Optimization of lithographic and dry etch conditions for on-chip AlN waveguides for photonic devices

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Aluminum nitride (AlN) is a wide-gap semiconductor with excellent thermal conductivity, dielectric, piezoelectric, and ferroelectric properties, making it a valuable material in electronic, electro-optic, MEMS, and sensor applications. Additionally, AlN has a high optical transparency in the UV to mid-IR regimes, making it an ideal candidate for telecom wavelength, on-chip photonic devices. As such, AlN continues to gain interest in application as a waveguide material. As these photonic devices are integrated into architectures involving quantum phenomena, AlN waveguide edge structures are certain to become increasingly important. The knowledge base for optimal and controllable lithographic patterning and etching are still limited. Here we investigate the effects of inductively coupled plasma (ICP) reactive ion etch process parameters and chemistries on fabrication AlN-based waveguides with an emphasis on understanding and controlling sidewall effects. Specifically, we will report on the systematic variation of halogen chemistry (fluorine vs. chlorine), gas ratios, substrate temperature, total pressure, and RF power on the etch rate, selectivity, sidewall angle, uniformity, and roughness. Additionally, we will investigate the impact of these etch processes on the optical losses in fabricated waveguides.