Atomic Layer Deposition (ALD) Bias Control

Oxford Instruments Plasma Technology
Introducing FlexAL substrate biasing

The FlexAL ALD system can now be equipped with table bias for extended process capabilities (e.g., higher conductivity, higher crystallinity, stress control).

- up to 600 °C temperature
- up to 100 W RF power
  - 13.56 MHz
- up to 500V resulting DC bias
- fully automated RF matching
Controlling stress by RF biasing

RF Substrate biasing

- RF biasing to increase ion energy change material from tensile to compressive at 200 °C.
- Tuning to less compressive at 25 °C.

Active biasing

- Densification of $\text{Co}_3\text{O}_4$ with CoCp$_2$ @ 300°C
Active biasing: TiO$_2$

- XRD analysis at 300°C
- No bias:
  - anatase (above 250°C)
- With −50 to −150V DC bias:
  - anatase and rutile
- −200V DC bias:
  - rutile
  → would otherwise need higher temperature or anneal.

Profijt et al., ESL 15, G1 (2012)
Biasing results TiN

- Using biasing generally a higher conductivity is expected for conductive nitrides. Allows shorter plasma exposure times and lower temperatures.

- TiN results:
  - Using TDMAT for 200 °C deposition a high conductivity was obtained already at short total plasma time (10s).
  - 20W bias for 5 s: 109 μΩcm for 33.2 nm thickness

General recipe
Plasma ALD TiN conformality in AR 21 trench

- SEM images of a TiN-covered 1 μm wide trench with an aspect ratio of 21. Size indicators show the estimated TiN film thickness (± 5 nm).
- Excellent conformality achieved.

H.C.M. Knoops, PhD thesis 2011
**FlexAL2D: Plasma ALD of MoS$_2$**

- **Robust ALD Process:** Self-limiting ALD growth over wide temperature window, high GPC (0.1 nm/cycle), Oxygen and carbon free (<2%)
- **Digital layer thickness control from mono-layer to few layer material**
- **Tunable morphology:** Control over basal plane or edge plane orientation
- **Potential applications:** Nano-electronics and catalysis

$C_{12}H_{30}N_4Mo$
$\text{bis(tertbutylimido)}$
$\text{bis(dimethylamino)}$
Molybdenum

ALD window $\rightarrow$ 150 - 450°C

2D MoS$_2$ $\rightarrow$ $\geq$300°C

www.oxinst.com/FlexAL2D