Optimization of Etch, Release, and Transfer of GaN HEMTs Devices

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1 BACKGROUND

GaN High Electron Mobility devices

- ✓ GaN's wide bandgap
- ✓ High electron mobility at the GaN/AlGaN interface
- ✓ Reliance on intrinsic charge carriers

- ✗ Require heterogeneous integration due to absence of logic
- ✗ Challenging integration into heterogeneous systems at large scale

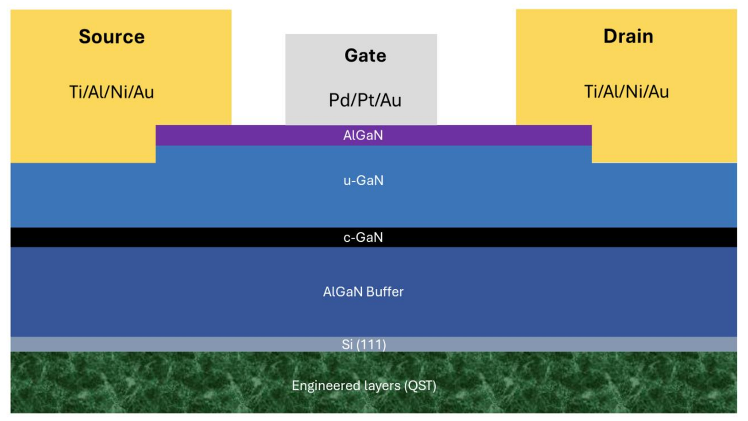


Figure 1: Cross section of a depletion mode device

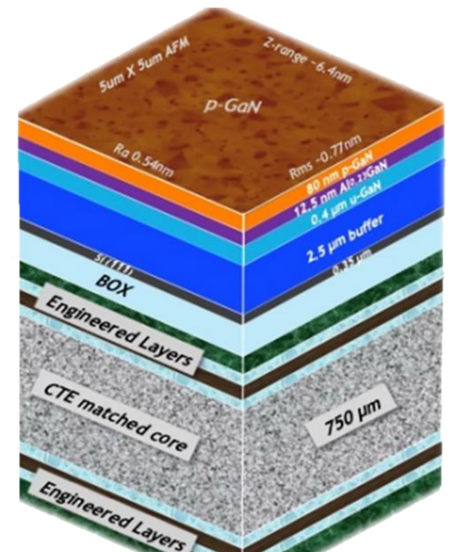
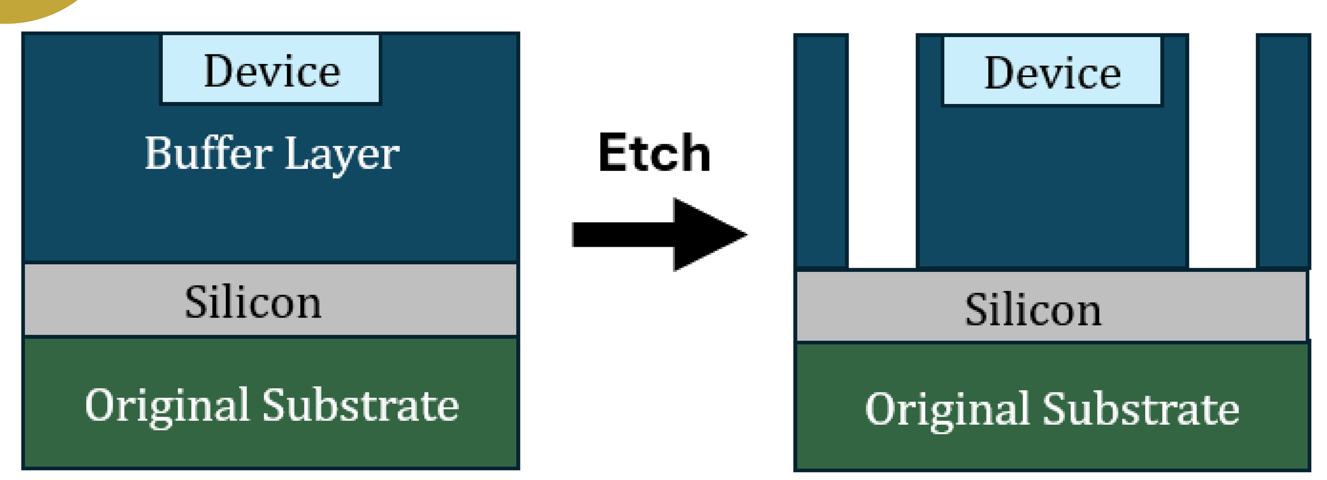


Figure 2: Qromis QST commercially available wafers

2 ETCH



- A nickel (Ni) hard mask was developed to provide a more robust etching process
- Explored two lithographic approaches, and both single and multicycles etching processes

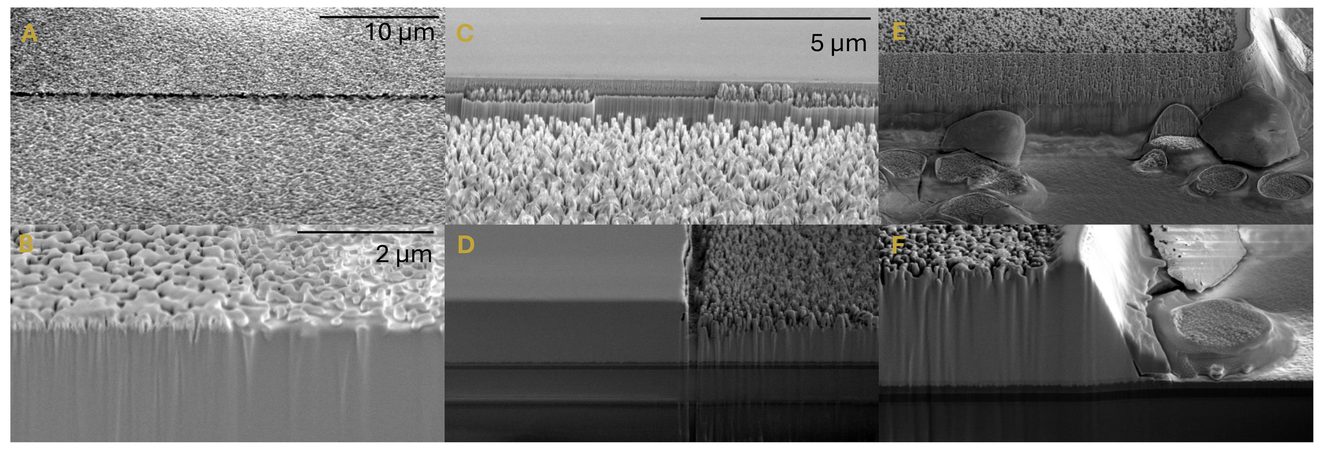
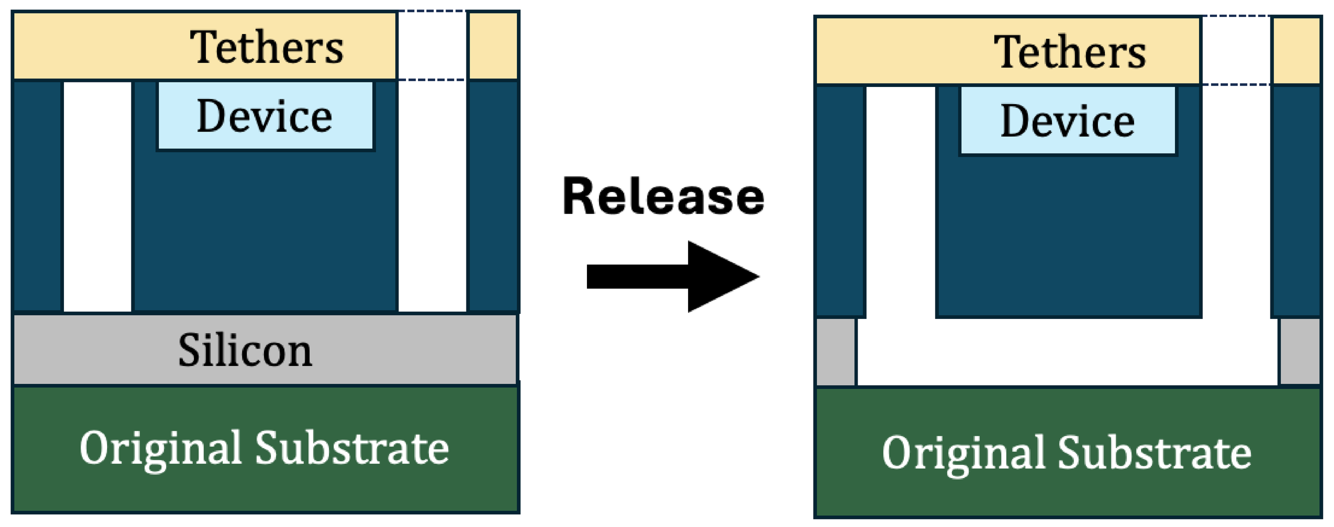


Figure 3. SEM cross sections of etched samples with hard mask developed using approach 2 (A,B) in single cycles, and approach 1 in single cycles (C,D) and multicycles (E,F)

3 RELEASE



- Device release was facilitated by tethers designed to stabilize GaN HEMTs during selective silicon layer etching using XeF_2
- Early tether designs faced stability issues ("popcorn effect"), prompting adjustments in size and configuration to improve reliability during release

4 TRANSFER

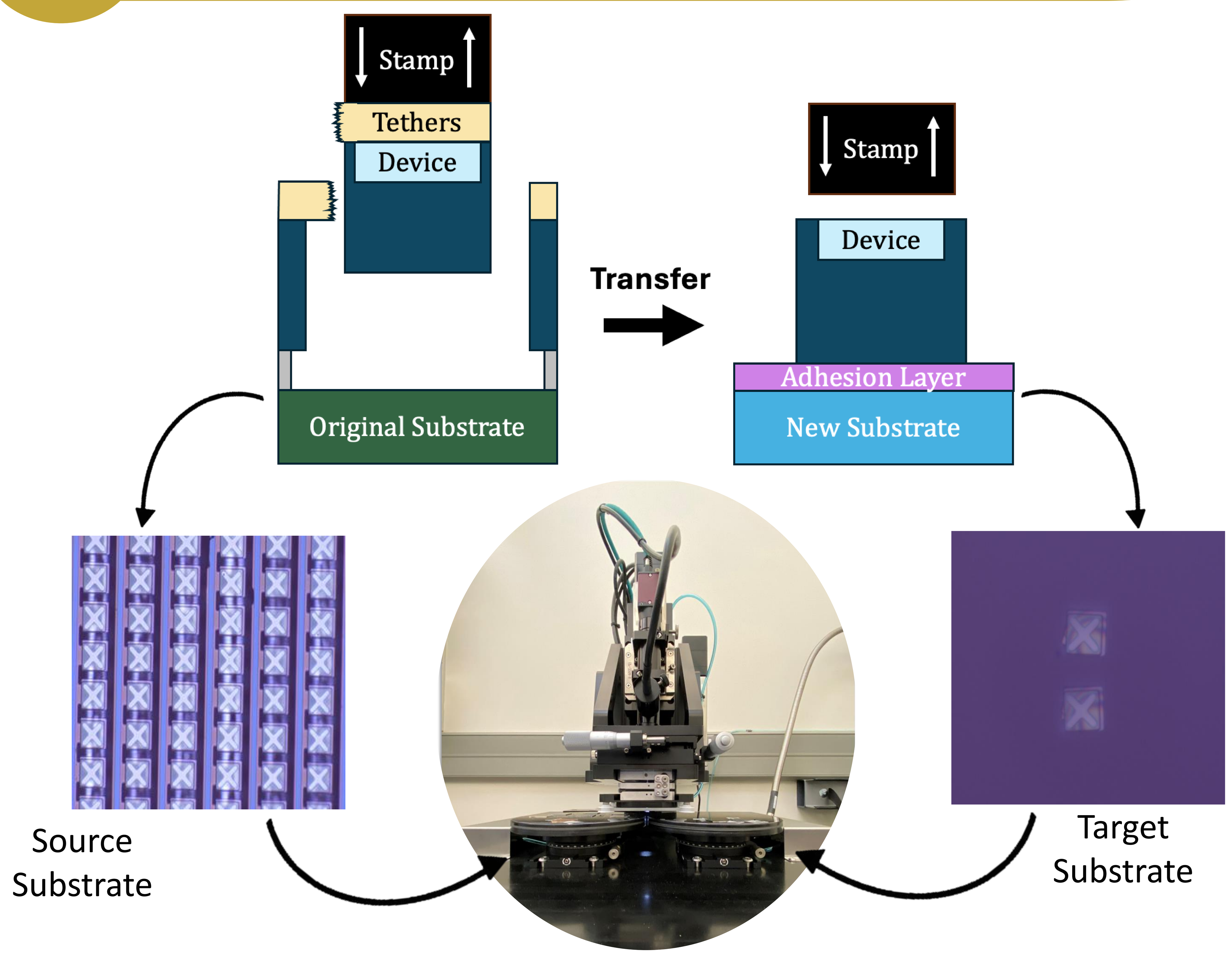


Figure 4. Illustration of micro-transfer printing process using a X-CelePrint micro-transfer printer, showing device on source substrate and transferred onto the target substrate

- Micro-transfer printing technique was used to transfer released devices onto the adhesive substrate

5 ADHESION LAYER

- Thickness of the adhesion layer crucial for its role as insulator or conductor
- 67 nm (1:10) and 5 µm (1:0) samples tested for extreme thicknesses
- 1:10 samples survived harsh temperature environment

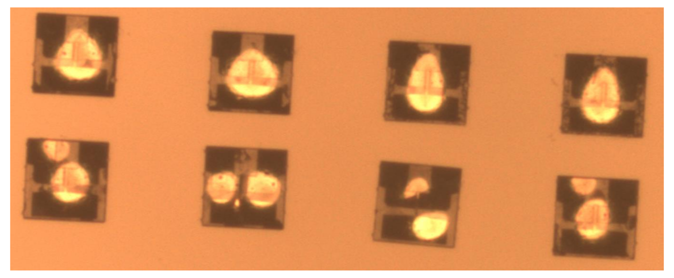


Figure 4. Transferred devices on 1:0 PR041 in Lake Shore vacuum chamber for thermal testing.

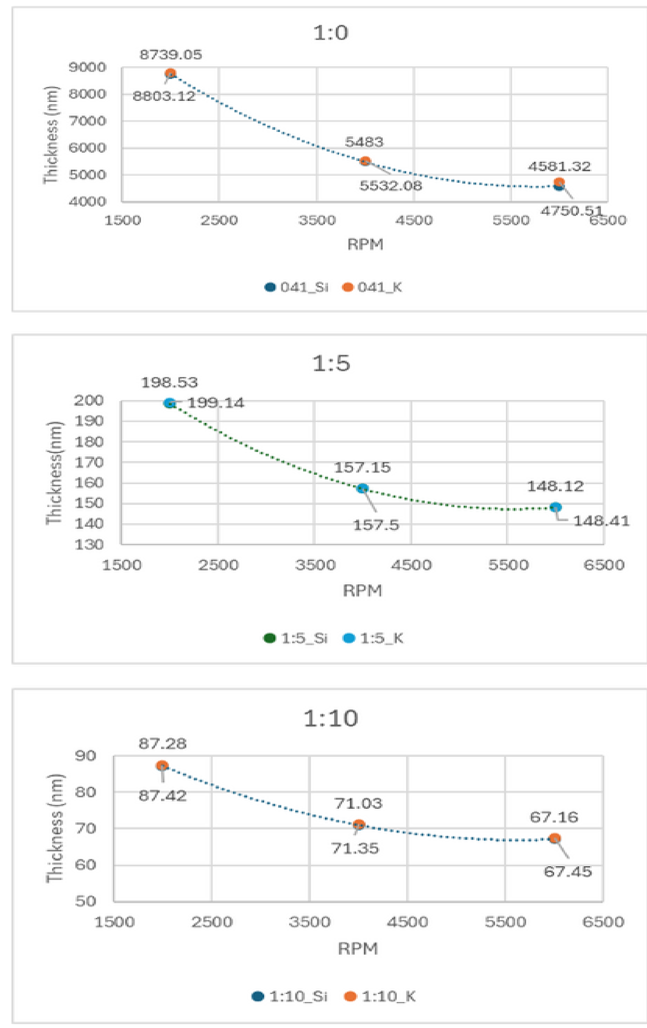


Figure 3. Measured thicknesses of 1:0, 1:5, and 1:10 dilutions of Protective Resist 041. Data fitted with two different models.

6 FUTURE WORK

- Optimize etching protocol to reach silicon layer
- Test improved tether designs for device release
- Investigate P041 performance at smaller thicknesses
- Refine transfer process for varied device release conditions
- Explore applications enabled by temperature-stable adhesion layer

7 ACKNOWLEDGMENTS

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