# Challenges and optimization in using HSQ as etch mask for on-chip AlN waveguides fabrication for photonic devices

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Pattern transfer in AlN photonics is challenged by the material's hydroxide-based developer susceptibility and reactive ion etch resilience, which renders conventional processing methods common to silicon photonics ineffective and necessitates several mitigation strategies. Our process includes the use of hydrogen silsesquioxane (HSQ) e-beam resist and protective stacks ($SiO_2$, $AlF_3$) to enhance selectivity and minimize developer-induced roughness. In addition, the insulator-on-insulator architecture of AlN/SiO2-based waveguides, while optically advantageous, exacerbates charge accumulation during electron beam lithography and plasma processing, manifesting as degraded plasmonic features such as grating couplers, which thwarts light coupling efficiency, and sidewall roughness, which increases propagation loss. These challenges are overcome by optimizing EBL dose and leveraging chemistry-dominant ICP-RIE, achieving propagation losses below 3dB/cm in our AlN waveguide system.