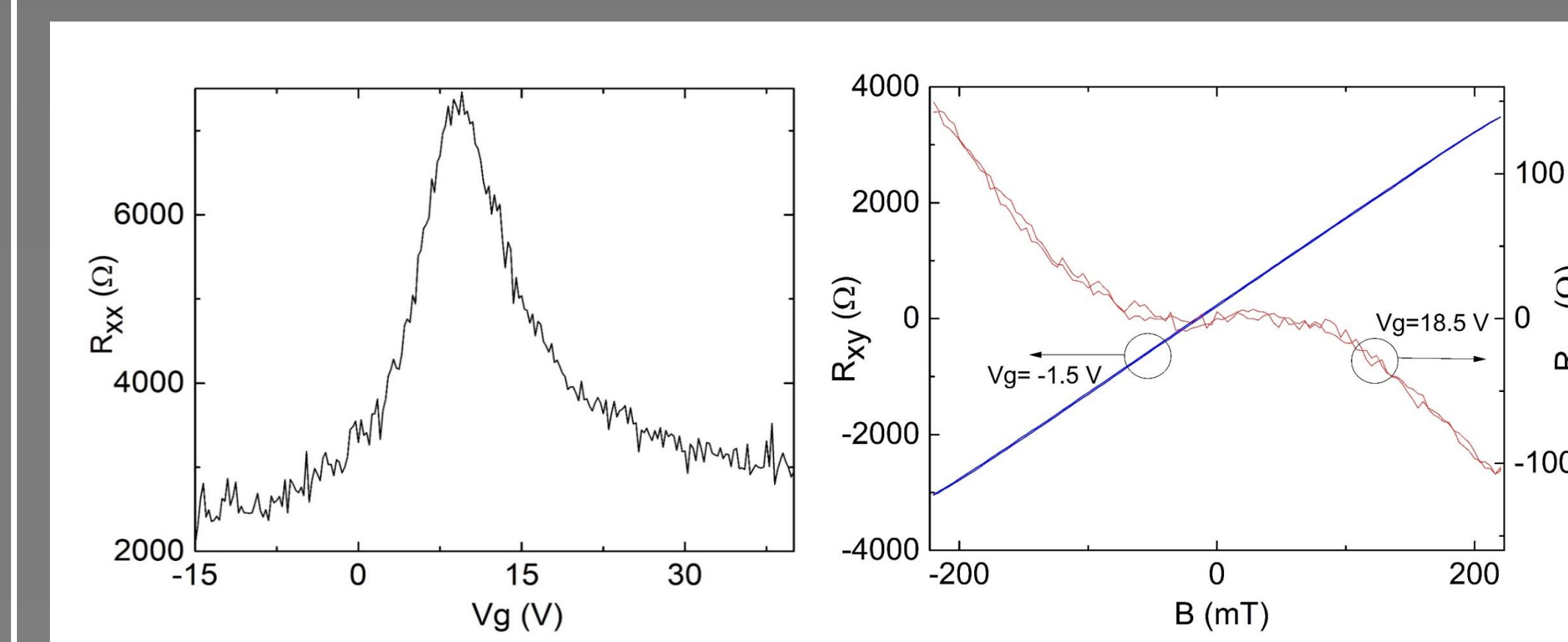
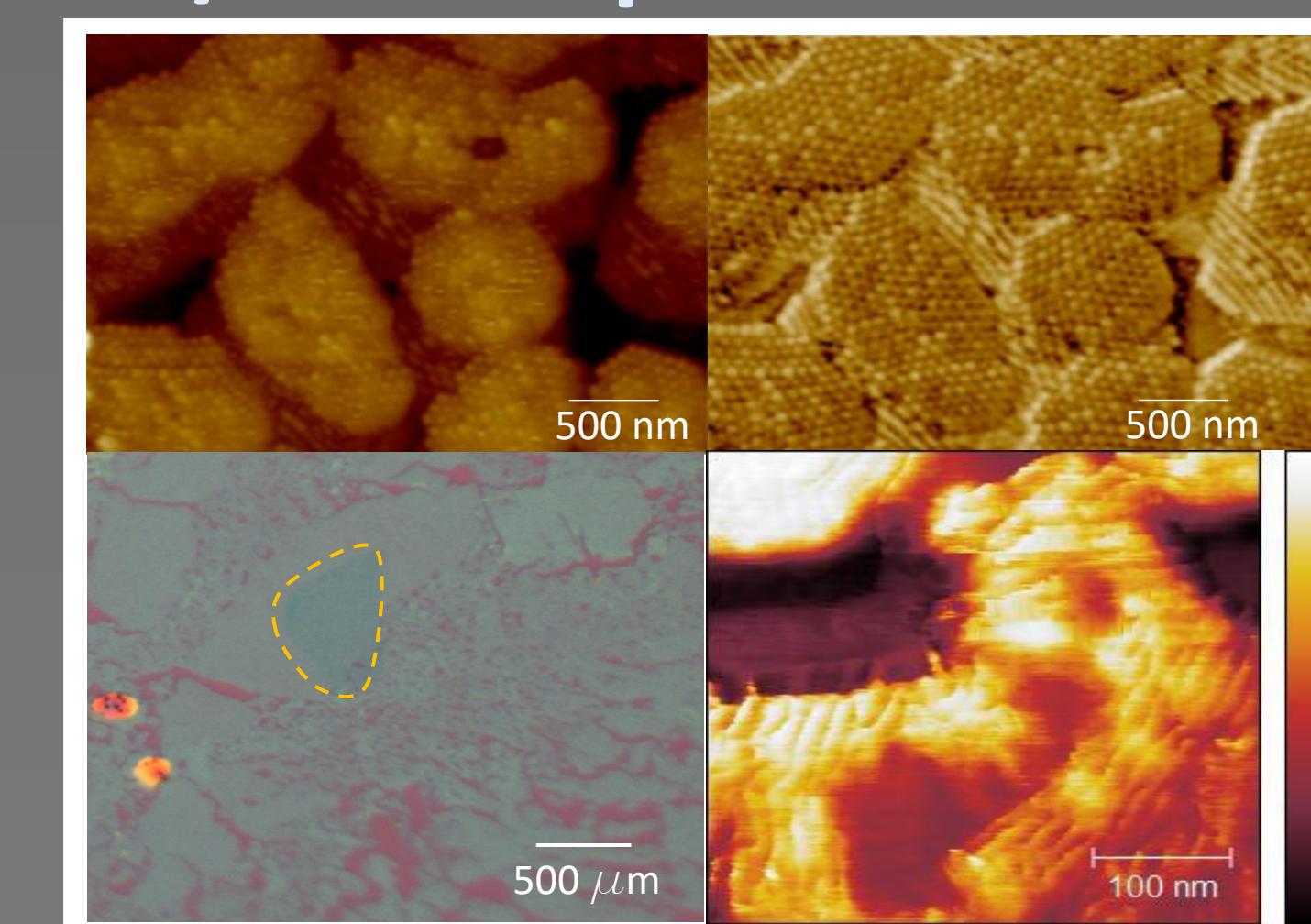
- Optical traps are used to mechanically manipulate the DNA hinge
- Nanoparticles attached to DNA hinges used to study dynamics of magnetism, plasmonics, and DNA origami structures

## 2D/0D Heterostructures

### Proximity effects in 2D/0D composites

#### Nanoparticle (NP) /graphene

- NPs form islands  $\sim 500$  nm
- Magnetic moments inside an island show different domains
- Graphene drapes over SPIONS making "terraces"
- Successful transfer of graphene on SPIONS



- Gate dependent resistance shows asymmetry
- Electron side shows anomalous Hall effect

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