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Enhancing AlGaN Based Semiconductors with Dislocation Analysis and Thin Film Optimization

Gallium nitride (GaN) based high electron mobility transistor (HEMT) structures are considered to be an alternative to gallium arsenide and silicon based devices due to their excellent characteristics when used in high power radio frequency applications. GaN based devices are also increasingly being used in advanced solid state optical and laser applications. However, these structures have been observed to yield different levels of performance, measured by mobility, from the same growth. Determining the cause of the variance becomes difficult after passivation, as novel non-crystalline dielectric layers are necessary to produce smaller line width devices. The problematic dislocation densities were analyzed using a series of electron channeling contrast imager (ECCI) images to identify dislocation counts, which were then plotted against mobility values. Results showed that higher dislocation densities yield lower mobility. Suitable growths must be passivated with a non-native dielectric layer. Atomic layer deposition (ALD) was utilized for fine thickness controlled deposition of Al2O3. Different thicknesses of Al2O3 were examined to determine the extent of the coverage at multiple cycles. Scanning electron microscope images showed complete coverage on all 100, 200 and 300 cycle samples. A variable angle spectroscopic ellipsometer was used to determine the final thickness of the Al2O3 layer using an established Cauchy layer produced from the control sample. Final ellipsometer results showed approximately 1.1 Å every ALD cycle, suggesting that an approximately 110 Å thick sapphire dielectric can be used for passivation.