Supplementary Information

Tuning Material Properties by Ion Energy Control during Remote Plasma-ALD on Planar and 3D Substrates

Tahsin Faraz,[1] Harm Knoops,[1,2] Marcel Verheijen,[1] Cristian van Helvoirt,[1] Saurabh Karwal,[1] Akhil Sharma,[1] Dennis Hausmann,[3] Jon Henri,[3] Ageeth Bol,[1] Mariadriana Creatore[1] and Erwin Kessels[1]

[1] Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, NL

[2] Oxford Instruments Plasma Technology, North End, Bristol, BS49 4AP, UK

[3] Lam Research Corp., 11155 SW Leveton Drive, Tualatin, OR 97062 USA

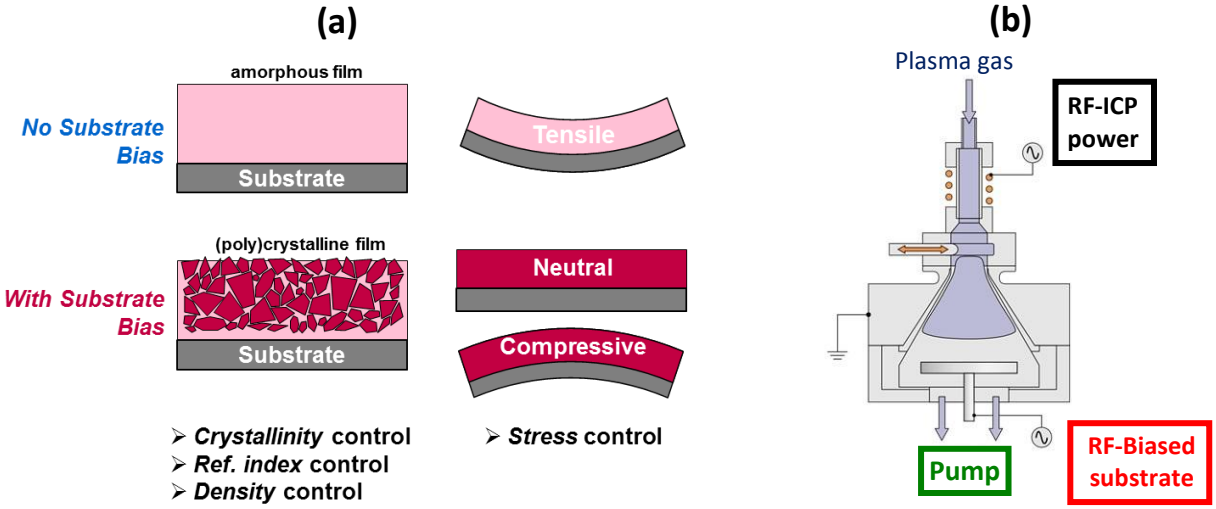

Figure S1. (a) Illustrative example of how material properties (e.g., crystallinity, refractive index, mass density, residual stress, etc.) of thin films can be tuned by means of substrate biasing during PEALD (b) Schematic of a FlexAL system with substrate biasing incorporated through a second RF power supply connected to the substrate table. This allows enhancement of ion energy independent of ion flux.

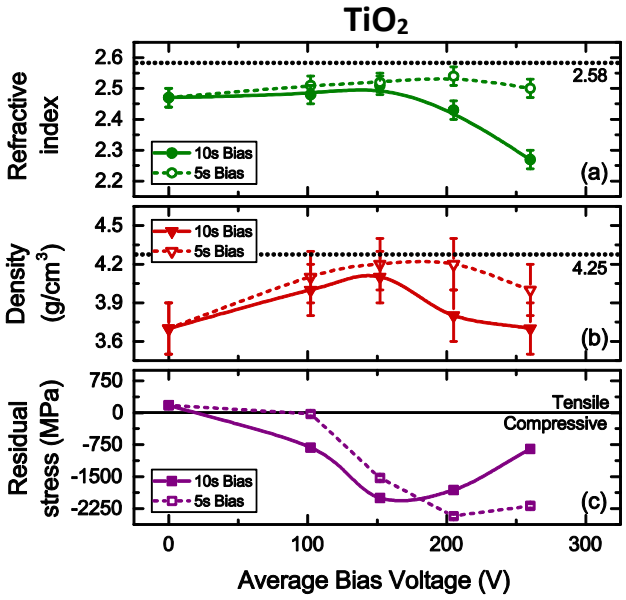

Figure S2. (a) Refractive index (b) mass density and (c) residual stress of TiO_2 films deposited at a temperature of 300 °C expressed as a function of the average bias voltage applied for the entire duration (solid lines) and last half (5s, dashed lines) of the 10s O_2 plasma exposure step. Higher refractive index and density obtained using lower bias duration.

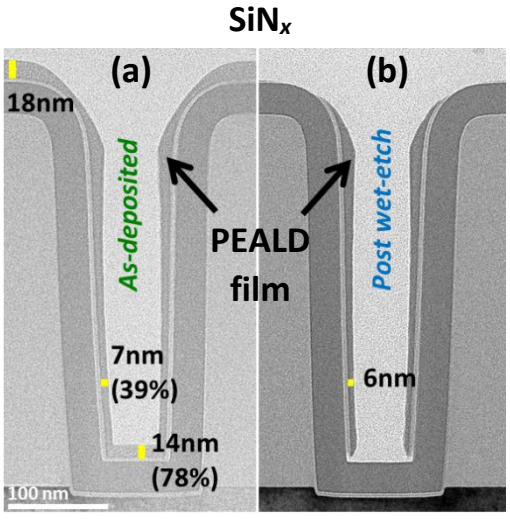

Figure S3. TEM images of (a) as-deposited and (b) post wet-etch (in 30 s dilute HF) SiN_x films grown on 3D trench nanostructures (AR = 4.5 : 1) using -65 V substrate bias applied during the last half (10 s) of the 20 s N_2 plasma exposure step. Film regions deposited at planar surfaces are completely removed while those at vertical sidewalls selectively remain after etch treatment.