The Role of Reactive Ion Species in Plasma Focused Ion Beam Induced Deposition

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Focused ion beam induced deposition (FIBID) is a maskless, direct-write nanofabrication technique in which a focused ion beam decomposes adsorbed precursor molecules, resulting in localized material deposition. Among deposition chemistries compatible with FIBID, platinum is one of the most extensively studied. As with most FIBID processes, however, Pt functionality is often impaired by the incorporation of contaminants originating from precursor ligands, residual chamber gases, and beam–matter interactions.[1]

Recent advances in plasma FIB systems capable of operating with multiple ion species have renewed interest in tailoring FIBID deposit composition, particularly through oxygen-based ion beams that enable reactive modification during growth.

Here, we demonstrate that oxygen FIBID (O-FIBID) enables direct-write fabrication of Pt nanostructures while simultaneously enhancing deposit purity through implanted oxygen–mediated reactions. By varying dwell time, accelerating voltage, and precursor pressure, the relative Pt, C, and O content can be tuned to achieve Pt concentrations up to 63 at.% (Figure 1), with resistivities slightly improved over Ga^{+} FIBID and orders of magnitude lower than electron-beam-induced deposition.

Continuum simulations reveal a mechanism governed by the balance between beam-activated oxygen and preferential Pt sputtering, which also strongly influences deposit morphology (Figure 2). These results establish O-FIBID as a promising route for reactive, composition-controlled FIBID.

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[1] Tao, T., Ro, J., Melngailis, J., Xue, Z. & Kaesz, H. D. Focused ion beam induced deposition of platinum. *Journal of Vacuum Science & Technology B: Microelectronics Processing and Phenomena* **8**, 1826–1829 (1990).

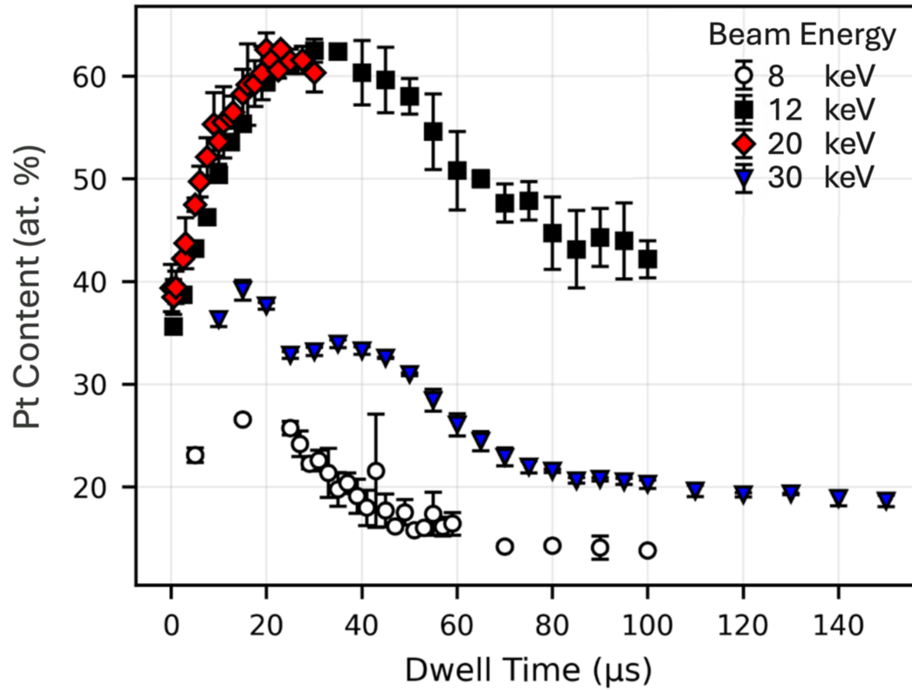

Figure 1: Averaged Pt composition (at.%) versus dwell time for 8, 12, 20, and 30 kV with error bars of ±1 standard deviation.

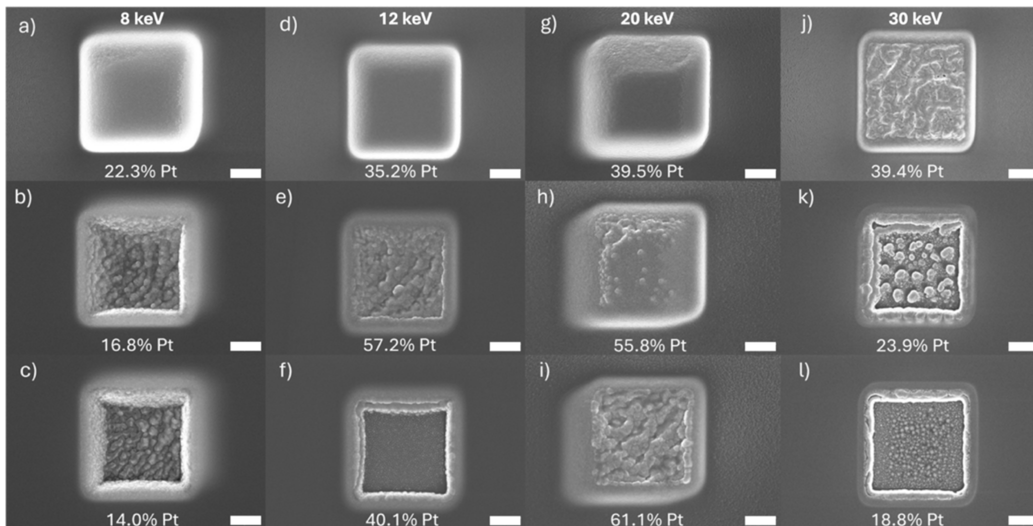

Figure 2: SEM images of O-FIBID Pt depositions and corresponding Pt composition for 8 keV (a–c), 12 keV (d–f), 20 keV (g–i), and 30 keV (j–l) with varying dwell times: (a) 5 µs, (b) 55 µs, (c) 100 µs, (d) 0.5 µs, (e) 40 µs, (f) 100 µs, (g) 0.5 µs, (h) 10 µs, (i) 30 µs, (j) 15 µs, (k) 70 µs, and (l) 150 µs. All scale bars are 1 µm.