Thickness-Related Instability of Cu thin films on Ag (100)

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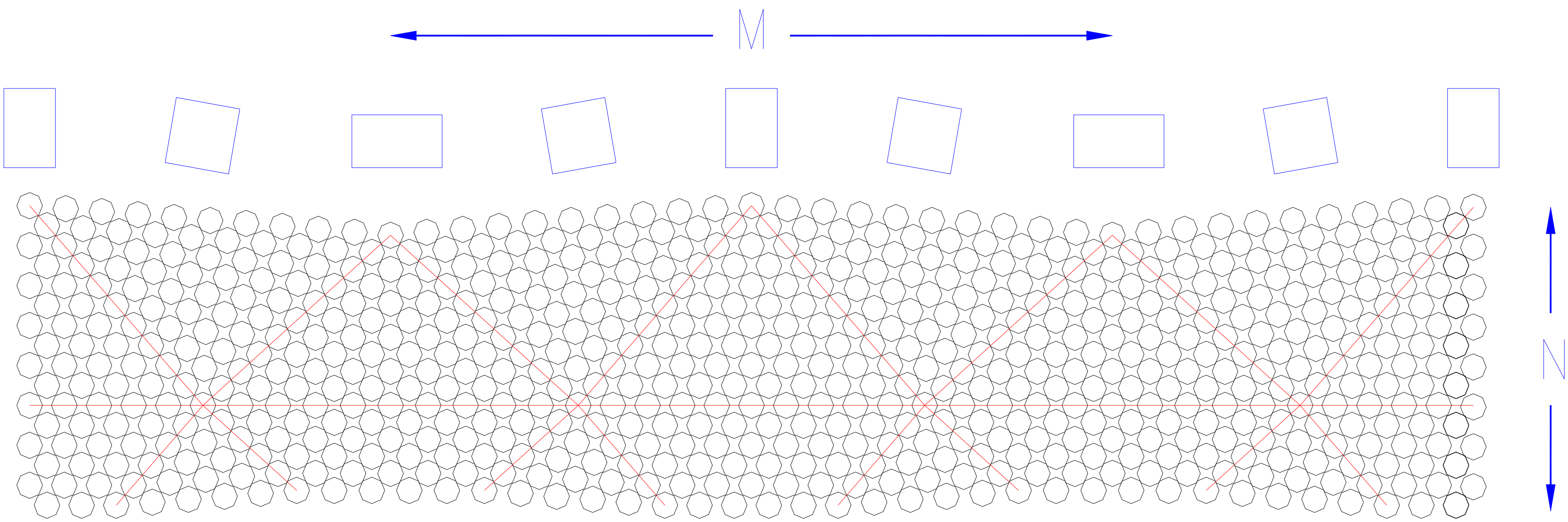
Beamline X16A at NSLS

Synopsis

Thin epitaxial films of Cu on Ag(100) adopt the BCC crystal structure; thicker films revert to the normal FCC structure. In between lies an unusual modulated phase.

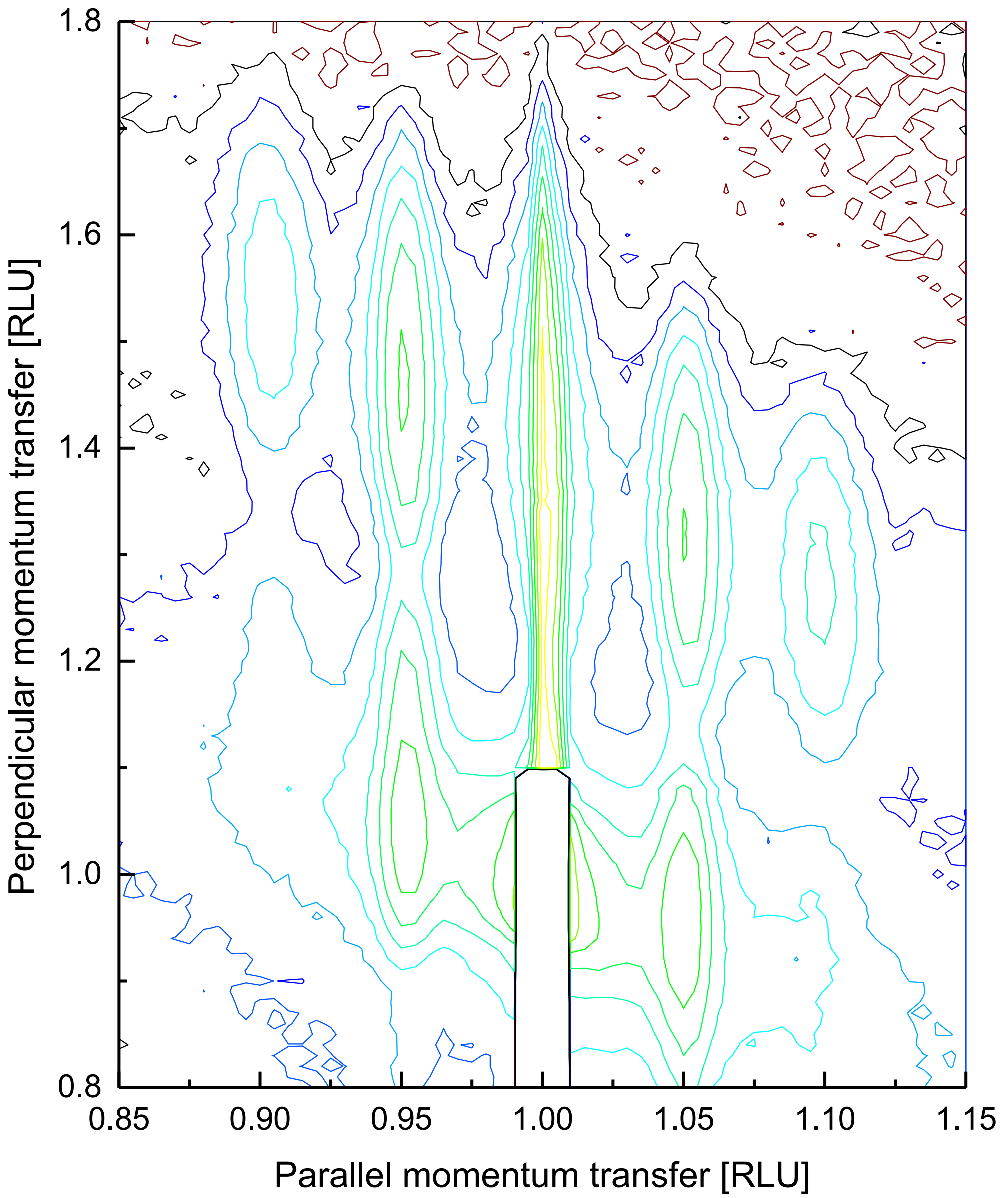
By analyzing the structure of this phase we will learn about the general relaxation mechanism of metallic films.

Model of Modulated Film



Preliminary Model

- Previous work on the electrochemical Cu/Au deposition system discovered a transition in film thickness at 10ML, above which the BCC cubic Cu film becomes unstable towards orthorhombic distortions.
- This led to this preliminary model shown above, with alternating domains.
- The model contains {110} slip planes but no dislocations.
- All atoms have full bcc coordination.

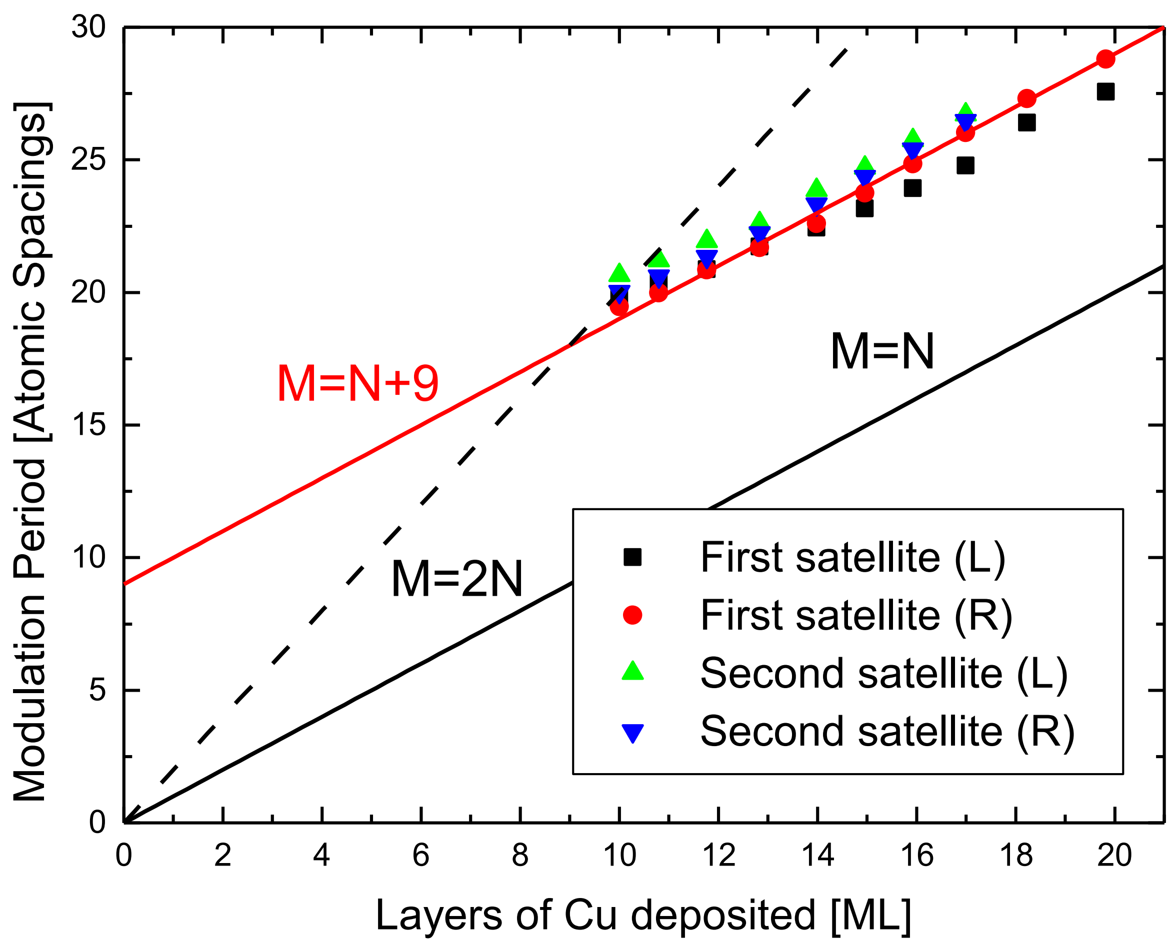


Contour plot of the intensity distribution in the vicinity of the $(101)_{tet}$ Bragg peak of a 15ML Cu film.

Current Experiment

- We performed a UHV deposition experiment of Cu on Ag(100) at the X16A surface diffraction beamline at NSLS.
- Below 10ML the Cu grows BCC in a layer-by-layer manner.
- Beyond 10ML the film becomes unstable and gives strong satellite diffraction features shown in the reciprocal-lattice map above.
- There are satellites also around the Ag substrate reflection (blocked out), showing the substrate is laterally modulated also.

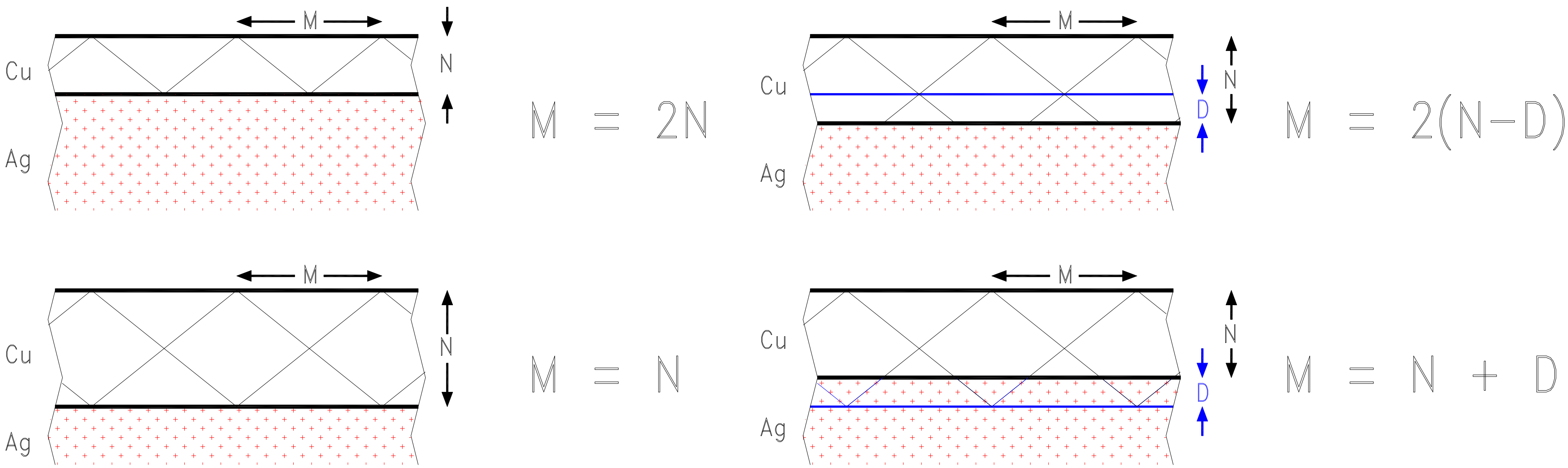
Modulation Period



Modulation Period

- This graph shows the modulation period (in unit-cell spacings) observed during deposition.
- There is a continuous trend with thickness once the instability sets in at 10ML.
- The trend is explained fairly well by the red straight line, offset from the origin by 9 unit cells.

Period variation with thickness



$M = 2N$

$M = 2(N-D)$

$M = N$

$M = N + D$

Conclusions

- Interpretation of the observed thickness trend using the model of alternating orthorhombic domains.
- Only the M=N+D model is consistent with the data.
- The observed value of D=9 suggests that the domain intersection structure is required for the modulated phase to exist.