SAND2018-7882C

Optimal contact photolithography techniques for HEMT substrates using i-line photoresist

Whitney Ingram, Adam Jones, Brianna Klein, Albert G. Baca, Andrew M. Armstrong, Andrew A. Allerman, and Erica A. Douglas,

Sandia National Labs

ABSTRACT

Gallium nitride-based high electron mobility transistors (HEMTs) utilize a variety of substrates, including those that are optically transparent in the visible and ultraviolet wavelength spectrum such as sapphire and silicon carbide(SiC). Compared to silicon substrates, SiC and sapphire substrates can exhibit a distinct set of photolithography patterning challenges such as backscattering (from the underlying chuck and other areas of the substrate) which can influence the critical dimension (CDs), pattern integrity, and pattern resolution. In this study, computational photolithography and rigorous coupled wave guide analysis are used to calculate the optical reflectivity, the transmission and absorption of a multilayered stack comprised of i-line photoresist and an antireflective coating on sapphire substrates with $Al_xGa_{1-x}N$ epitaxial layers (with x ranging from 0 to 1). These simulations are used to target optimal resist and arc thickness, and exposure energy needed to reach the target feature with high fidelity. As a proof of concept, fully resolved patterns down to 0.5 μm are experimentally obtained on sapphire substrates using conventional contact photolithography driven by simulated for optimal conditions. Due to the lack of experimental information on photolithography on optically transparent substrates with ultra-wide bandgap heterostructures, this method can provide relevant insight into determining optimal process window for optically transparent substrates.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. This work was funded by DOE LDRD.