Revealing Magnetic Spin Structures on Mn/Bi/Ag(111) By Spin-Polarized Scanning Tunneling Microscopy

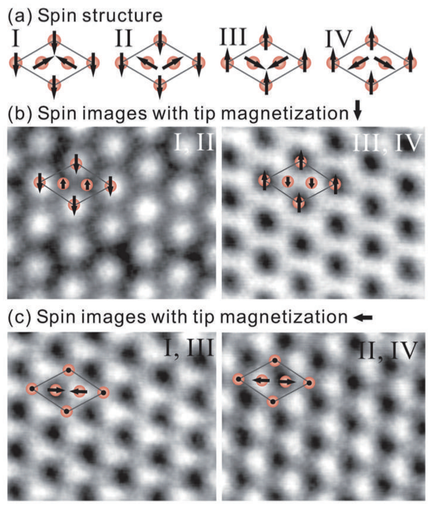
Chieh-Lin Li[1]*, Chia-Ju Chen[1], Yu-Tung Lin[1], Yi-Ping Chen[1], Pin-Jui Hsu[1]

[1]*Department of Physics, National Tsing Hua University, Hsinchu, Taiwan*

Presenter: Chieh-Lin Li E-mail: lichiehlin@gapp.nthu.edu.tw

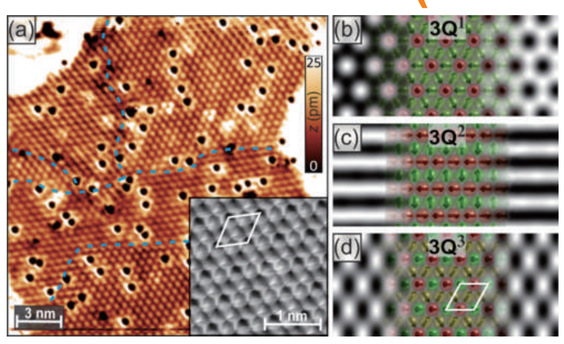
Introduction

I. Previous Work: Mn/Ag(111)



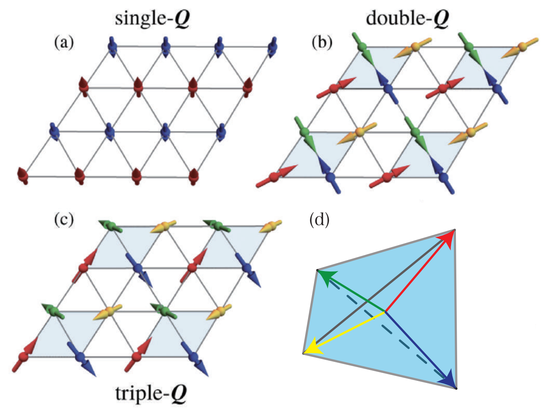
(a) Four possible configurations of the 120 Néel structure (b), (c) show that SP-STM measurement result of 120° Néel structure of Mn deposition on Ag(111) with different tip magnetization. The magnetic unit cells are marked in the images together with the projection of the sample spin polarization onto the tip spin polarization direction.[1]

II. Previous Work: Triple-q state in Mn/Re(0001)



(a) SP-STM image of the hcp-stacked Mn monolayer showing three types of rotational domains of the 3Q state. (b)-(d) Spin structures and SP-STM simulations of three differently oriented 3Q states, with tip magnetization pointing up and down.[2]

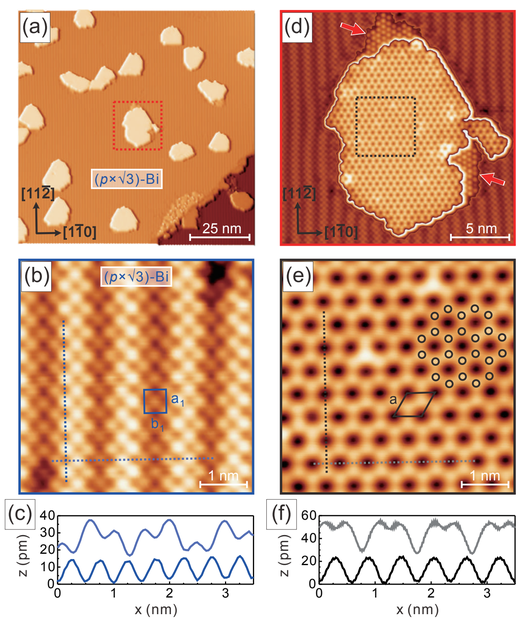
III. Triple-q state



Triple-q (3Q) state can be constructed by a superposition of three symmetry-equivalent RW-AFM states (single-q). (a) Single-q collinear, (b) double-q coplanar, and (c) triple-q noncoplanar. (d) show that the four spin vectors of in tetrahedron.[3]

Experiment Results

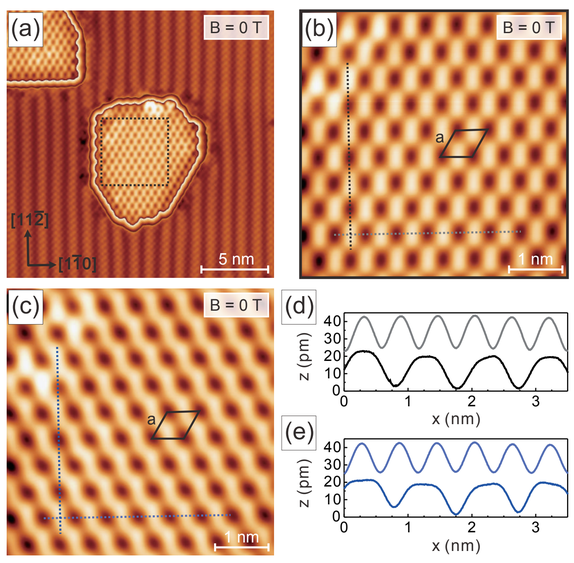
I. Atomic Structures of Bi/Ag(111) and Mn/Bi/Ag(111) Honeycomb



● Mn grown on (p × $\sqrt{3}$) Bi on Ag(111) forms uniform (2 × 2) honeycomb structure, which suggested that the honeycomb is formed by one element.

● There is $\sqrt{3} \times \sqrt{3}$ $BiAg_2$ alloyed structure on the side of honeycomb nanoisland, which indicate that there's local rearrangement of atomic structure.

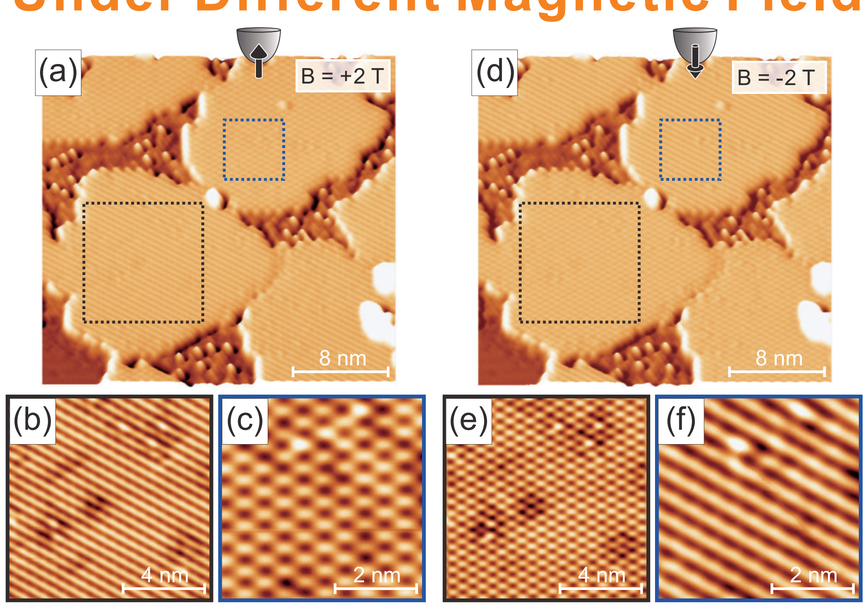
II. SP-STM Result of Mn/Bi/Ag(111)



● With Cr tip, the honeycomb nanoisland exhibiting 2 different kinds of spin pattern (stripe and checkerboard) when we change the tip.

● The patterns both exhibiting a 2×2 periodicity.

III. SP-STM Result of Mn/Bi/Ag(111) of Different Island Under Different Magnetic Field

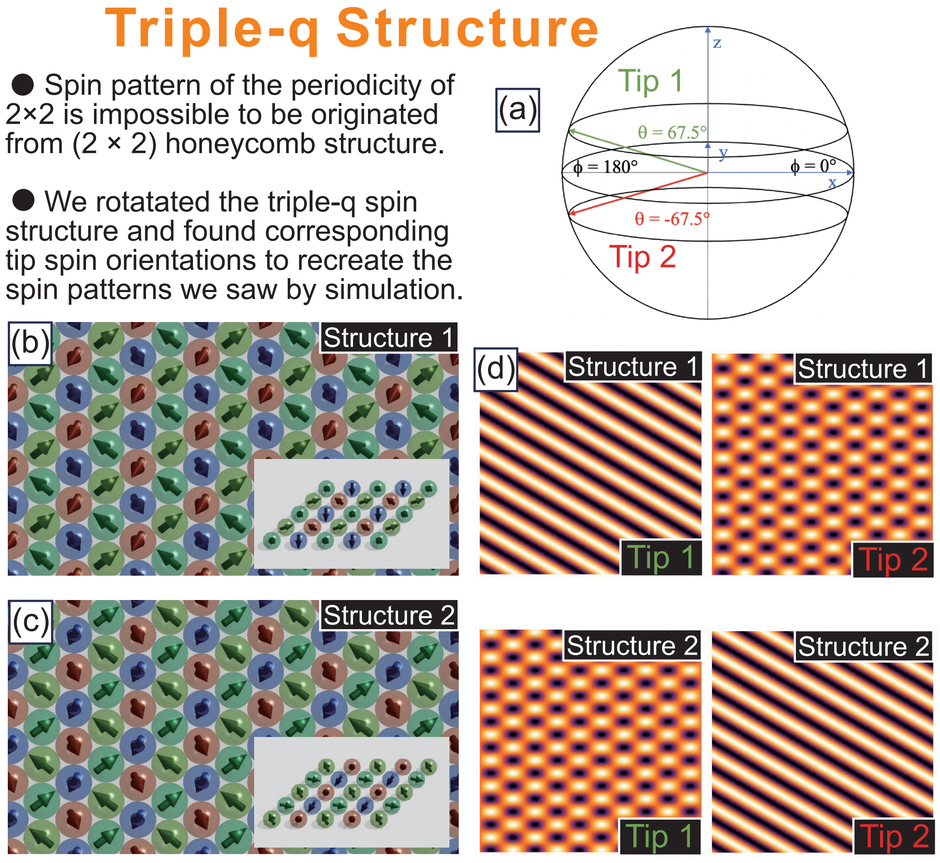


● SP-STM images of two island with different spin structure under +2.0 T, -2.0 T magnetic field show that the tip spin orientation effects the spin pattern (magnetic signal) we see.

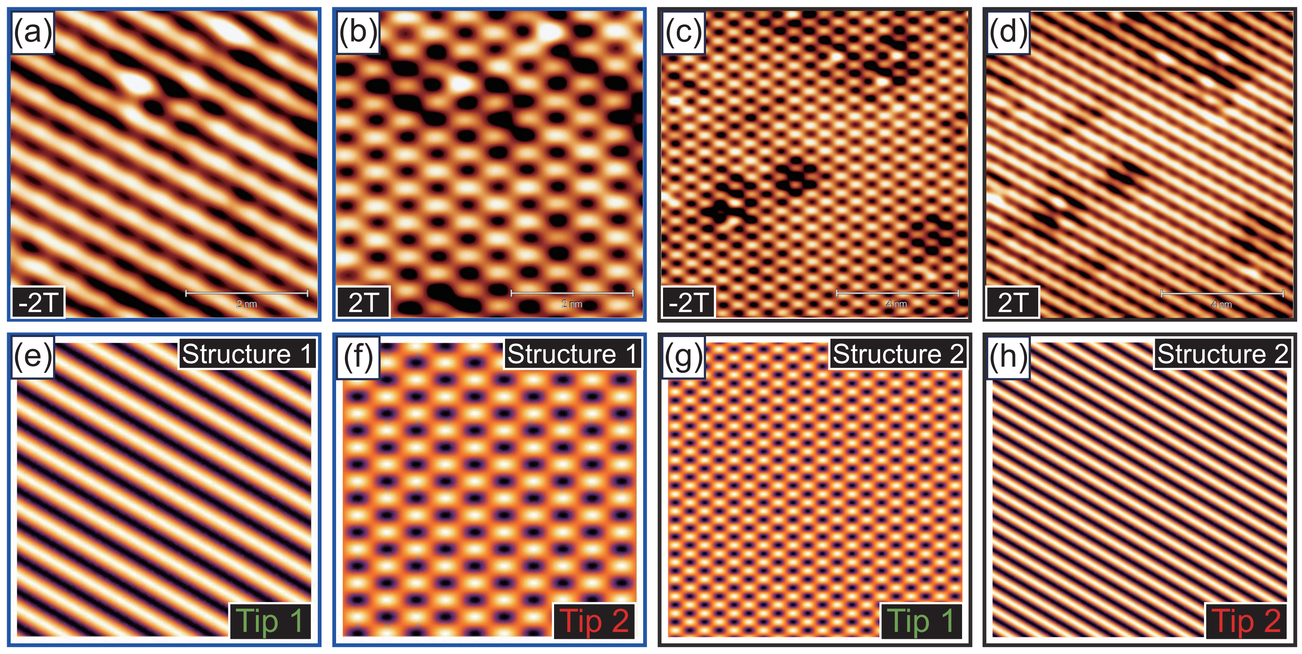
IV. SP-STM Simulation of Triple-q Structure

● Spin pattern of the periodicity of 2×2 is impossible to be originated from (2 × 2) honeycomb structure.

● We rotatated the triple-q spin structure and found corresponding tip spin orientations to recreate the spin patterns we saw by simulation.



V. Comparison With SP-STM Simulation of Triple-q Structure



● We proposed that the tip spin orientation had flipped from Tip 1 to Tip 2 under the change of magnetic field. And the 2 regions in topography image are Structure 1 and Structure 2 respectively. Compare the topography images and the simulation result, you can find that the periodicity and the pattern fit perfectly.

Summary

The deposition of Mn on (p × $\sqrt{3}$)Bi/Ag(111) gives rise to the formation of an uniform honeycomb lattice structure. Field-dependent SP-STM measurements have unveiled magnetic signals exhibiting a 2x2 periodicity. These result suggest that these magnetic signals originate from close-packed Mn beneath the Bi honeycomb (Bismuthene) layer.
Our SP-STM simulations allow us to find the possible configurations of triple-q spin state and corresponding tip magnetizations.

References

[1] Jonas Spethmann et al. , *Phys. Rev. Lett.* **124,** 227203 (2020).

[2] C.L. Gao et al. , *Phys. Rev. Lett.* **101**, 267205 (2008).

[3] Cristian D. Batista et al. , *Phys. Rev. Lett.* **121**, 227201 (2018).