

Improved plasma ALD of nitrides by substrates biasing

Subtitle of presentation

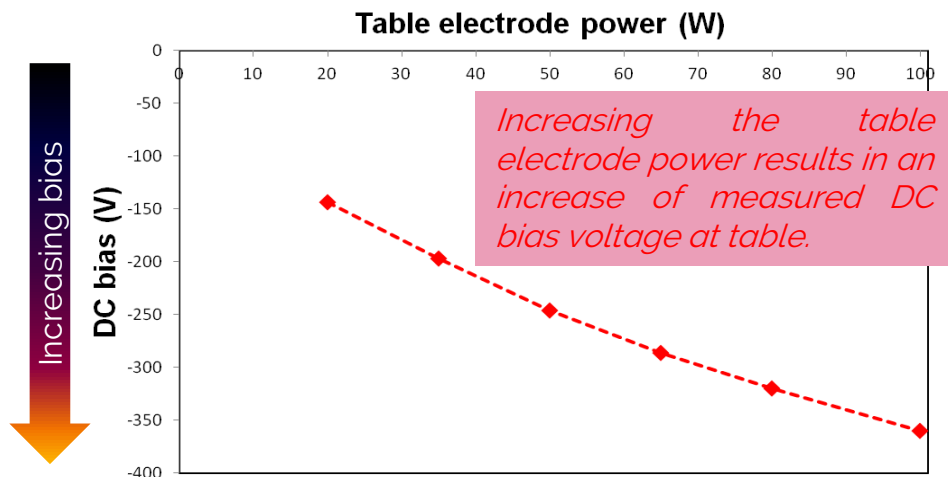
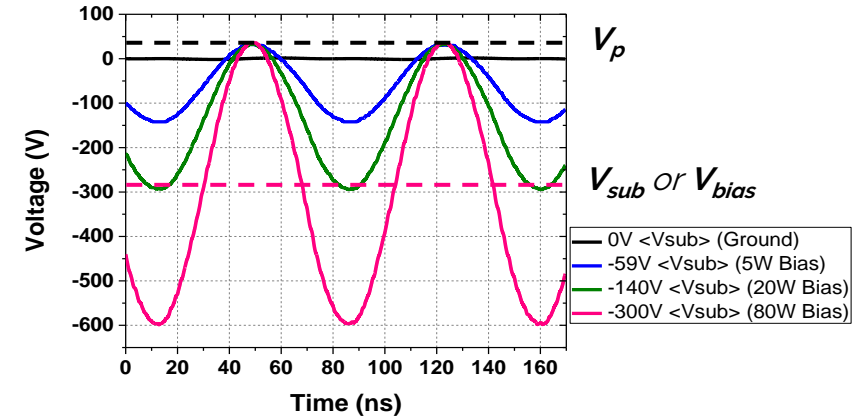
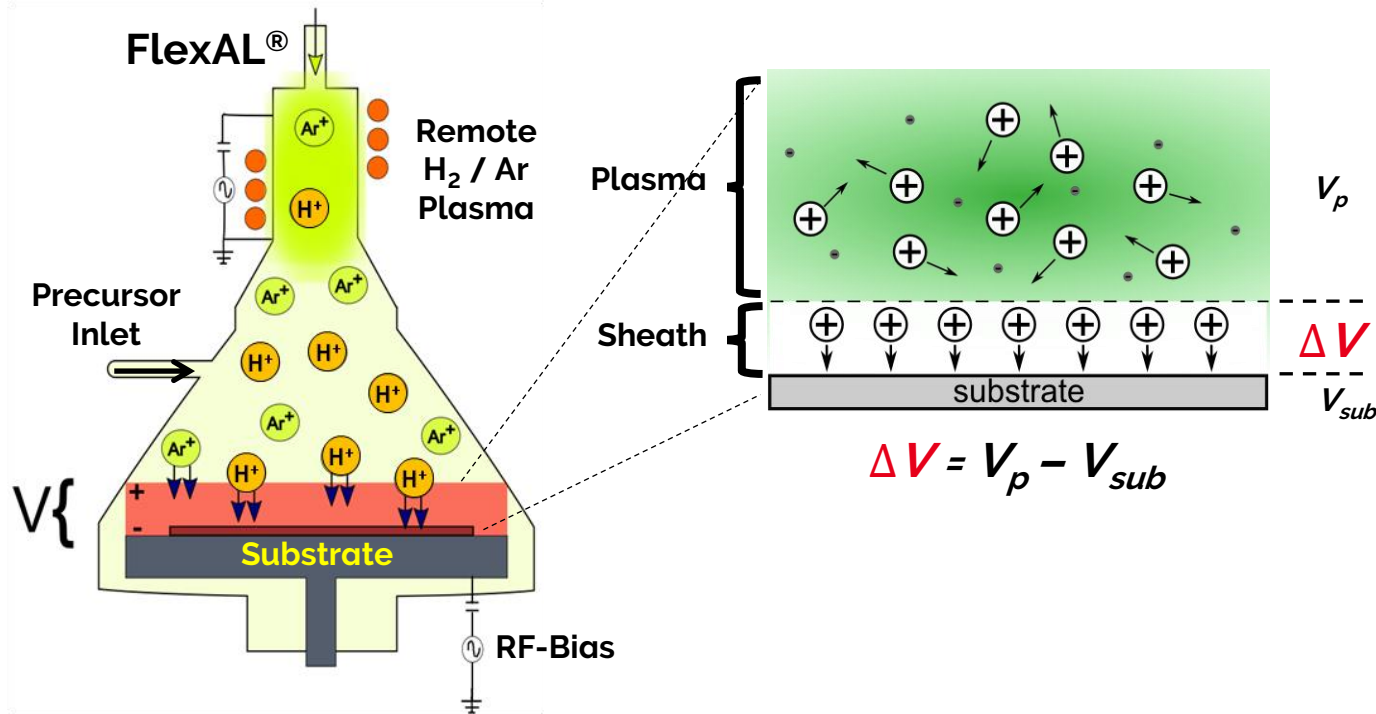
Shohei Ito

OI Japan Service Manager

Introducing FlexAL RF Substrate Biasing

FlexAL system equipped with substrate biasing enables extended process capabilities

RF substrate biasing can be applied during thin film deposition to increase the ion energy and influence film properties such as refractive index, conductivity, stress, crystallinity, density, ...



Material	TiN	TiN	TaN
Precursor	TiCl ₄	TDMAT	TBTDMT
Co-reactant	N ₂ /H ₂ plasma	N ₂ /H ₂ plasma	H ₂ plasma
Deposition temperature	300°C - 550°C	100°C - 350°C	250 °C – 350 °C
Thickness per cycle	~0.35 Å/cycle @ 350 °C	~0.5 Å/cycle @ 200°C	~0.4 Å/cycle @ 300 °C
Thickness uniformity 200 mm	< ±3.5%	< ±3.5%	< ±3.5%
Resistivity	< 150 μΩcm @ 350 °C < 100 μΩcm @ 550 °C	< 300 μΩcm @ >200 °C < 150 μΩcm (RF bias)	< 1000 μΩcm @ 350 °C < 300 μΩcm (RF bias)

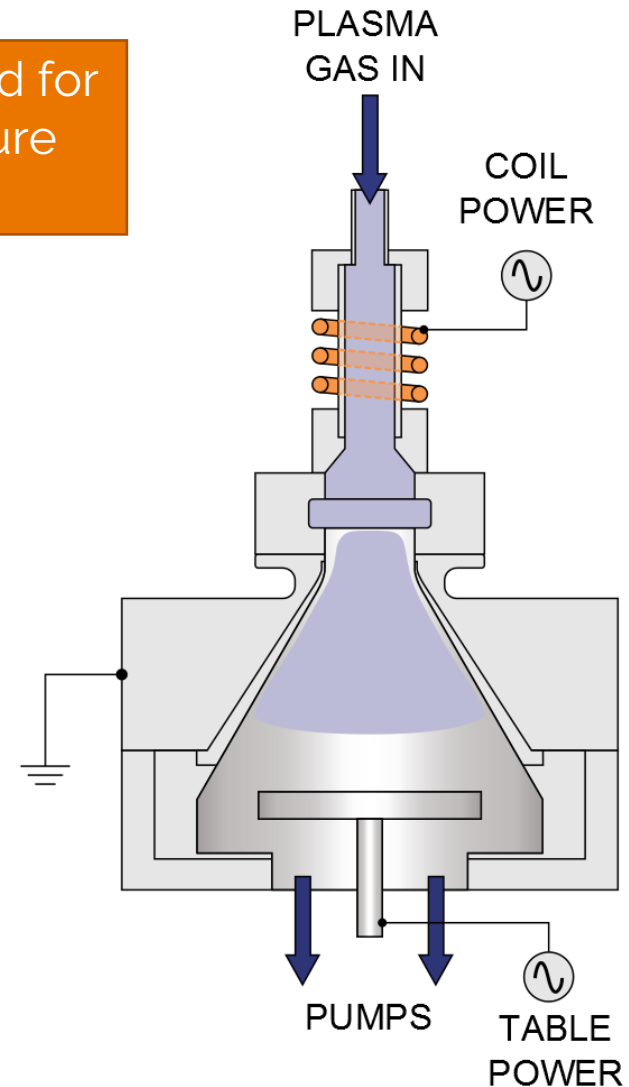
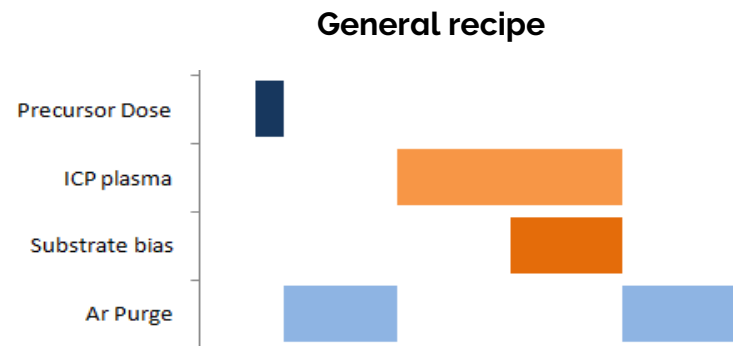
- TiN deposition with low resistivity using both halide precursors (TiCl₄) and also metal-organic precursor (TDMAT).
- TiN and TaN benefit from RF substrate biasing by lower film resistivity.

General recipe for RF substrate biasing



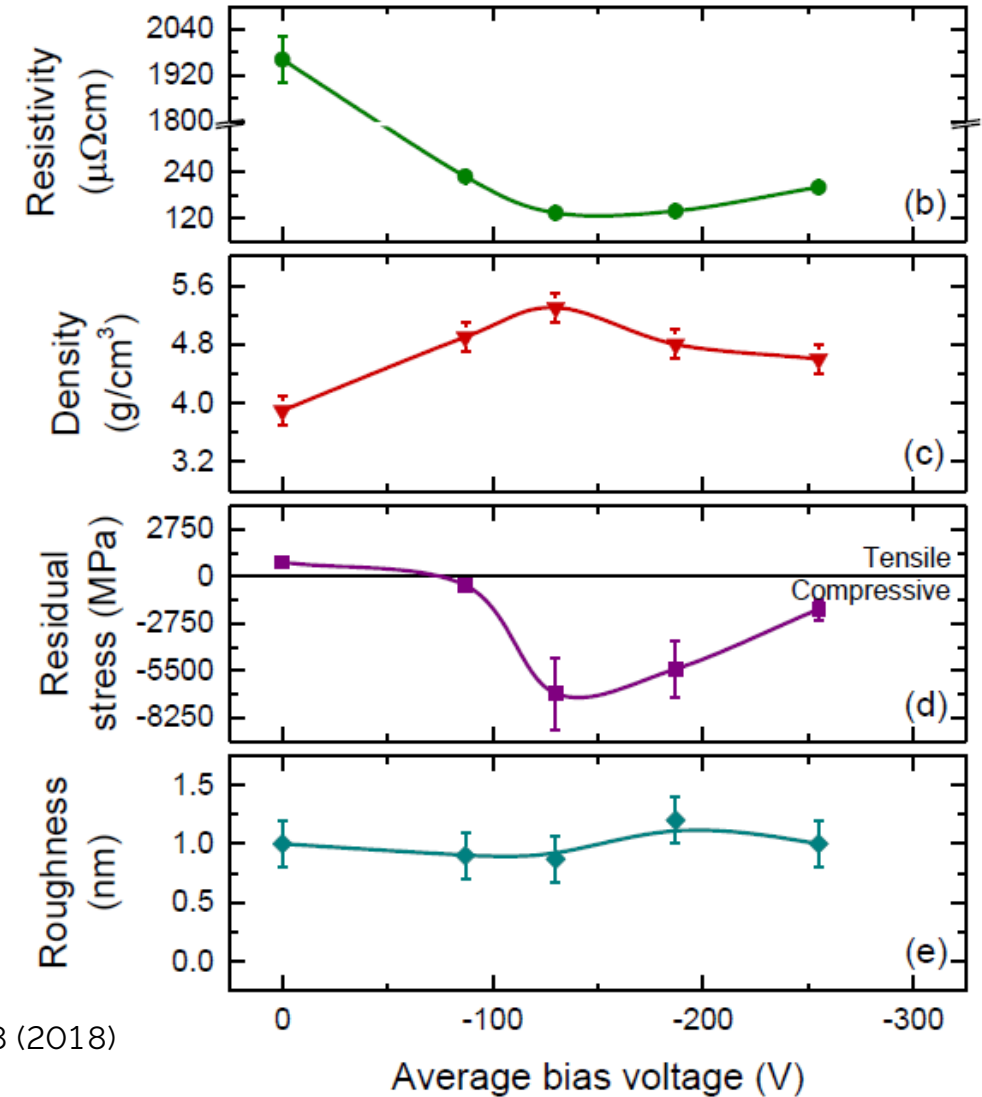
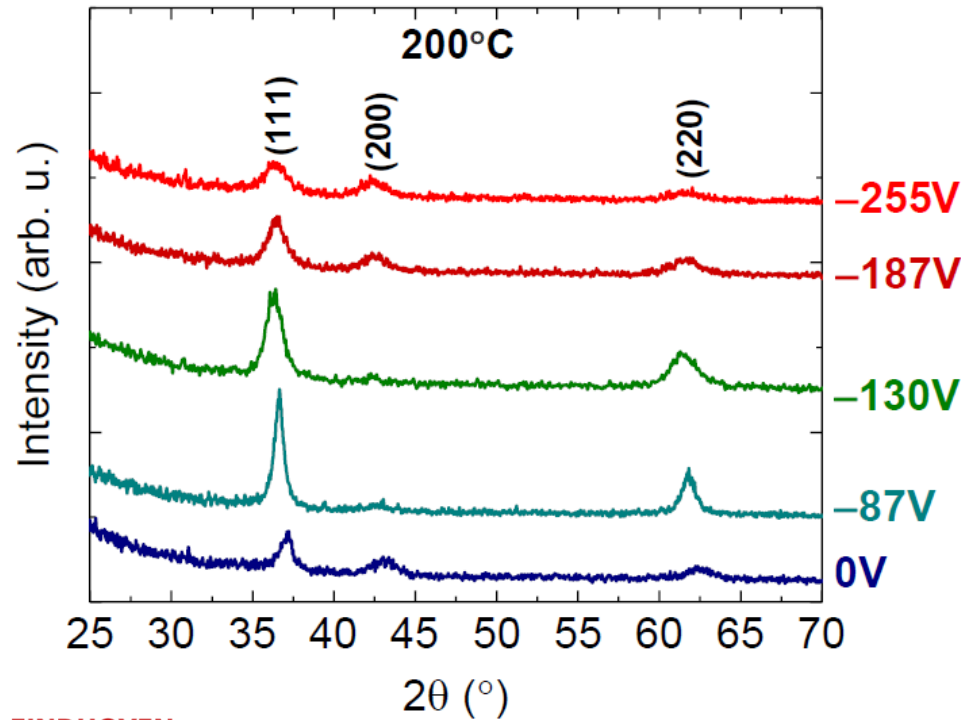
Using biasing generally higher conductivity obtained for conductive nitrides. Allows shorter plasma exposure times and lower deposition temperatures.

- TiN results:
 - Using TDMAT for 200 °C deposition a high conductivity was obtained already at short total plasma time (10s).
 - 20W bias ($\sim 100\text{-}150 V_{bias}$) for 5 s:
109 $\mu\Omega\text{cm}$ for 33.2 nm thickness



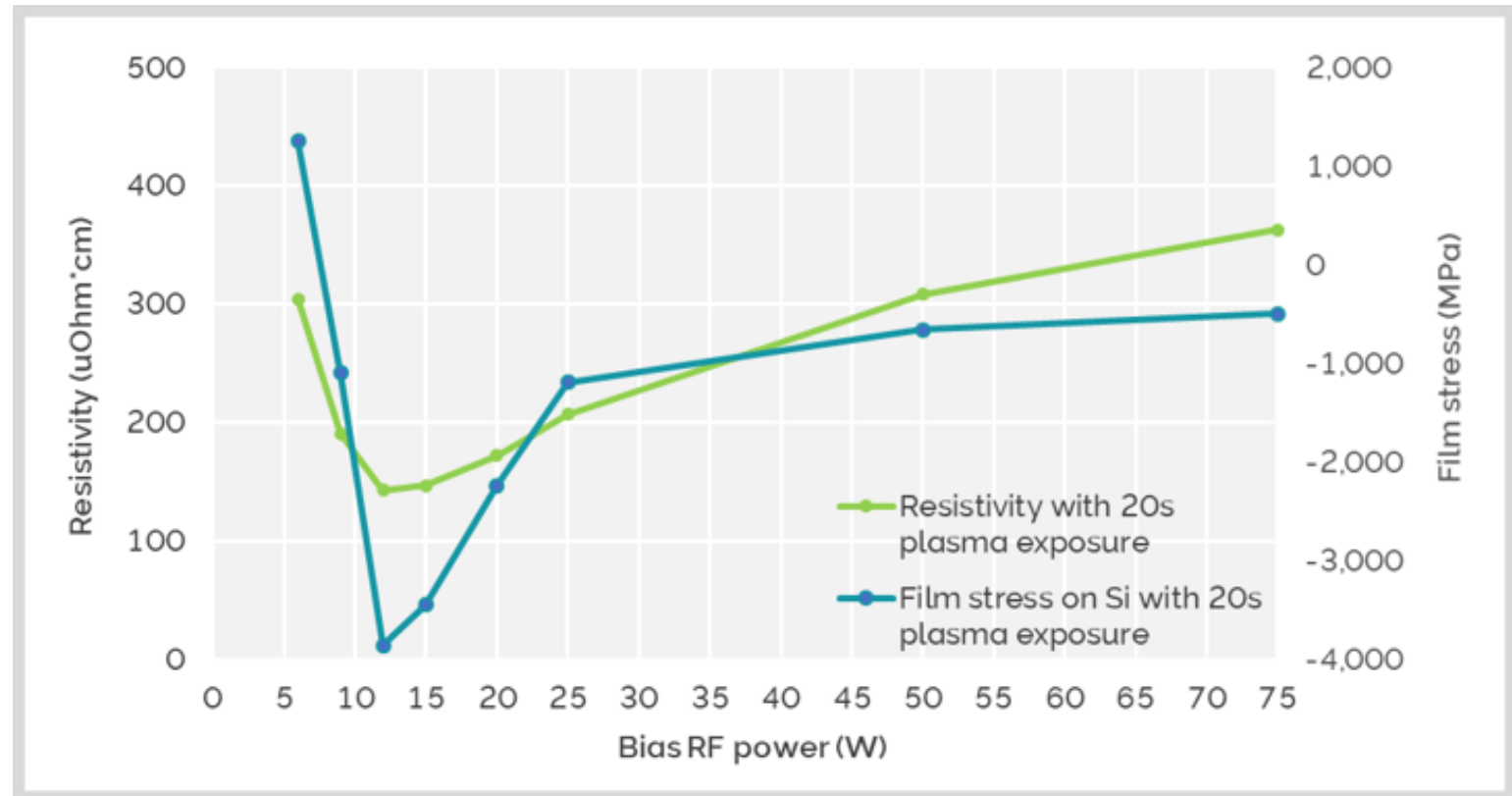
Effect of bias on plasma ALD TiN

- ALD by TDMAT and 10 s H₂/Ar plasma at 200 °C.
- Tuning of crystallinity, resistivity, density, and stress.



Resistivity and Film Stress (on Si substrate) vs Biasing Power for NbN Films processed at 250 °C

- Resistivity and film stress can be controlled by tuning substrate biasing power
- Coincidence and possible correlation can be observed between resistivity and film stress
- NbN film deposit with 12W RF substrate biasing power has biggest film stress and lowest resistivity measured



Comparison of Superconductivity with Different NbN Plasma ALD Solutions

- Lower Room temperature (RT) resistivity usually indicates higher critical temperature T_c
- The plasma ALD solution offered by Oxford Instruments (OIPT) shows excellent performance even at low process temperature for NbN deposition

