Novel Epitaxial Lift-off Process for GaAs Substrate Reuse and Flexible Electronics

Cheng-Wei Cheng, Kuen-Ting Shiu, Ning Li, Shu-Jen Han, Leathen Shi, Devendra K. Sadana

IBM T.J. Watson Research Center

1101 Kitchawan Rd., Rt. 134, Yorktown Height, NY, 10598 USA

Since its inception in 1978, the epitaxial lift-off (ELO) process has been extensively explored to minimize the high cost of III-V devices via substrate reuse and to fabricate nano-devices[1]. Although GaAs thin films have been successfully transferred onto different foreign substrates with the conventional ELO process, it has been proven that the re-use of GaAs substrate is difficult, typically requiring several post-process steps. Here we will introduce the fundamentals of ELO process and the drawbacks of the conventional method, then present a novel ELO scheme where the conventional aluminum-arsenide based sacrificial layer and HF based etchant are replaced with phosphide based materials and HCl (Figure 1). This new approach minimizes the amount of post-etching residues and provides the surface passivation that keeps the surface smooth during the ELO process, leading to direct re-use of the GaAs substrate[2].

Successful direct re-use of GaAs substrate is confirmed by the performance comparison of solar cells grown on the original and reused GaAs substrate. Following the features of this new ELO process, a high throughput lift-off technique called surface tension assisted ELO (STA-ELO) (Figure 2) was developed to lower the overall substrate cost. In addition to showing full wafer GaAs thin film transfer onto both rigid and flexible substrates, we also demonstrate several devices, including light-emitting diode (LED) and metal-oxide-semiconductor capacitor (MOSCAP) on foreign substrates, first built on thin active layers and then transferred to secondary substrates. These results show promise of using this new ELO process for low cost, high volume III-V device fabrication.

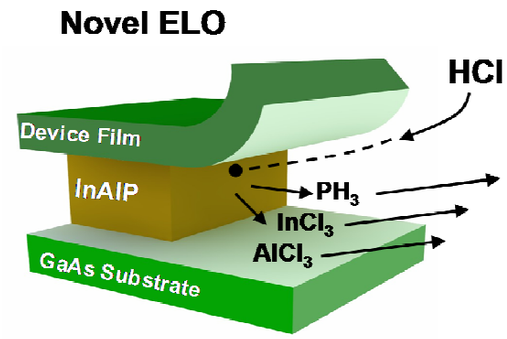

Figure 1. Schematic illustrations of the chemical reactions near the sacrificial layer/etchant interfaces during the the novel ELO process.

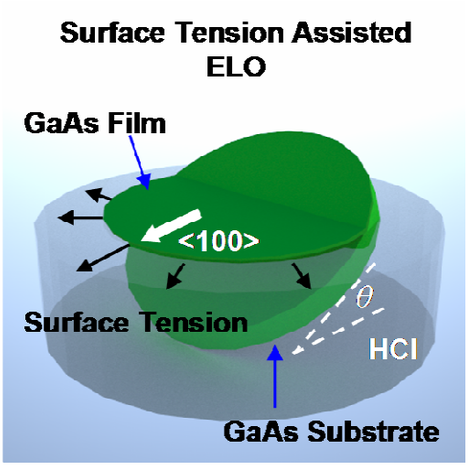

Figure 2. Schematic illustration of the surface tension-assisted (STA) ELO process.

Reference:

[1]J. Yoon, S. Jo, I. S. Chun, I. Jung, H.-S. Kim, M. Meitl, E. Menard, X. Li, J. J. Coleman, U. Paik & J. A. Rogers, *Nature*, **465**, 329 (2010).

[2]C.-W. Cheng, K.-T. Shiu,N. Li, S.-J. Han, L. Shi, D.K. Sadana, *Nature Communications*, **4**, 1577 (2013)