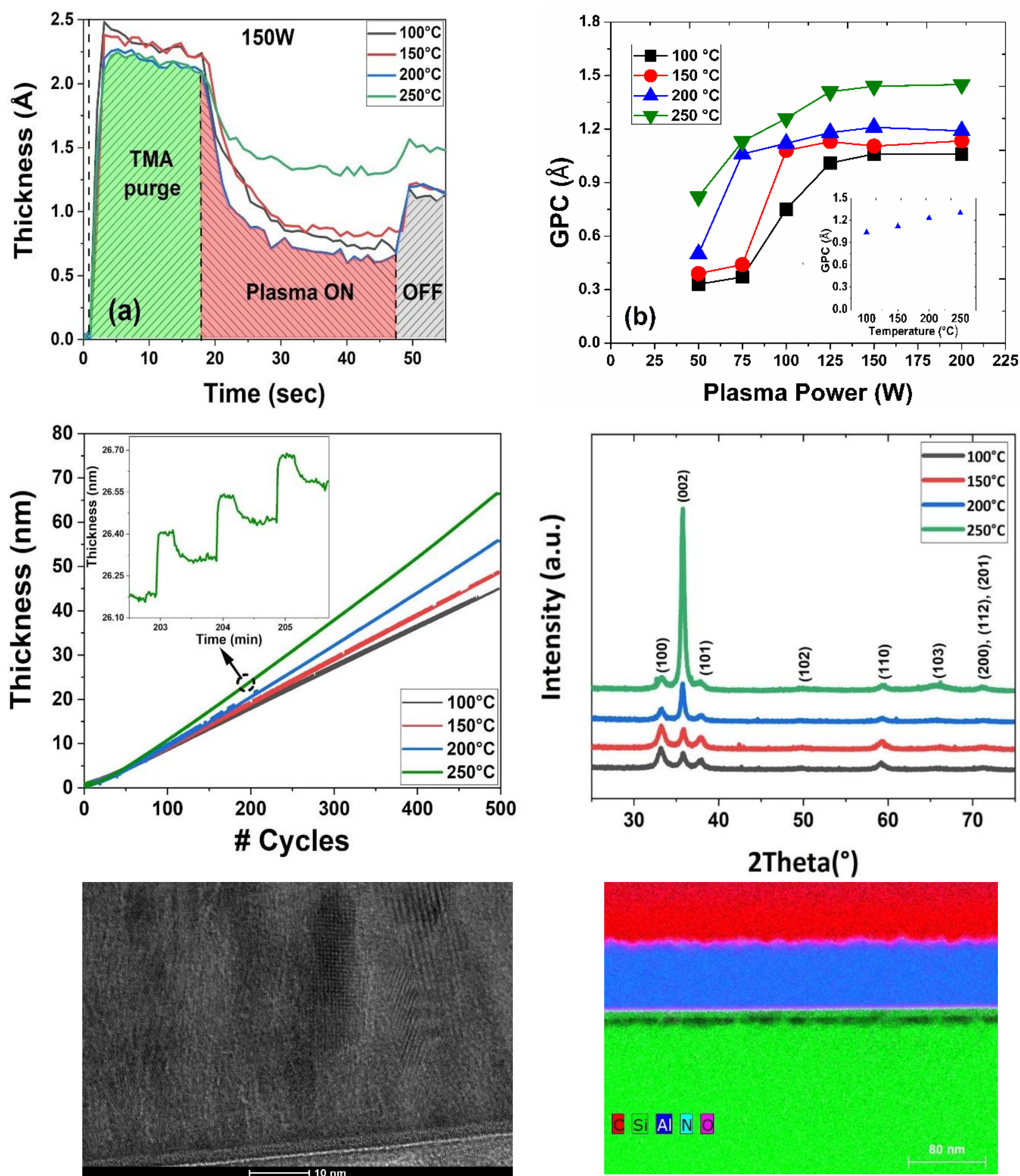


**Fig. 1.** (a) Real-time measured in-situ ellipsometric film thickness data showing the TMA chemisorption and ligand exchange reactions. (a) the GPC at different plasma power (inset: at fixed plasma power of 150 W for different substrate temperatures). (b) substrate temperature dependence of GPC (fixed parameters: plasma power 100 W, TMA dose 15 msec, plasma duration 30 sec, purge time 10 sec). (c) 500-cycle linearity curves of AlN HCPA-ALD process recorded with real-time in-situ ellipsometry. (inset) Zoomed-in ALD cycles showing sequential TMA chemisorption and plasma-assisted ligand removal/exchange reactions. (d) GIXRD measurement spectra for 500-cycle AlN samples grown at different substrate temperatures. (e) HR-TEM image of the ALD-grown AlN film depicting the polycrystalline domains (f) Elemental mapping of the cross-sectional TEM image for AlN confirming the low carbon and oxygen impurities within the film bulk.