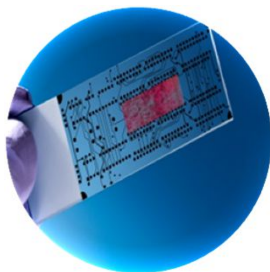
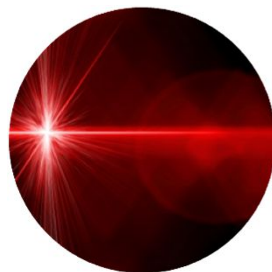
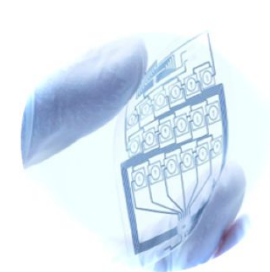
Atomic Layer Deposition (ALD) Bias Control

Oxford Instruments Plasma Technology



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Introducing FlexAL substrate biasing

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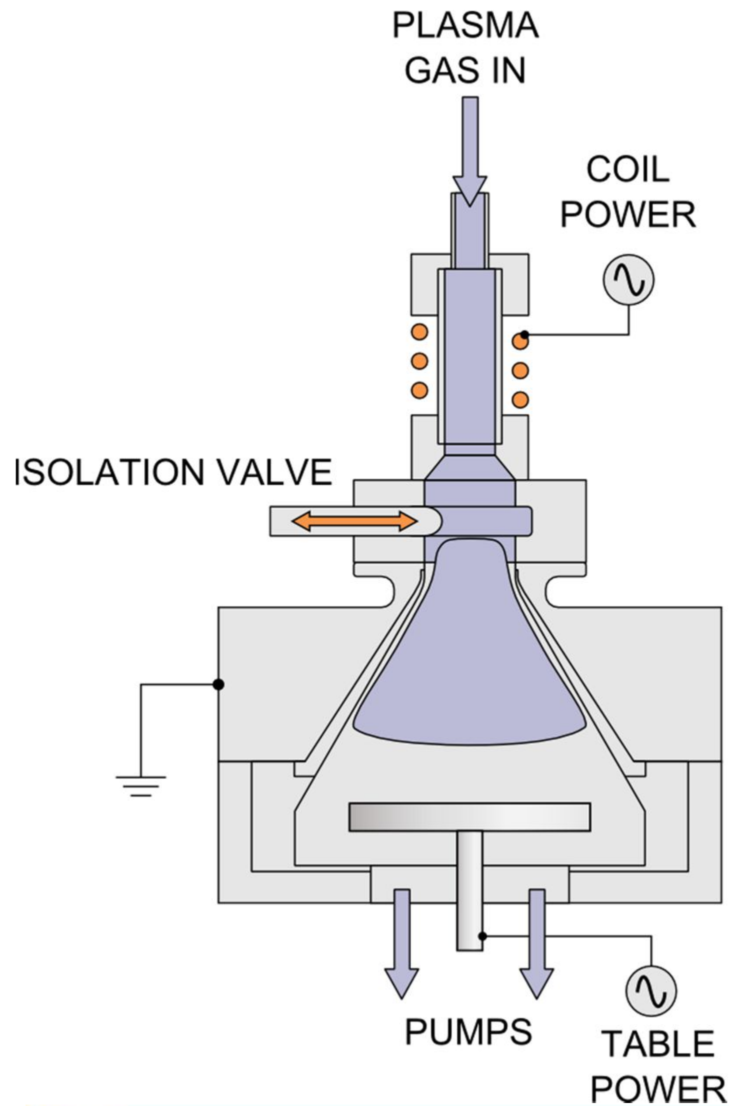

The FlexAL ALD system can now be equipped with table bias for extended process capabilities (e.g., higher conductivity, higher crystallinity, stress control).

- 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

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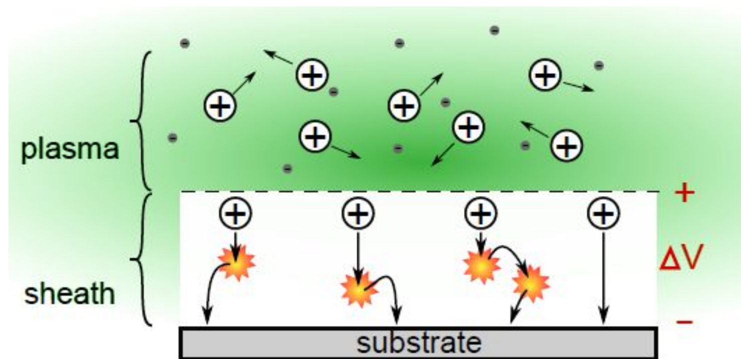

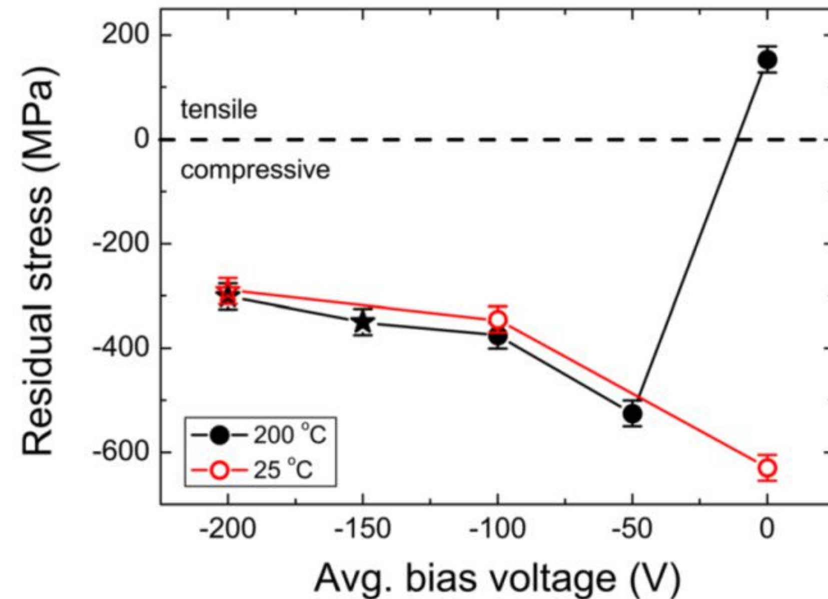

- RF biasing to increase ion energy change material from tensile to compressive at 200 °C.
- Tuning to less compressive at 25 °C.

Technische Universiteit Eindhoven University of Technology

Profijt et al., *J. Vac. Sci. Technol. A* **31**, 01A106 (2013)

Active biasing

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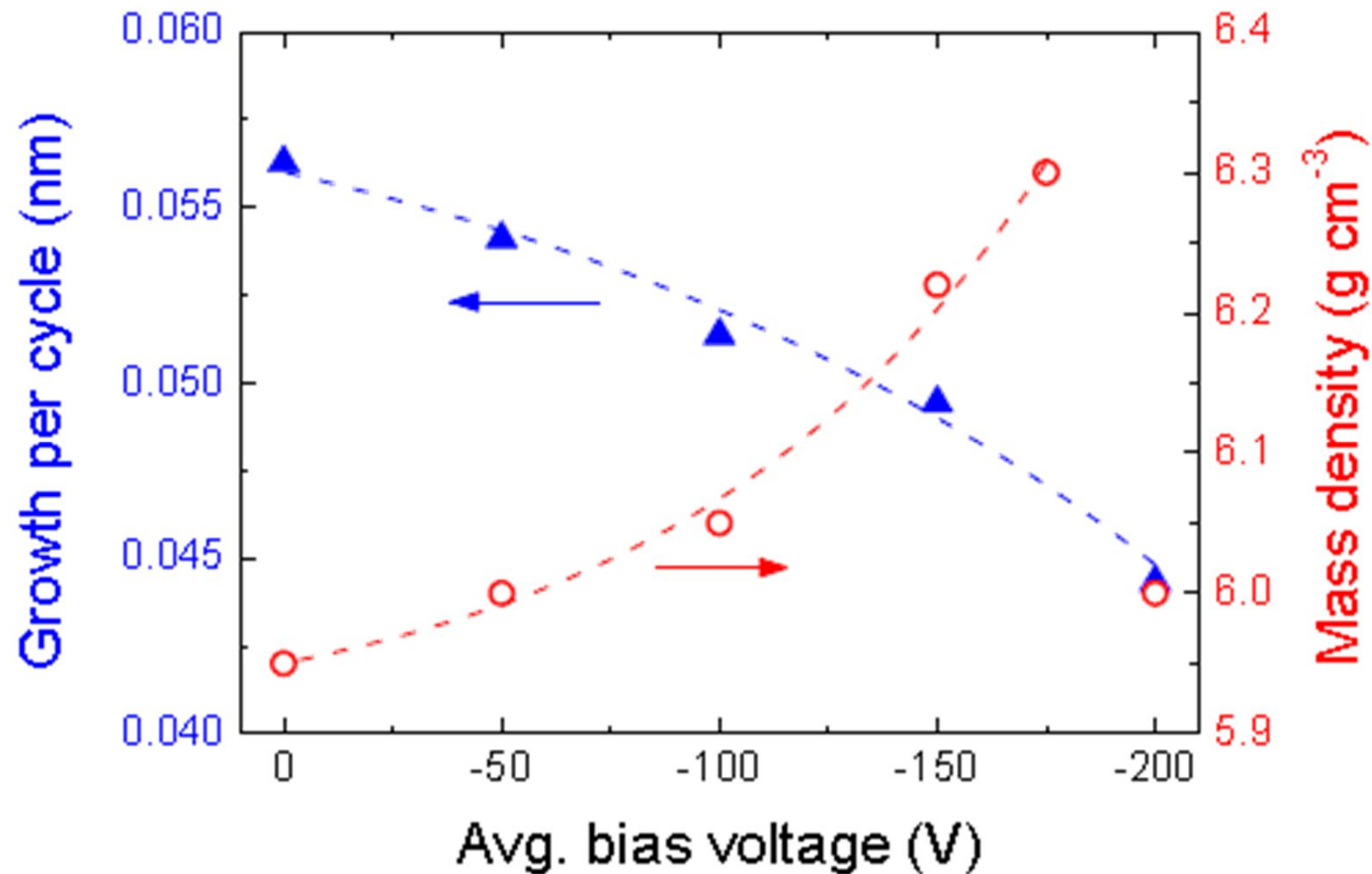

- Densification of Co_3O_4 with $CoCp_2$ @ 300C

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Active biasing: TiO_2

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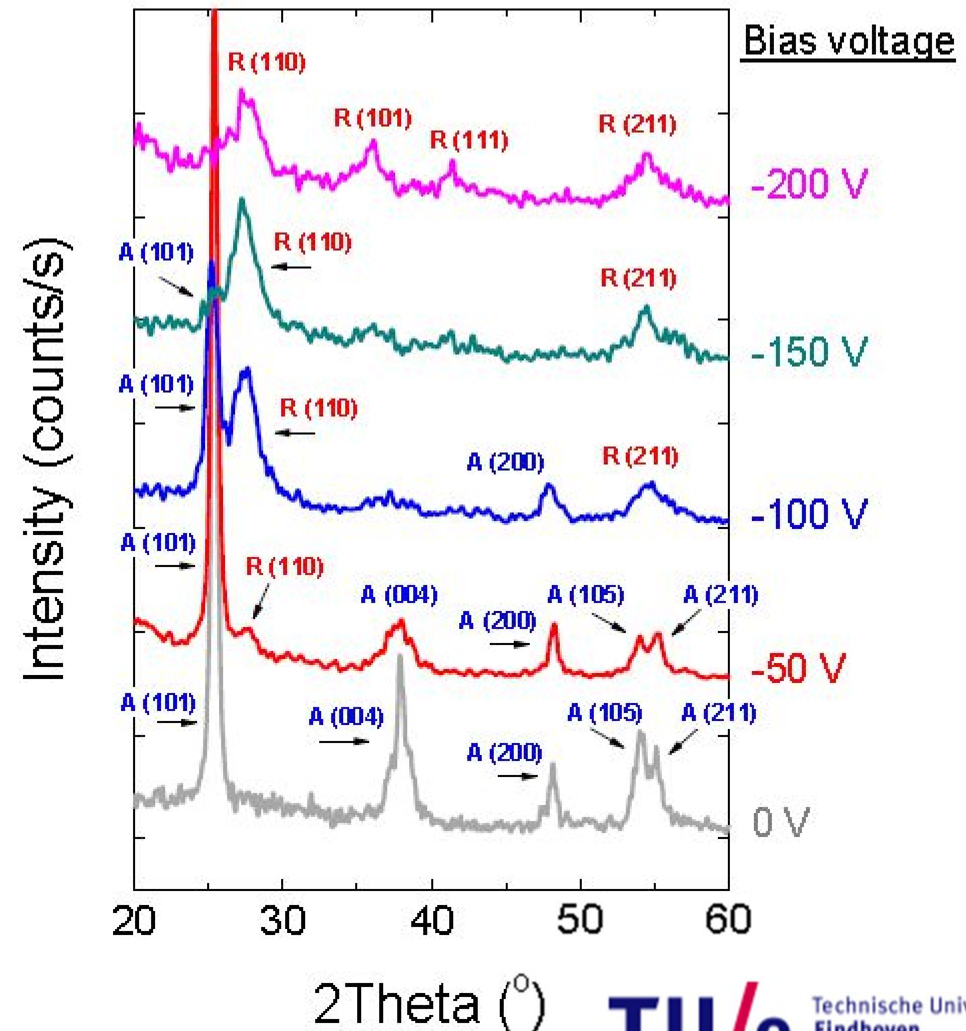
- XRD analysis at 300°C
- No bias:
  - anatase (above 250C)
- With –50 to -150V DC bias:
  - anatase and rutile
- -200V DC bias:
  - rutile

    → would otherwise need higher temperature or anneal.



Profijt et al., *ESL* **15**, G1 (2012)

Biasing results TiN

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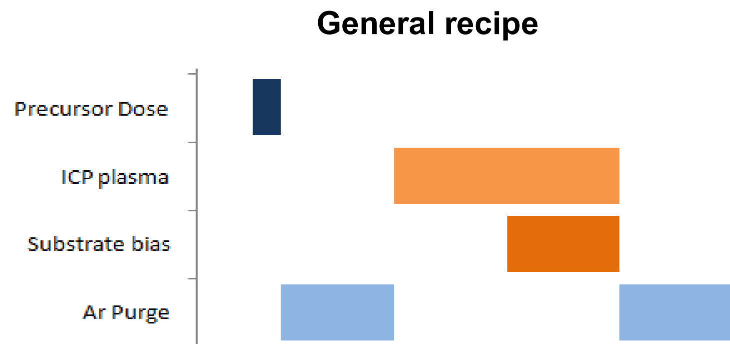
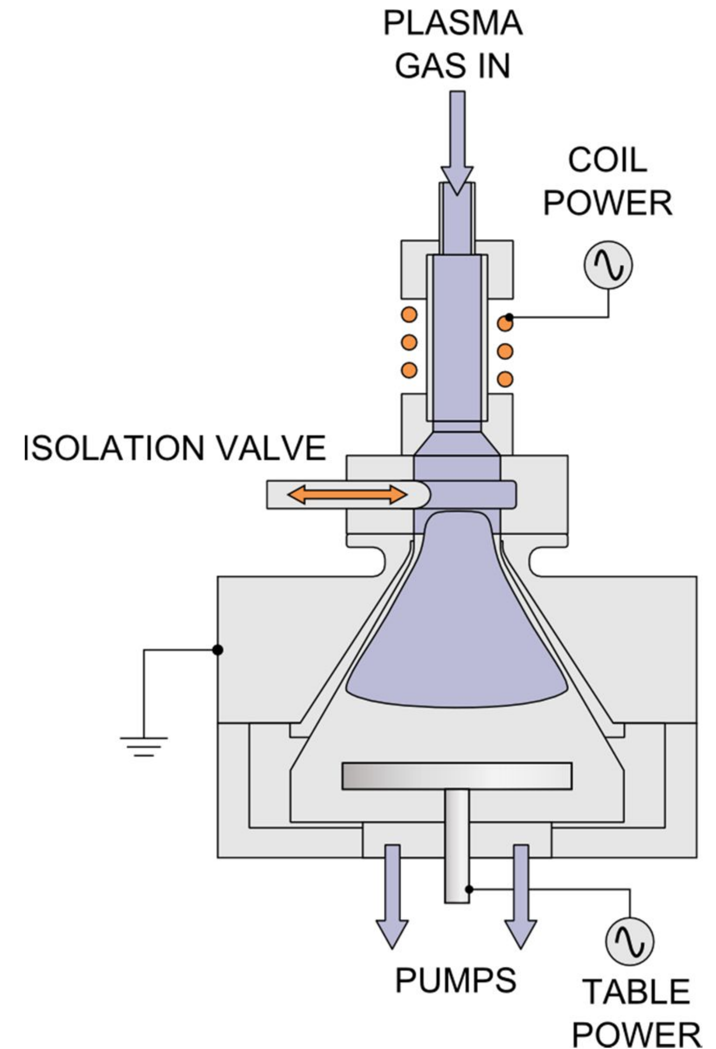
- Using biasing generally a higher conductivity is expected for conductive nitrides. Allows shorter plasma exposure times and lower temperatures.
- TiN results:
  - Using TDMAT for 200 °C deposition a high conductivity was obtained already at short total plasma time (10s).
    - 20W bias for 5 s:
      109 μΩcm for 33.2 nm thickness





Plasma ALD TiN conformality in AR 21 trench

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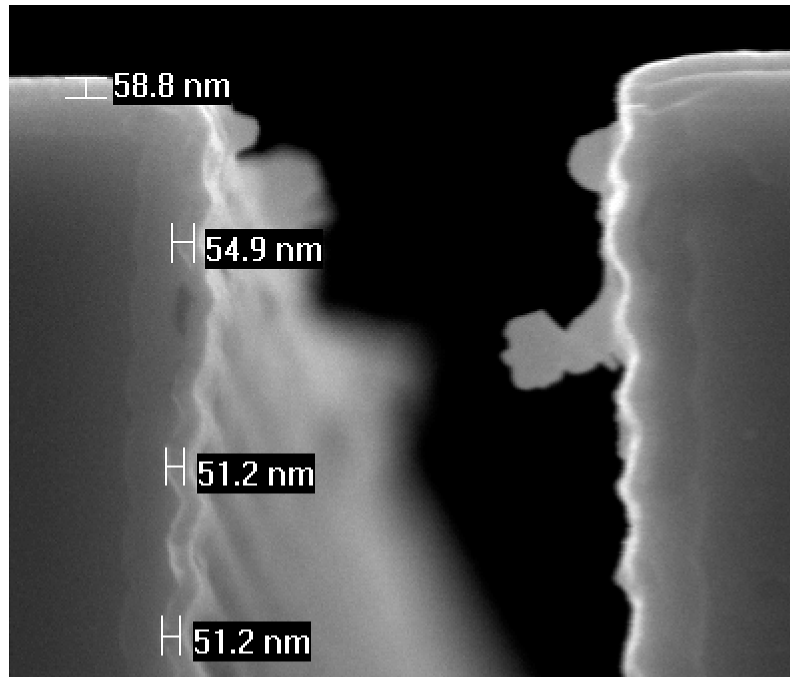
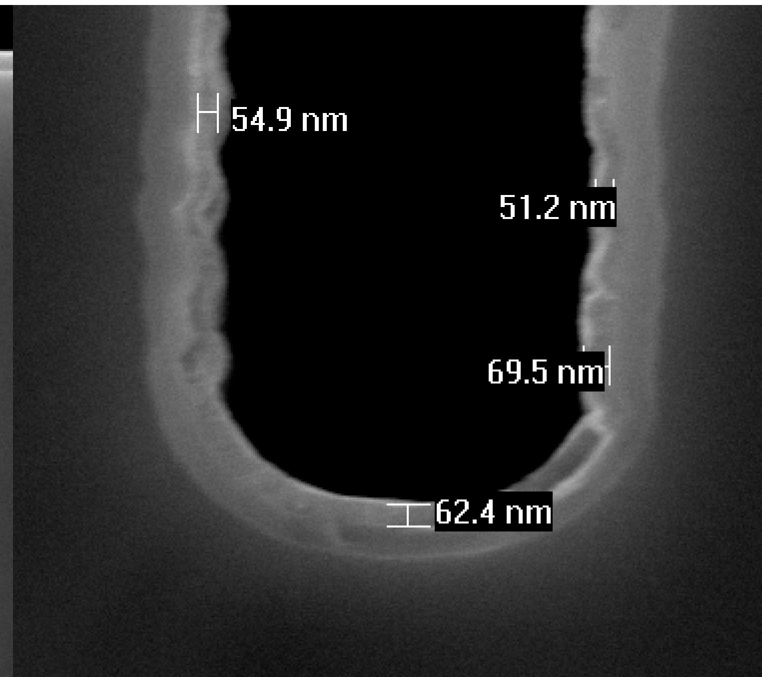
top of trench



bottom of 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

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FlexAL2D: Plasma ALD of MoS_2

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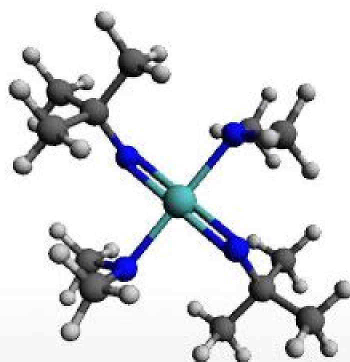

H_2S Plasma

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

ALD window → **150 - 450°C**

2D MoS_2 → **≥300°C**

- **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

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www.oxinst.com/FlexAL2D