Isotropic Atomic Layer Etching of ZnO on 2D and 3D substratesusing acetylacetone and O_2 plasma

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Atomic layer etching (ALE) holds great potential for Ångström-level processcontrol in 2D and 3D material removal. Therefore, it is intensively studied asan alternative technology option to overcome the challenges innanomanufacturing faced by conventional etching techniques. Recent research hasresulted in the development of two main categories of ALE: ion-driven plasmaprocesses yielding anisotropic (or directional) etch profiles andthermally-driven processes for isotropicmaterial removal. In this work, we describe another approach to obtainisotropic etching by using a plasma-based ALE process for ZnO. This ALE processis radical-driven and utilizes acetylacetone (Hacac) and O_2-plasmaas reactants. The process was demonstrated on planar and on 3D substratesconsisting of a regular array of semiconductor nanowires conformally-covered byALD-grown ZnO. In-situ Spectroscopic Ellipsometrymeasurements on the planar substrates indicate self-limiting half-reactions withetch rates ranging from 0.5 to 1.3 Å/cycle at temperatures between 100 and 250 ^{o}C.Transmission Electron Microscopy studies conducted on the ZnO-covered nanowiresbefore and after ALE demonstrated the isotropic nature and the damage-freecharacteristics of the process. In-situInfrared Spectroscopy measurements were used to elucidate the self-limiting natureof the ALE half-reactions and to understand the reaction mechanism. Persistentacac-species adsorbed on the ZnO surface are suggested as the cause of theself-limiting behavior during the Hacac etch reaction step. The subsequent O_2plasma step resets the surface for the next ALE cycle. High etch selectivities(~80:1) over SiO_2 and HfO_2 have been demonstrated. Preliminaryresults suggest that this ALE process approach can be extended to other oxidessuch as Al_2O_3.

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