A Universal Atomic Probe: integrating digital and analog lithography and Near Field Spectroscopy

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The steady advance of nanotechnology from investigation to application and to manufacturing is increasing the demands of nanoscale metrology and lithography. As dimensions shrink to the nano-scale and to quantum-scale, the available metrologies, necessary for any advanced manufacturing process, become limited. There is also a constant need of direct feedback after a fabrication process, so that it is usually favorable, but not trial, to have a metrology and lithography combined in a single system.

Our approach is to realize a Multipurpose Atomic Force Microscopy (AFM) probe that integrates UV lithography, field emission lithography and digital lithography in a single system that allows patterning generation with atomic accuracy, real time inspection with atomic resolution and nano meter Raman Spectroscopy.
The MAFM is fabricated integrating Si cantilever with SiO2 waveguides and GaN Nano Wires (GaN NWs) is used as a tip. GaN NWs, fabricated with a top down etching method with aspect ratios up to 100, have high stiffness, and strong durability. Desirable conductivity, for field emission lithography and digital lithography, is obtained doping GaN during the MOCVD growth. Desirable tip sharpness, up to 2-atom apex, is achieved thought a high temperature regrowth or through a dry etching process. Finally, UV emission is obtained thought optical pumping of the GaN using the Si/SiO2 probe/waveguide, so that the GaN NWs acts as a lasing tip.
Strong durability, 365 nm laser emission with 1.5 nm FWHM, lithography patterning as low as 7 nm in field emission lithography configurationa and 2 atom lithography in scanning tunneling mode are some of the combined properties of the MAFM.
The single wide-bandgap tip technology offers the functionality and versatility of several incumbent technologies in one single, universal, system that conventional materials, such as W, diamond, SiN3 or Si can’t provide.