Controlling ferromagnetism in $LaMnO_3/SrTiO_3$ thin films using Ti oxygen scavenging layers

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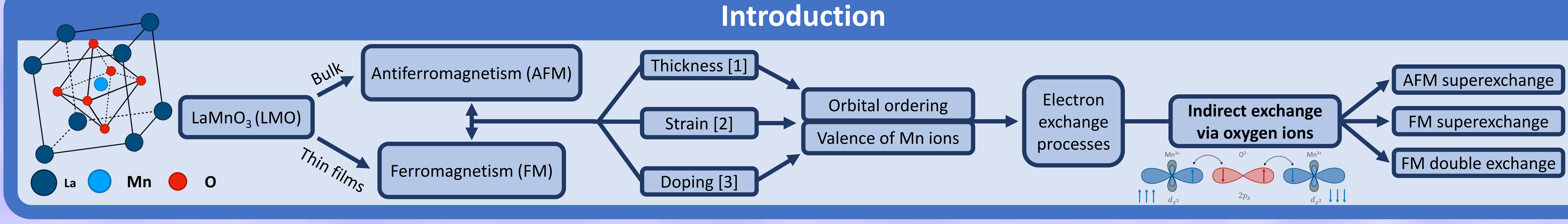
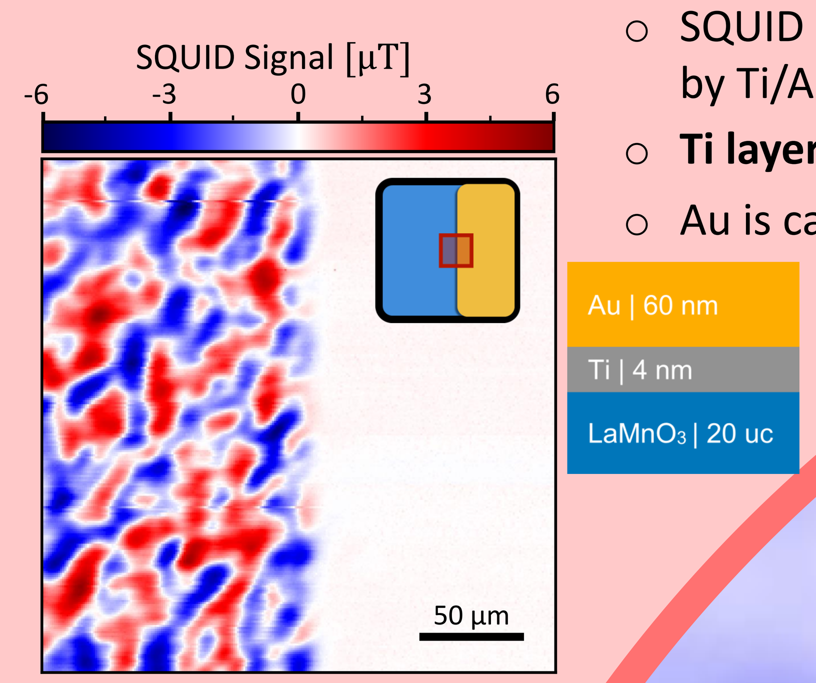
Introduction



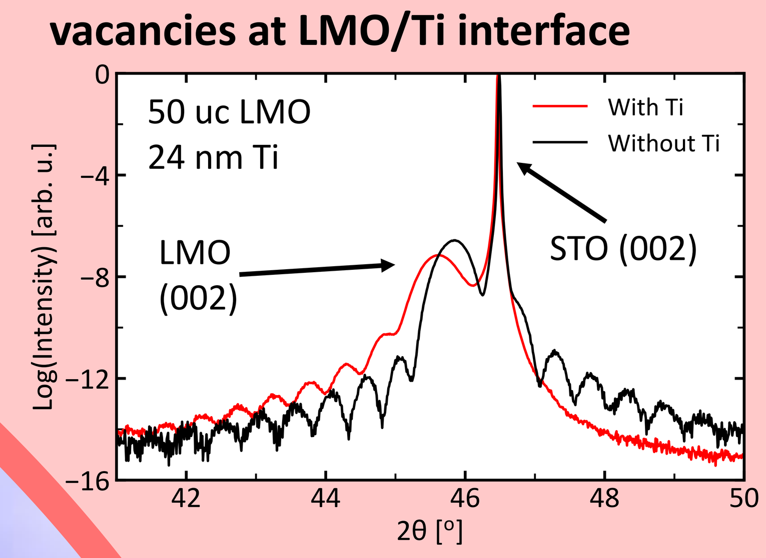
Suppression of ferromagnetism using Ti layers



- SQUID measures noise for LMO/STO covered by Ti/Au
- **Ti layer influences FM of LMO**
- Au is capping layer
- Uncovered LMO/STO has clear FM signal
- SSM pickup loop (15-20 μm^2) convolutes FM domains by averaging
- True $LaMnO_3$ ferromagnetic domains are smaller

Oxygen scavenging by the Ti layer

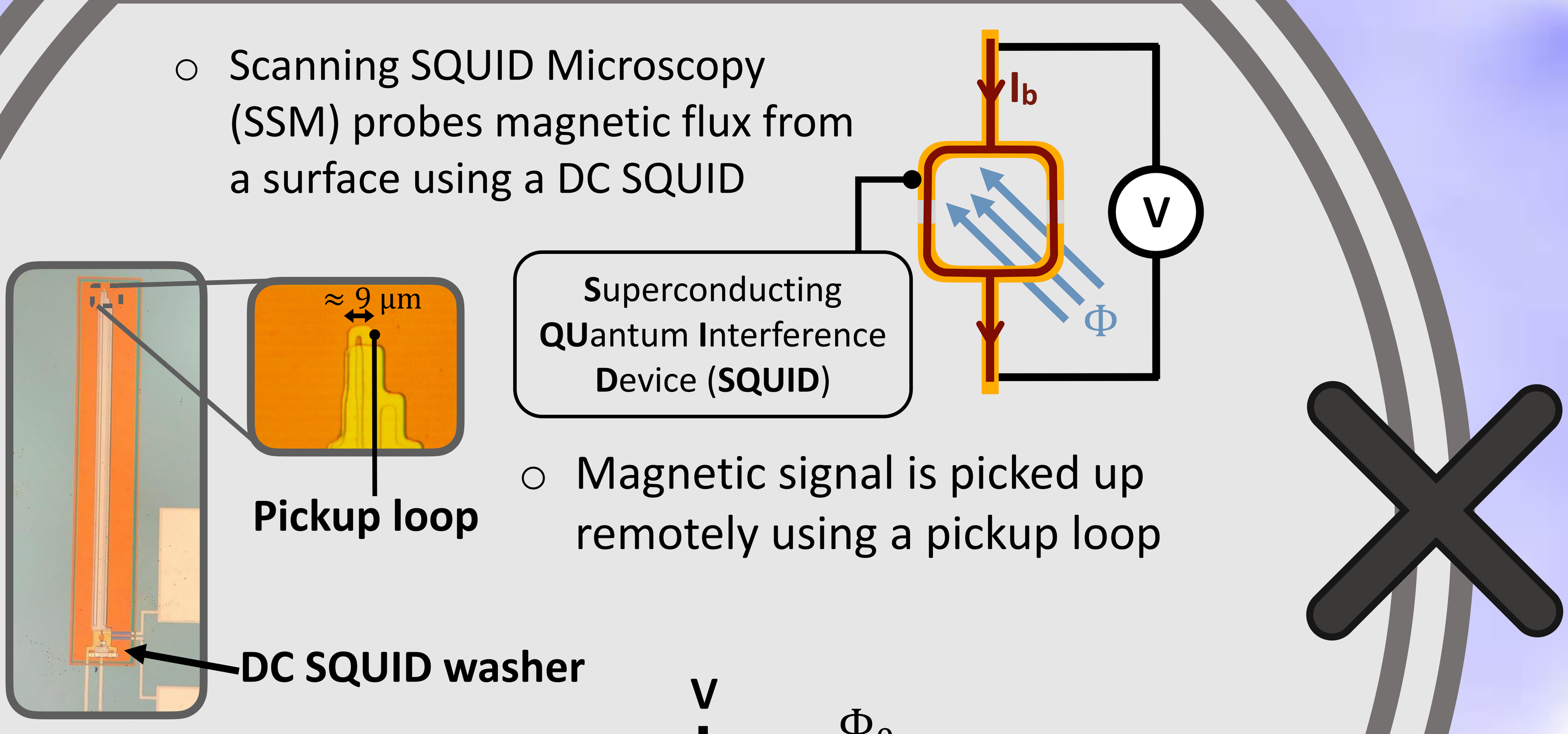
- Decrease in FM dependent on:
  - i. **Time**
  - ii. **Ti and LMO layer thickness**
- Reactive metals like Ti are oxygen scavenging, creating **oxygen vacancies at LMO/Ti interface**



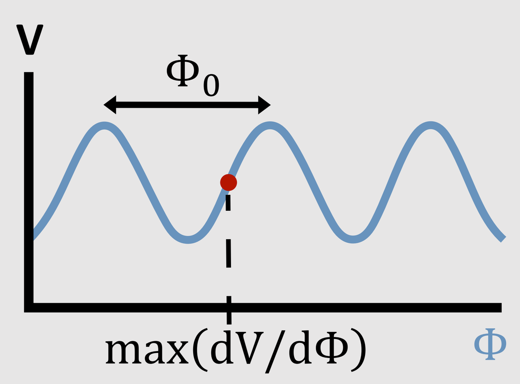
- Oxygen vacancies can:
  - i. Change the valence of Mn ions
  - ii. Cause strain relaxation
- XRD indicates change in lattice parameter due to shift of LMO (002) reflection

Scanning SQUID Microscopy

- Scanning SQUID Microscopy (SSM) probes magnetic flux from a surface using a DC SQUID



- Magnetic signal is picked up remotely using a pickup loop
- High sensitivity due to flux-locked loop and modulation coil

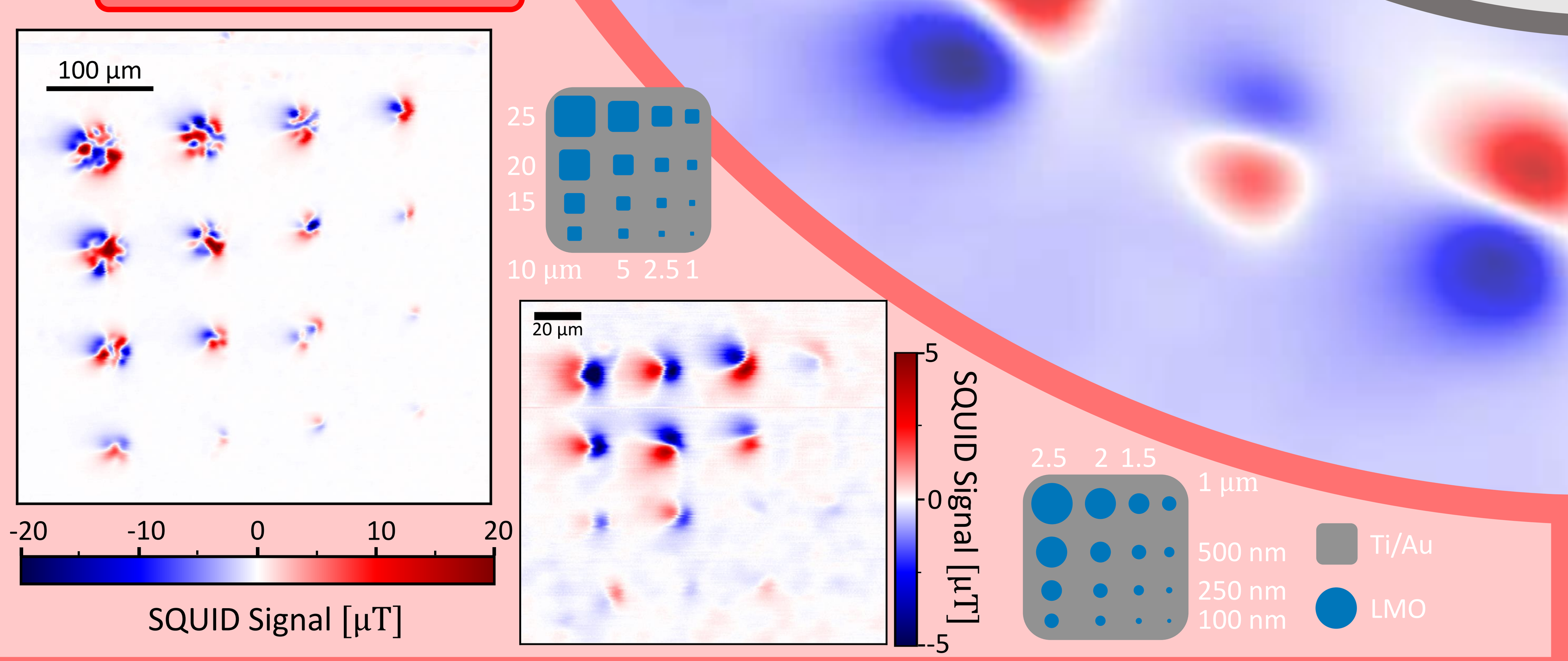


Our SSM:
Spatial resolution ~ 5-10 µm
Field resolution ~ 10 nT

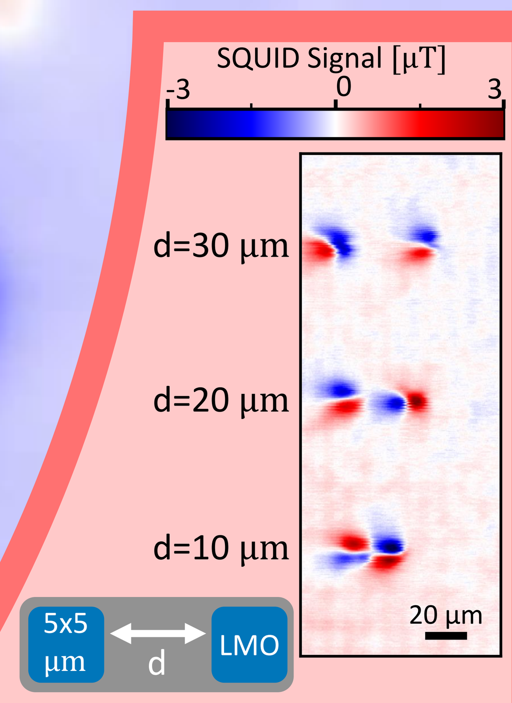
Patterning ferromagnetism in $LaMnO_3$

- **Patterning FM structures in LMO persists till nanoscale**
- Small structures have smaller SQUID signals
- Below ~ 5 µm signal is like in-plane magnetic dipole

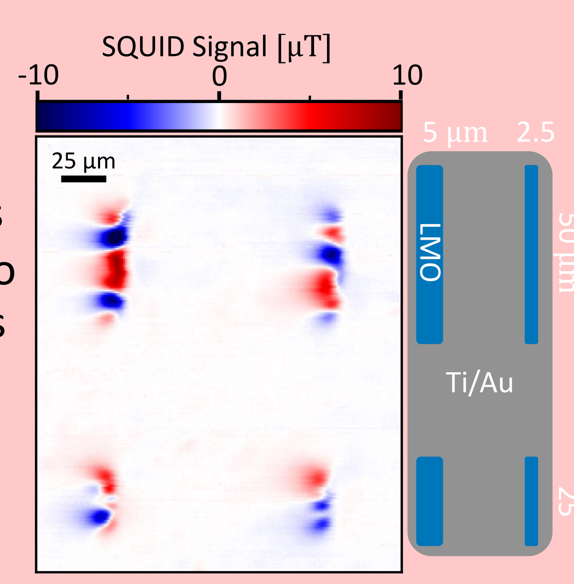
Single domain LMO?



Shape restraints and interactions



- Decreasing distance between micromagnets leads to **interactions**
- Shape restraints force 'dipole' signals to orient along the structures long-axis
- Asymmetric structures show multiple domains



Conclusions and Future Work

- **Ti layers suppress ferromagnetism in $LaMnO_3$**
- **Ti oxygen scavenging can influence the FM to AFM transition**
- **FM can be structured down to nanoscale dipole-like magnets**
- TEM investigation of the Ti/LMO interface
- Interactions between LMO nanomagnets
- Mechanisms for ferromagnetism in LMO

References

[1] Wang et al. *Science* **349**: 716 (2015)

[2] Ahn et al. *Physical Review B* **64**(11): 115103 (2001)

[3] Hemberger et al. *Physical Review B* **66**(9): 094410 (2002)

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