Characterization and Processing Improvements for Fabricating β-Ga2O3 Substrates for Next-Generation Power Electronics

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Abstract: Gallium oxide (β-Ga_2O_3) is an ultra-wide bandgap semiconductor of significant interest for power electronics applications. In addition to its material properties, β-Ga_2O_3 is particularly attractive for next-generation devices because it is the only ultra-wide bandgap semiconductor which can be crystallized from a melt at an industrial scale. A key challenge is to fabricate the bulk crystals into high-quality, uniform substrates for epi growth and subsequent device fabrication.

Our group has researched and developed processes for fabricating β-Ga_2O_3 crystals into up to 50 mm epi-ready substrates. By partnering with commercial wafer suppliers and epi growers, our goal is to establish a vertically integrated feedback loop to realize continuous improvements in substrate and epi quality. In this poster, we will show our latest results for improving the β-Ga_2O_3 chemi-mechanical polishing (CMP) process for Czochralski (Cz) grown (010) substrates. By using a three-step CMP process, we can achieve an excellent surface finish with average roughness values between 1-1.5 Å while realizing an approximately 10X reduction in cycle time.

We will also highlight our β-Ga_2O_3 characterization work with a focus on surface topography, crystalline quality, defect, and subsurface damage analysis. In particular, we utilize high-resolution x-ray diffraction (HRXRD) for assessing the substrate and epi quality as well as subsurface damage by in-plane or grazing incidence XRD (GIXRD). We have also developed an etch pit density (EPD) mapping and analysis tool to characterize nanopipes and dislocations in the Cz grown boules. Our current work includes continuing to apply advanced characterization techniques to quantify and minimize subsurface damage, realizing additional improvements in the CMP or surface preparation steps, evaluating the impact of off-cut/off-axis angle on the epi properties, and characterizing the uniformity of 50 mm β-Ga_2O_3 device wafers.