Writing Gallium Oxide on GaN Nanowires With The AFM Tip

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Superior inherent properties of gallium nitride (GaN) semiconductor nanowires (NWs) such as defect free nature, high surface to volume ratio, wide band gap, large break-down voltage, high electron saturation velocity and mobility, high-temperature operation make them highly promising for the future metal-oxide-semiconductor (MOS) based high power and high temperature devices. However, much work will have to be done in order to achieve high quality gate oxide. Gallium (III) oxide, the native oxide of GaN, has a potential of fulfilling the aforementioned requirement [1].

Here, we study a continuous GaN film formed from GaN NWs [2]. The NWs are grown first at a low V/III ratio (1:1), and radially overgrown using a high V/III ratio on the order of 1000:1. Amplitude-modulated atomic force microscopy (AFM) characterization shows that the top c-plane of the NWs is defect free. In addition, we simultaneously monitor topography and conductivity of the GaN film. In agreement with the intended doping levels, we find significant conductivity only at the position of the GaN cores. Importantly, we observe both a height increase (see Fig. 2) and a drop in conductivity at the GaN cores upon imaging the film with a bias of 6 V or more applied between the sample and the AFM tip. This demonstrates that we can locally induce a thin gallium oxide barrier over the GaN cores, where the rest of the surface is unaffected, see Figure 2. We will present a systematic investigation of the oxide thickness as a function of growth parameters, as well as the tip loading force and applied voltage and polarity.

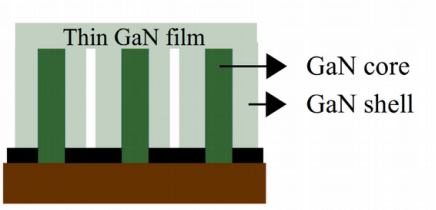

Figure 1. Schematics of the sample

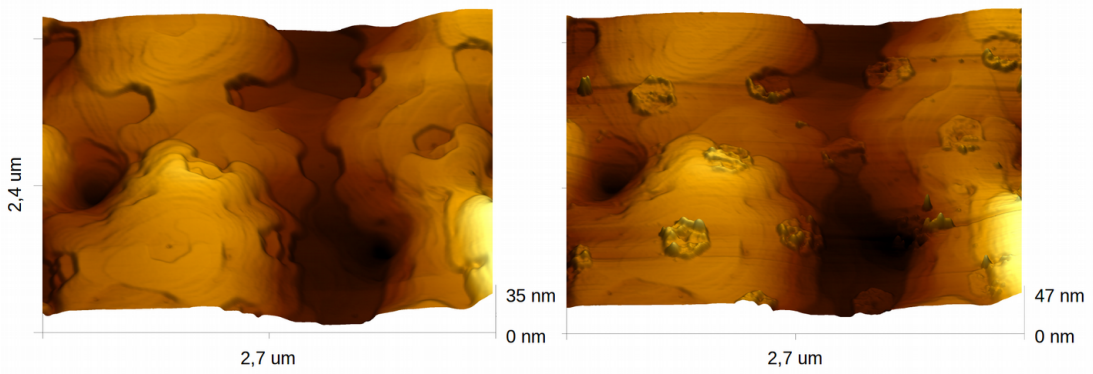

Figure 2. AFM topography image before (left) and after (right) applying 6 V sample bias

[1] H. Oon, K. Materials Science in Semiconductor Processing**, 16**, 5, 2013
[2] W Seifert, US Patent 9,024,338, 2015