GaN Nanowires as Probes for Scanning Tunneling Microscopy

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The high spatial resolution makes scanning tunneling microscopy/spectroscopy (STM/S) an excellent tool for advanced surface characterization, such as local density of states mapping on atomic scales. The most common probes today are metallic (W, Pt/Ir), however, over the years effort has been aimed towards developing probes with particular electronic, optical and mechanical properties[1]. Semiconducting materials, such as doped diamond and InAs nanowires (NWs)[2] have for example been proposed as alternatives.
The electronic, optical and mechanical properties of GaN NWs could make them interesting for both STM/S and Scanning Nearfield Optical Microscopies (SNOM). For the electrical measurements an important potential advantage is if tunneling can be made to occur from a narrow band of states close to the band-edge of the semiconductor. The X-ray optical density of GaN is much lower than W/Pt which significantly simplifies simultaneous STM and synchrotron radiation experiments. Such experiments are difficult with W probes due to the shadowing effect of the probe. Additionally, the large band gap GaN NWs can potentially function as light guides for SNOM applications. Finally, for the mechanical properties, GaN has a hardness which is on par with W and thus constitute a viable candidate in terms of stability and robustness.

We have successfully used GaN NWs based on LED technology[3] as probes in STM/S. We demonstrate atomic resolution imaging on GaAs (110) surfaces (Fig. 1(c)-(d) and STS (not shown). The morphology of the NWs has been tailored for STM by growing them with a sharp tip for measurements (Fig. 1(b)) and high thickness for robustness (Fig. 1(a)). The NWs are *n*-doped and grown by catalyst-free metal organic vapor phase epitaxy using a two-step process. The first growth forms the GaN NW core and the second growth adds a layer of high quality GaN which also builds up the ultra-sharp tip. Several different options for viable probe fabrication based arrays of grown NWs have been evaluated.

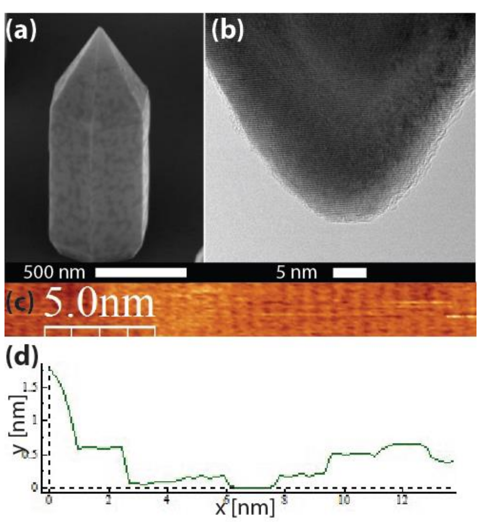

Figure 1 *– (a) SEM image of a GaN NW. (b) TEM image of a GaN NW tip apex. (c)-(d) STM image and line scan of a GaAs(110) surface acquired using a GaN NW probe.*

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