Tuning the Growth Mode of Bi on Cu(111) via a Co Interlayer

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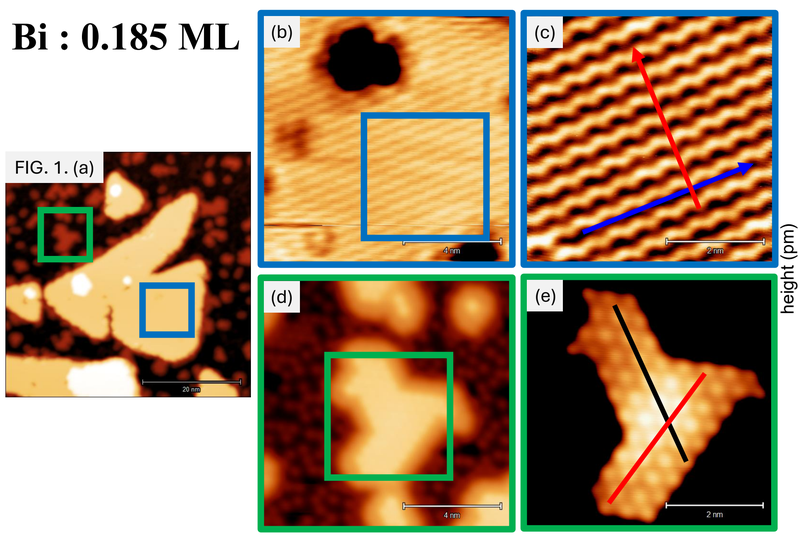
Introduction

Bi/Cu(111) has been extensively studied due to its coverage-dependent structural transitions and electronic states. Prior work has shown that Bi deposition leads to surface alloying at low coverage and dealloying at higher coverage[1], and Bi[2012] superstructure on Cu(111) can create stable Dirac nodal line[2]. Building on these findings, we introduce a ferromagnetic Co interlayer between Bi and Cu(111) to provide an additional tunable interface. By adjusting the Bi and Co deposition amounts, we achieve multiple surface superstructures and examine how the magnetic interlayer alters phase formation and electronic properties.

Experimental Results

Low Co Coverage (0.55 ML)

Bi : 0.185 ML



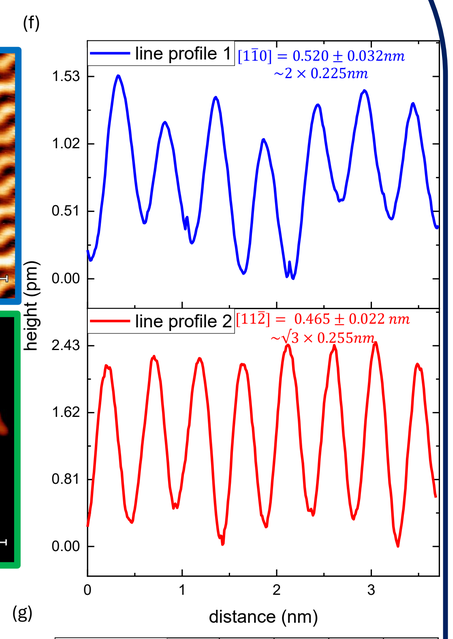
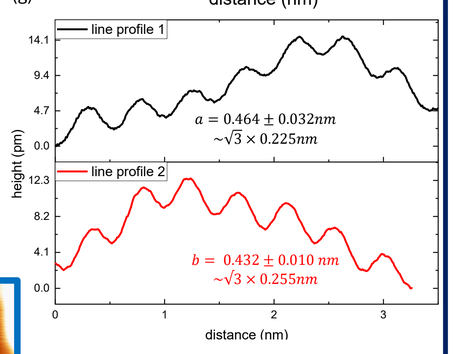


FIG. 1. (a) to (e) are STM images when deposition of Bi is 0.185 ML. (a) Forming two different structures : islands and patches. (b)(c) Zoom in images on island . (d)(e) Zoom in images on patch . (f) Line profiles and lattice constants along lines depicted in (c). (g) Line profiles and lattice constants along lines depicted in (e).



Bi : 0.522 ML

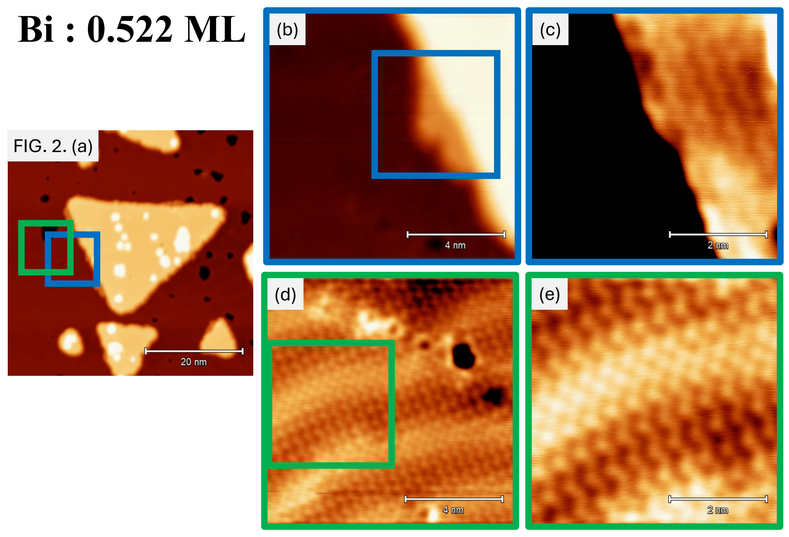


FIG. 2. (a) to (e) are STM images when deposition of Bi is 0.552 ML. (b)(c) Zoom in images on island . (d)(e) Zoom in images on lower area.

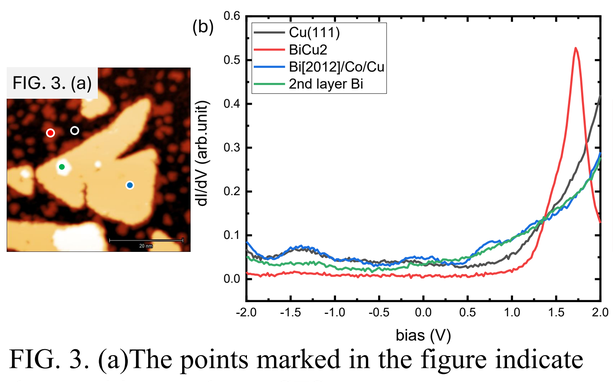


FIG. 3. (a)The points marked in the figure indicate the positions where STS measurements were performed. (b) STS corresponding to each data points in (a).

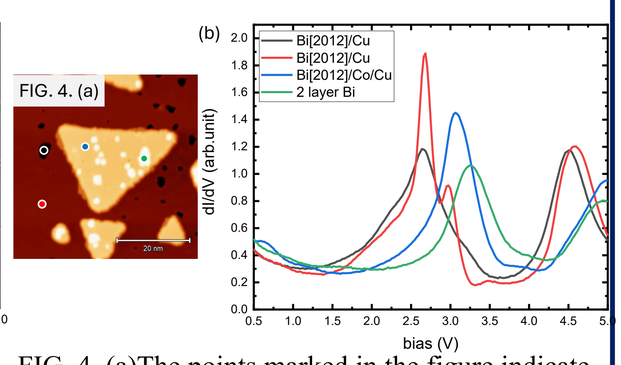


FIG. 4. (a)The points marked in the figure indicate the positions where STS measurements were performed. (b) STS corresponding to each data points in (a).

FIG. 5. (a)(b) Structure models and unit cell of $BiCu_2$ and Bi[2012] on Cu(111).

FIG. 6. LEED patterns for tuning Bi deposition under low Co coverage.

High Co Coverage (2.30 ML)

Bi : 0.30 ML

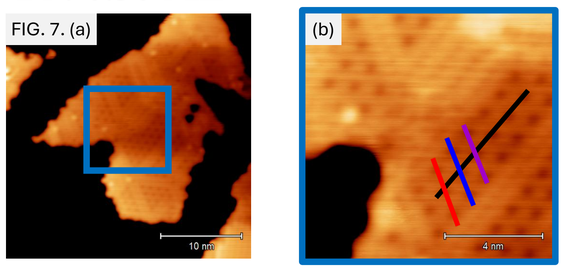
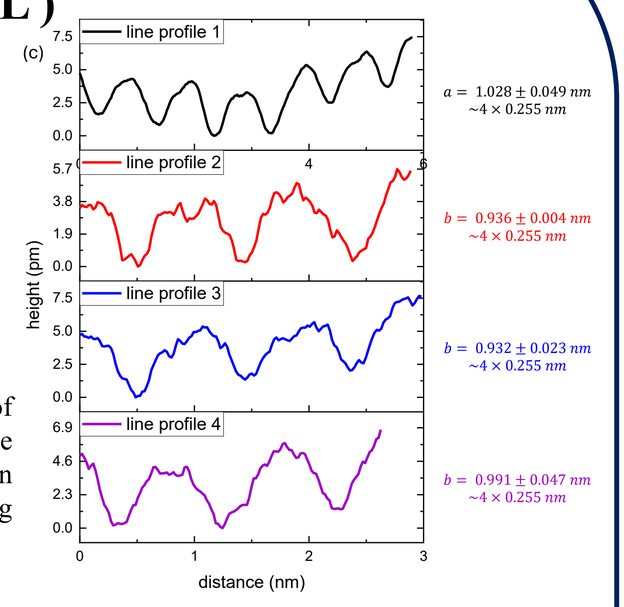
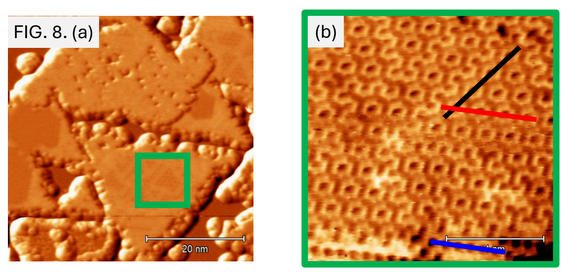


FIG. 7. (a)(b) are STM images when deposition of Bi is 0.30 ML. (a) Periodic structures can be observed on the island. (b) Zoom in image on island. (c) Line profiles and lattice constants along lines depicted in (b).



Bi : 0.36 ML



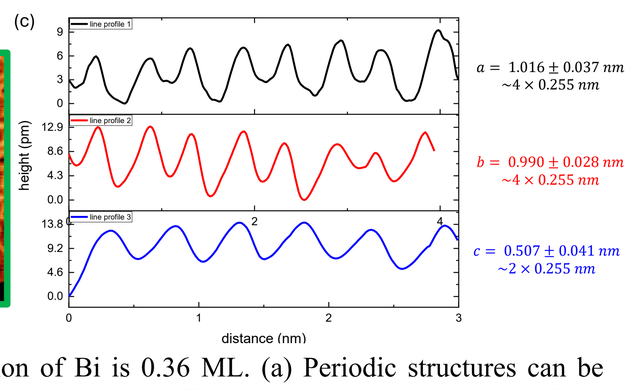


FIG. 8. (a)(b) are STM images when deposition of Bi is 0.36 ML. (a) Periodic structures can be observed on the island (This image is dI/dV mapping). (b) Zoom in image on island . (c) Line profiles and lattice constants along lines depicted in (b).

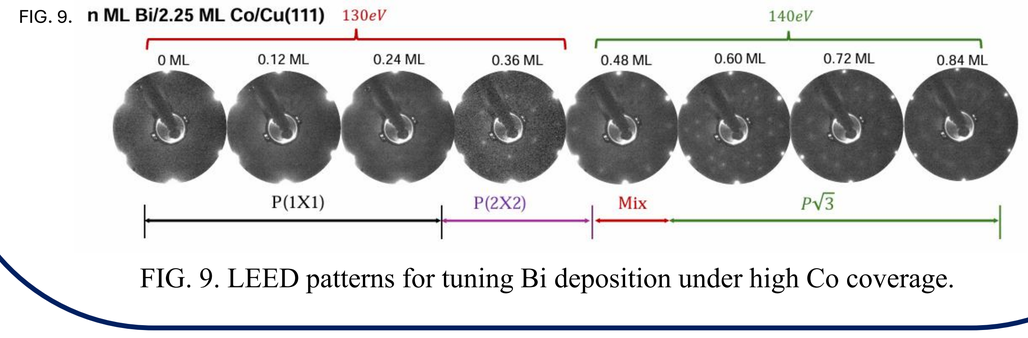


FIG. 9. LEED patterns for tuning Bi deposition under high Co coverage.

Conclusions

- By tuning the deposition amounts of Bi and Co on the Cu(111) substrate, various surface superstructures can be realized.
- Under low Co coverage, increasing the Bi deposition induces a structural evolution from $BiCu_2$ $\sqrt{3} \times \sqrt{3}$ R30° phase to the Bi[2012] (or $P\sqrt{3}$) structure formed on Co islands, and eventually to the Bi[2012] phase on the Cu(111) substrate. This evolution is consistent with the LEED patterns observations.
- Under high Co coverage, $P(4 \times 4)$ structure and a possible $P(2 \times 2)$ phase are observed. Combined with the LEED patterns, the latter is tentatively attributed to a $P(2 \times 2)$ superstruction. However, the larger periodicity in STM images suggests that the growth may not yet be optimized, preventing the formation of a well-developed long-range $P(2 \times 2)$ structure.

References

[1] Y. Girard et al., *Growth of Bi on Cu(111): Alloying and dealloying transitions*. *Surf Sci.* **617**,118 (2013).

[2] M. Y. Tian et al., *Creation of the Dirac Nodal Line by Extrinsic Symmetry Engineering*. *Nano Lett*. **20**, 2157 (2020).