**COMBINATORIAL NANOSTRUCTURED FILMS USING GLANCING ANGLE DEPOSITION**

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### MOTIVATION

For material analysis, particularly on the nanoscale, there is a need for high throughput methods that allow for simultaneous generation of varied compositions, sizes, or structures created under the same conditions. A method was developed to simplify multi element nanofabrication when using glancing angle deposition.

### DESIGN

Introduction of a barrier that asymmetrically intercepts vapor flux results in a gradient of the film thickness across the length of a substrate.

Two-dimensional calculation of typical thickness profile

\[
\frac{r - \beta}{|\beta|} = \cos \gamma
\]

\[
\cos \gamma = \frac{r^2 + r(h \sin \alpha - m \cos \alpha)}{\sqrt{r^2 + m^2 + h^2 - 2rm \cos \alpha}}
\]

\[
t = \int_N^M \cos \gamma \, dm
\]

The thickness was calculated by integrating over all points on a source reaching the substrate.

### TECHNIQUE: Glancing angle deposition (GLAD)

**Glancing angle deposition**

\[
T : \sim 90 - 300K
\]

**Material:** Ti

\[
\alpha = 85^\circ
\]

\[
\varphi \text{ stationary}
\]

### METHOD

- Barrier placed inside chamber above crucible sources
  - Constrained by chamber dimensions
  - Actual height, over 500 mm above the source, shifts expected gradient

**Singlar deposition**

**Binary deposition**

Gradients observed correspond to calculations.

- Ternary samples were also analyzed with energy-dispersive X-ray diffraction and demonstrated the

### RESULTING GRADIENTS

**Material:** Ti

- **Theoretical and experimental comparison**

**EFFECT OF BARRIER ON CONTINUOUSLY ROTATING SAMPLES**

Center-directed orientation of columns

- Structures have the expected morphology of a rotated sample
  - Due to rotation the structures have a helical appearance
  - The inclusion of the barrier leads to the development of columns oriented towards the center
  - Center columns are vertically aligned

### CONCLUSION

- Introduction of vapor barrier creates multidirectional gradients of a nanostructured film
- Allows for independent control of morphology, orientation, and composition in a single deposition
- Method can be tuned to dimensions of deposition chamber, crucible, and substrate
- Facilitates post-deposition processing under the same conditions

References

