

Electronic Supplementary Information

Epitaxial Electrodeposition of Cu(111) onto an L-cysteine Self-assembled Monolayer on Au(111) and Epitaxial Lift-off of Single-crystal-like Cu Foils for Flexible Electronics

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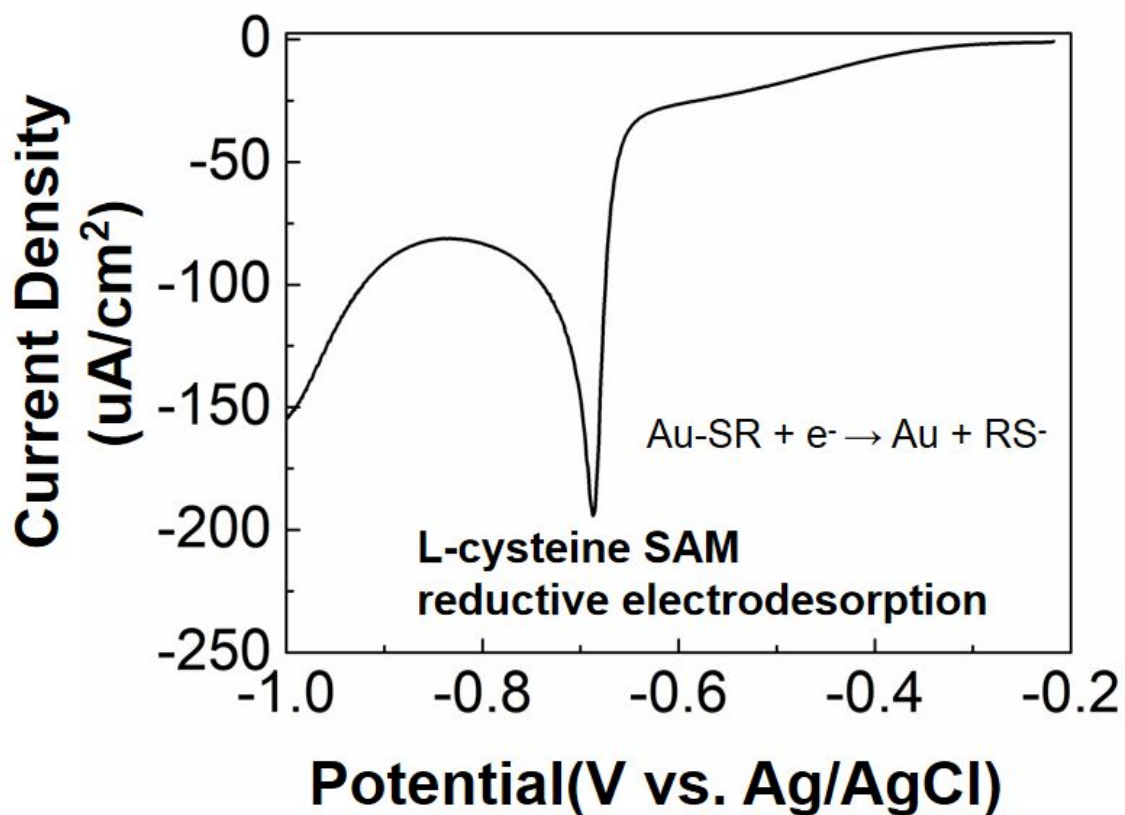


Figure S1. Typical LSV of L-cysteine SAM/Au(111)/glass in 0.1M NaOH from $-0.2V_{\text{Ag/AgCl}}$ to $-1V_{\text{Ag/AgCl}}$ showing sharp desorption peak of L-cysteine around -0.7 V .

Table S1: Properties of Cu deposited on L-cysteine/Au(111)/Si(111).

Category	Time (s)	Charge (C)	Area (cm ²)	Thickness Calculated (nm)	Thickness experimental (nm)	Faradaic Efficiency	Experiment al resistivity (Ω·m)	Bulk Cu resistivity (Ω·m)
Cu/L-cysteine /Au/Si(111)	600	3.69	2	678	400	59%	3.75×10^{-8}	1.72×10^{-8}

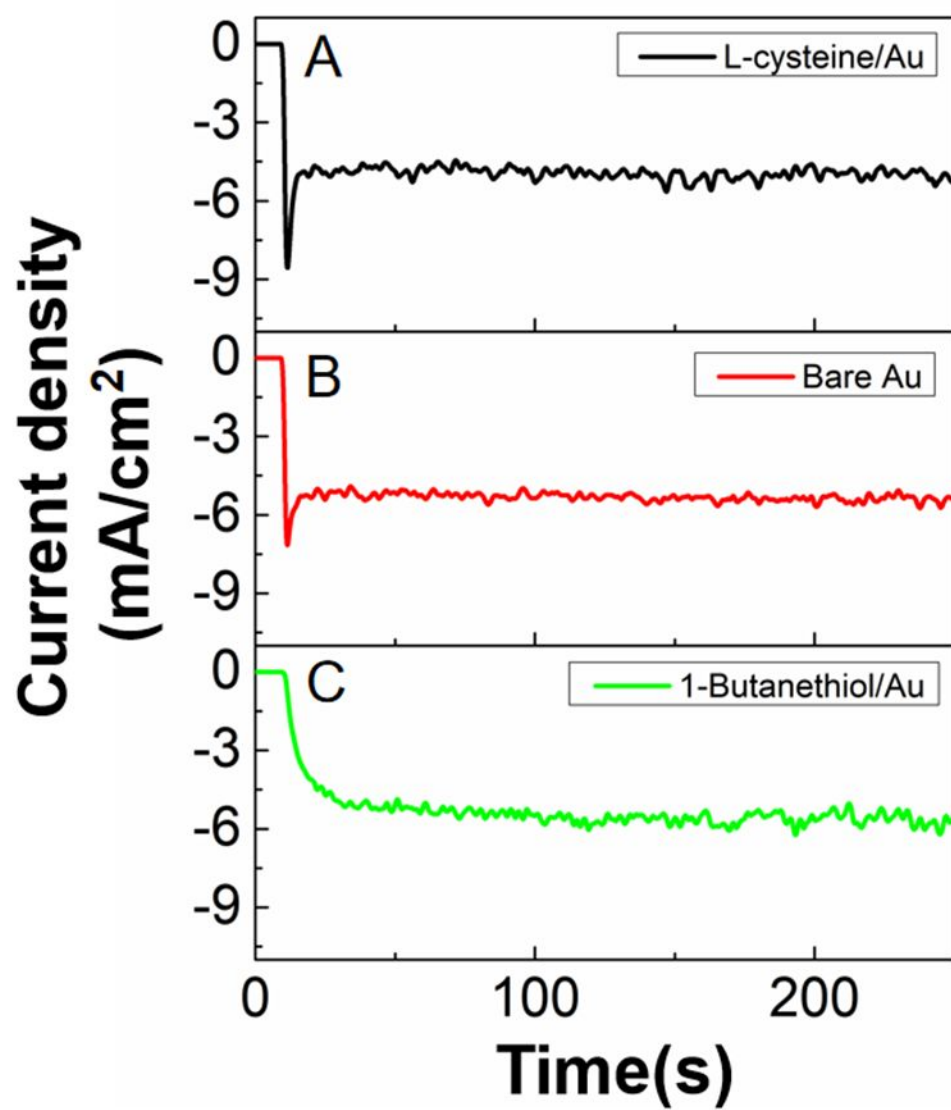


Figure S2. Typical current-time curves of Cu deposition on (A) L-cysteine/Au(111)/Si(111), (B) bare Au(111)/Si(111) and (C) 1-butanethiol/Au(111)/Si(111) at -0.25 V vs $V_{\text{Ag/AgCl}}$ in 100 mM K_2SO_4 , 12 mM H_2SO_4 and 20 mM CuSO_4 at room temperature.

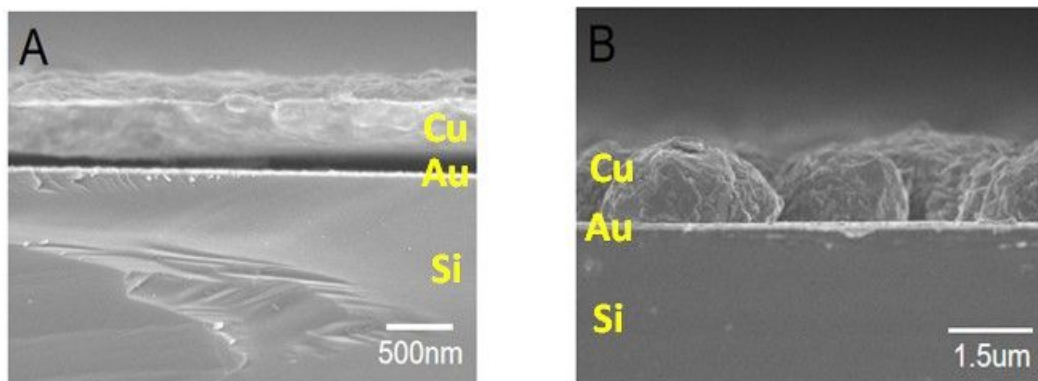


Figure: S3. Scanning electron microscope (SEM) images of Cu films on two kinds of SAMs. (A) cross-section view SEM image of smooth Cu on L-cysteine/Au(111)/Si(111); (B) cross-section view SEM image of mushroom-like Cu on 1-butanethiol/Au(111)/Si(111).

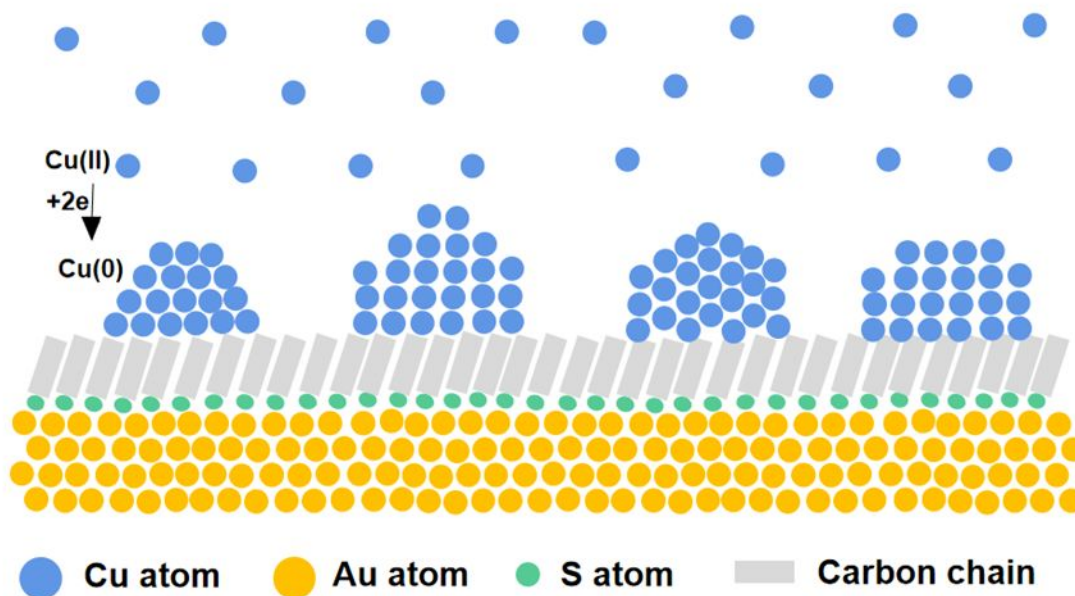


Figure S4. Schematic representation of proposed mechanism of polycrystalline Cu deposition on 1-butanethiol SAM/Au(111). Due to the lack of functional groups that can direct the epitaxial growth, Cu starts nucleating with a variety of orientations and prefers to grow on itself instead of the SAM, forming the 3D globular morphology.

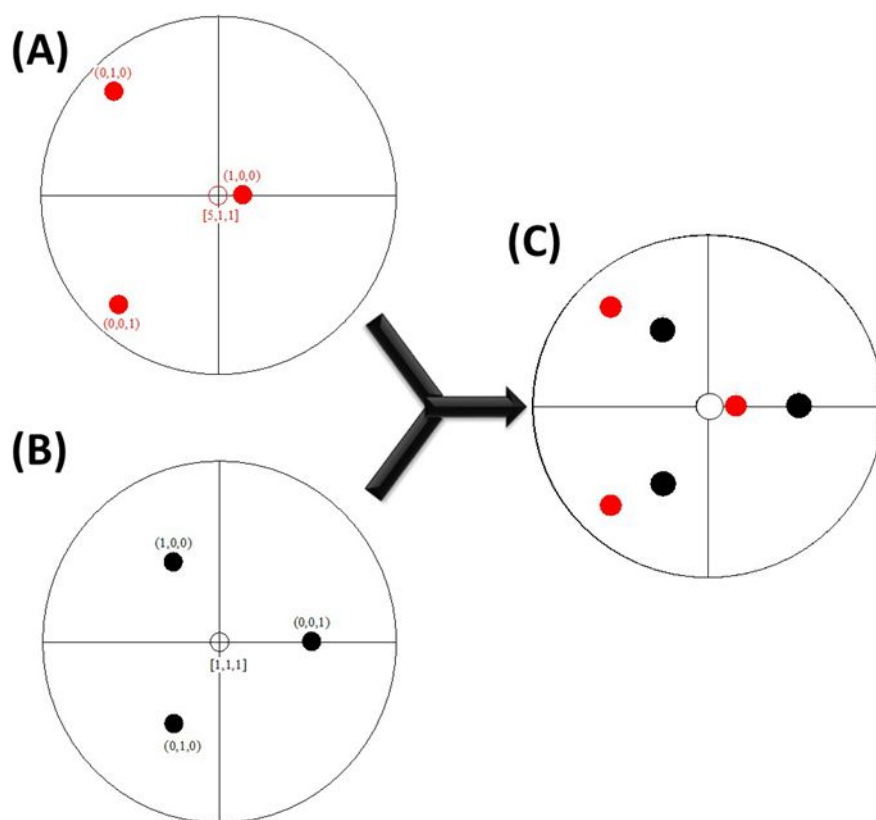


Figure S5. Stereographic projections for (200) pole of ideal single crystal Cu(111) having [111] (A) or [511] (B) out-of-plane orientation. Overlaying both the (200) poles for a single domain (C).

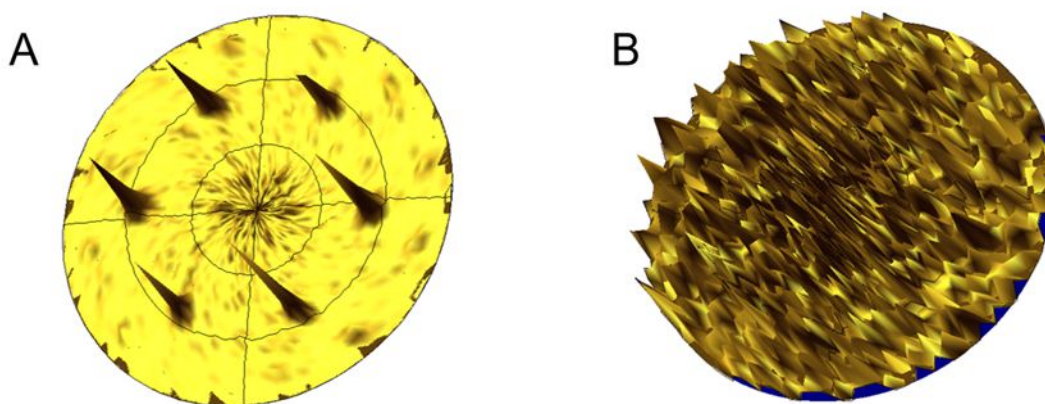


Figure S6. 2.5D projections of Cu (200) pole figures of Cu/L-cysteine/Au(111)/Si(111) (A) and Cu/1-butanethiol/Au(111)/Si(111) (B).

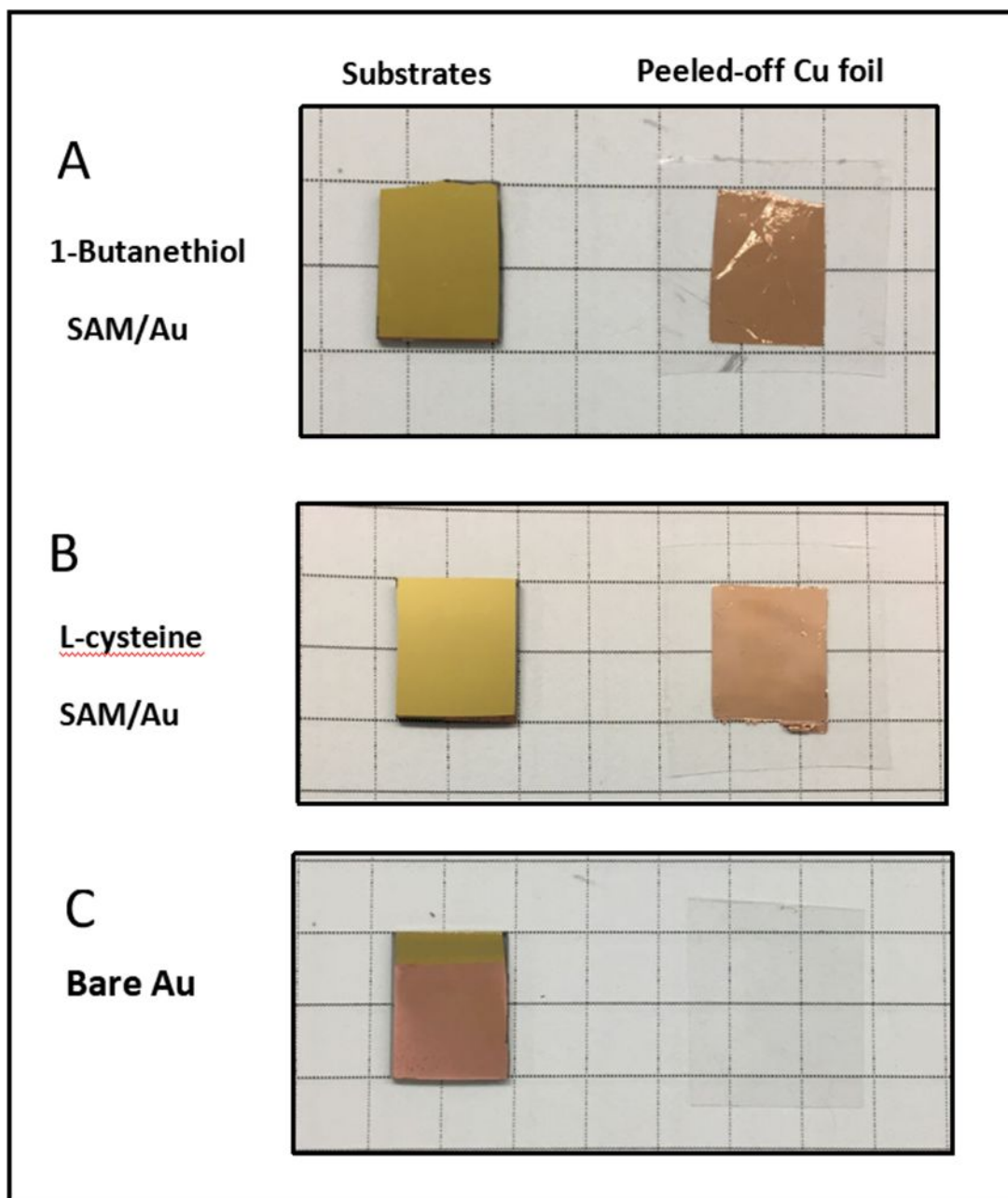


Figure S7. Peel test of Cu foil from (A) 1-butanethiol/Au/glass, (B) L-cysteine/Au/glass and (C) bare Au/glass substrates. The exhibited Cu surfaces are the inner faces contacting with SAMs before peel-off operation by tape.

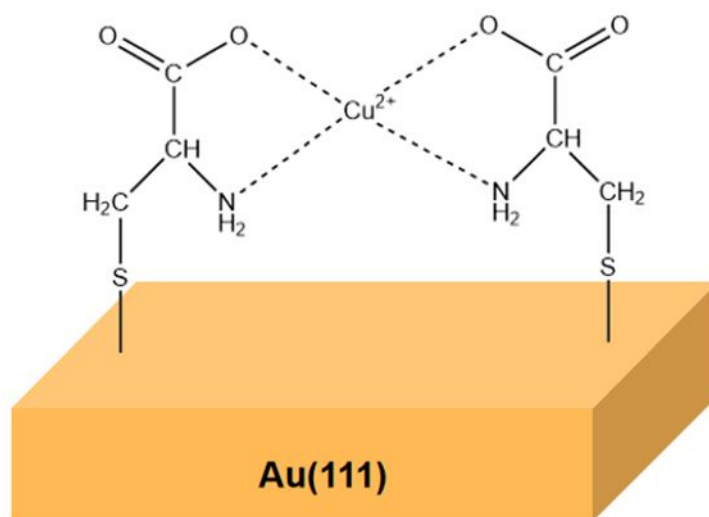


Figure S8. Possible structure of the $\text{Cu}(\text{L-cysteine})_2$ complex at a gold surface.

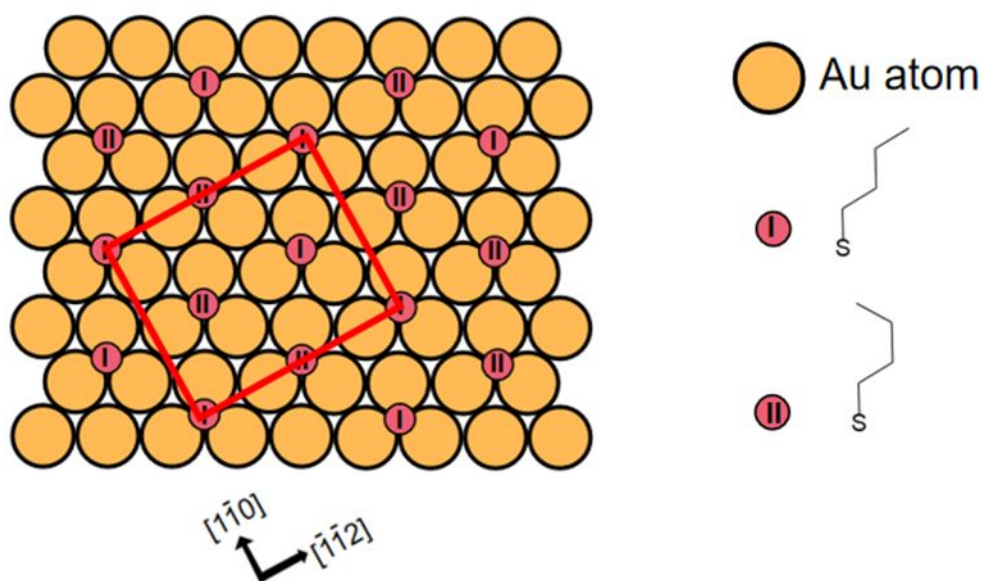


Figure S9. 2D schematic drawing of $c(4 \times 2)$ structure for the adlayer of 1-butanethiol SAM on Au(111).

1-butanethiol molecules could be either parallel (conformation I) or tilted (conformation II) relative to the normal direction of the Au(111) plane.

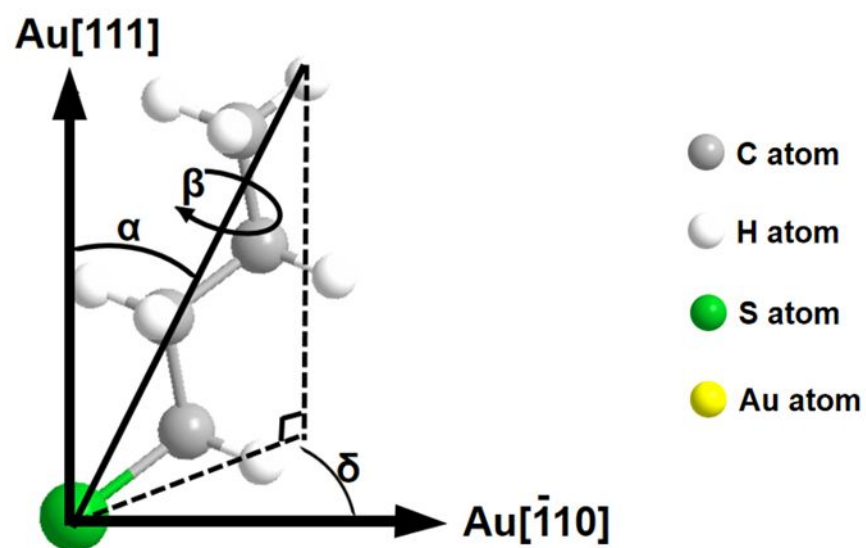


Figure S10. 3D model of 1-butanethiol and its degrees of freedom. In this model, the tilt angle α is 30° and the tilt direction δ is 23° . The twist angle for the $c(4 \times 2)$ model is $\beta = +35^\circ$ and -55° .

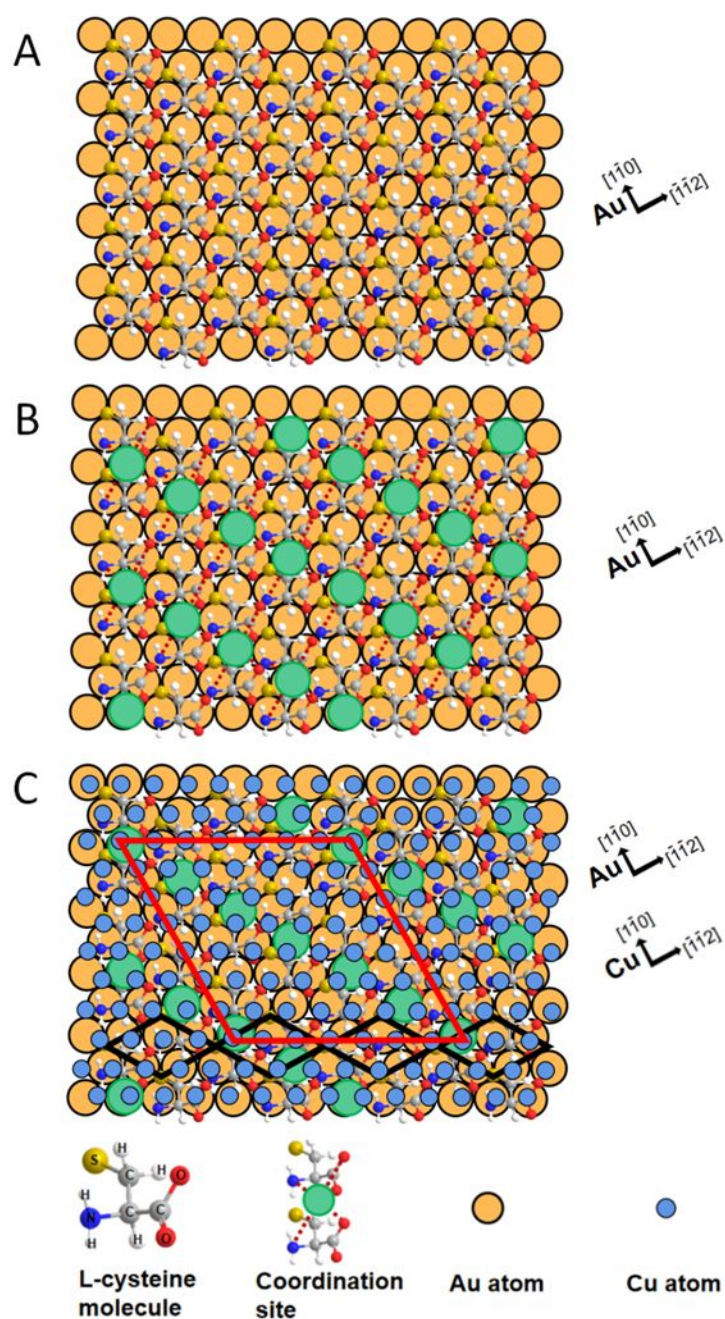


Figure S11. Schematic drawing of possible coordination site of L-cysteine SAM and relationship with Cu lattice on Au(111). (A) Possible spatial conformation of L-cysteine molecule on Au(111); (B) possible coordination site of L-cysteine SAM; (C) Diagram of Cu lattice matching with coordination site of L-cysteine SAM in every 7 unit meshes of Cu with 2 unit meshes of L-cysteine SAM and results in a mismatch of +3.41%.

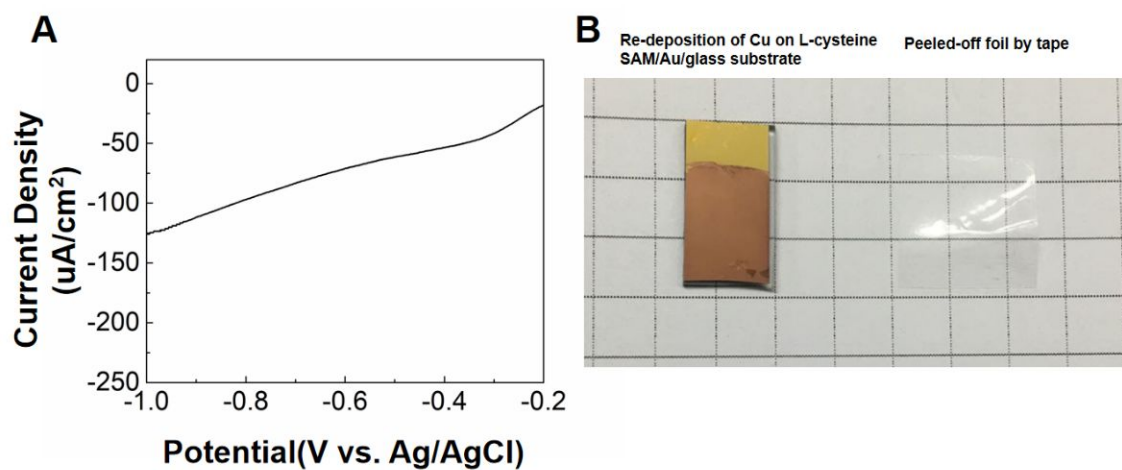


Figure S12. Evidence for L-cysteine SAM lifted together with the Cu(111) film. (A) LSV of L-cysteine SAM/Au/glass after peeling off Cu foil in 0.1M NaOH from $-0.2V_{\text{Ag/AgCl}}$ to $-1V_{\text{Ag/AgCl}}$ showing no sharp desorption peak of L-cysteine around -0.7 V ; (B) Peel test of re-deposition of Cu on L-cysteine SAM/Au/glass substrate after peeling off Cu foil. Re-deposited Cu foil cannot be peeled off again.