Studying Plasma Atomic Layer Etching applications in fabrication of AlGaN/GaN RF and High electron mobility transistor devices

Short Description: Improving processing techniques for AlGaN/GaN devices utilised for RF applications and HEMT devices. Specifically, the fabrication steps where atomic layer etching (ALE) could be employed to produce better final device performance.

Background: Atomic layer Etching is set to become one of the key processes for further downscaling of integrated circuits (IC) allowing for the continuation of Moore’s Law. First reported in 1988 ALE has witnessed a large increase in number of publications per year due to shrinking critical dimensions within ICs. To create these smaller critical features on a chip more accurate etch techniques are required. ALE is ideal for these etch processes due to its high level of etch control, smoothing effect and selectivity to the desired etched material. Production of Gate all around transistors and future technologies such as 3D NAND will be facilitated by ALE processes.

Current Si based high power and high frequency communication devices are running up against the theoretical limit of scaling and performance. To continue the pursuit of better communications devices, with ever smaller footprints and faster switching speeds, new materials will have to be leveraged. One such material being considered for this application is AlGaN/GaN. When these materials are stacked together a 2D electron gas (2DEG) is formed at the interface, the presence of which imparts a high carrier concentration as well as a high electron velocity within the channel region of the device.

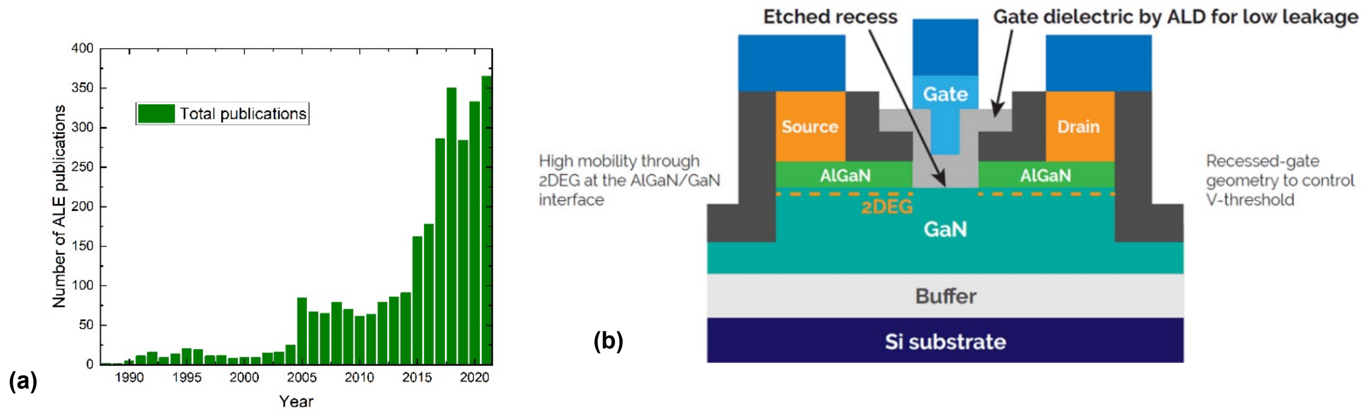

Fig 1: (a) Graph showing uptake in ALE publications, (b) Gate recessed HEMT device showing the 2D electron gas being blocked underneath the gate stack.

However, the presence of the 2DEG means current constantly flows through the channel region, leading to increased power consumption and safety issues. One way to prevent this always on behavior is to recess the gate (Fig1b), which raises the threshold voltage above zero. Commonly the recess is etched by reactive ion etching, however this is hard to control and can often leave a damaged etch front which ultimately degrades device performance. Therefore, this project will investigate the possible applications of ALE within this field to enable the further advancement of AlGaN/GaN devices.

Project: In this project the student will evaluate routes towards normally off AlGaN/GaN based devices, identifying key steps within the fabrication process that could be replaced by an ALE step to enhance device performance. The student will focus on isotropic ALE of the AlGaN/GaN surfaces, depending on progress there is the possibility to look at anisotropic ALE as well. The option to run simulations of etching is also possible if the student desires.

Location & Supervision: This work will be largely lab based, the daily supervisor will be Nick Chittock & Adrie Mackus, working in the PMP group lead by prof.dr.ir Erwin Kessels.

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