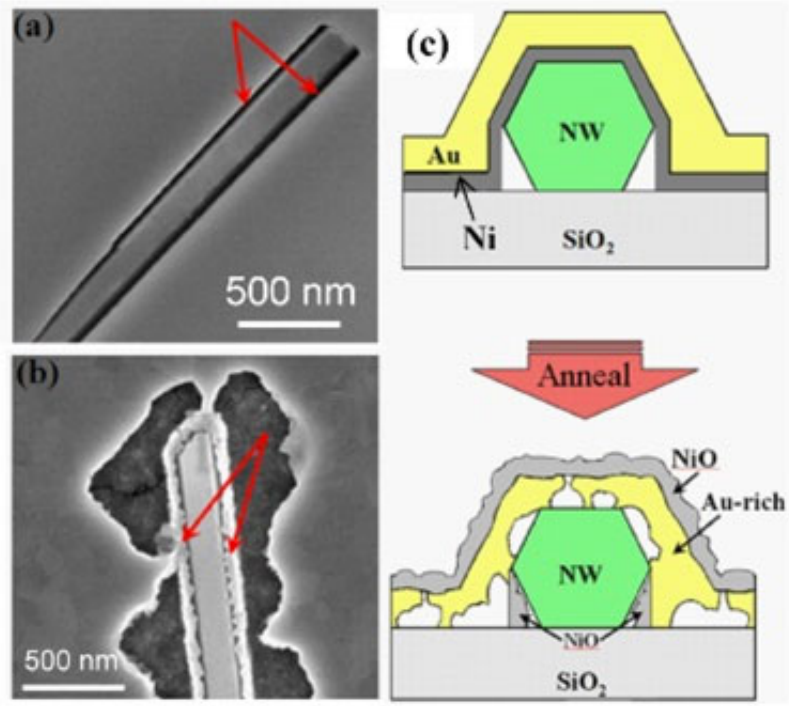
nanotechweb.org

LAB TALK

Aug 23, 2012

Void formation in nanowire contacts revealed

Many applications of the semiconductor GaN depend on reliable electrical contacts to p-type material. For visible LEDs made from GaN, the most common contacting scheme is a thin NiAu metal stack, which is annealed in oxygen mixtures and reinforced with transparent oxides. Unfortunately, although this fabrication method works very well with smooth planar films, the three-dimensional geometry of GaN nanowires dramatically enhances void formation during the annealing process. This void formation has been revealed by a series of experiments in which the metal layers were removed from the process wafers with microscopy tape and examined with an electron microscope from the underside. The work also identifies possible solutions, namely the addition of Ti and Al layers to alter the metallurgical reactions in the contacts such that the metal layers adhere strongly and void formation is suppressed.



(http://images.iop.org/objects/ntw/journal/11/8/12/image1.jpg)
Void formation upon annealing for NiAu contacts to GaN nanowires
(http://images.iop.org/objects/ntw/journal/11/8/12/image1.jpg)

The void formation and the poor adhesion of the original metal stack to the silicon dioxide substrates both enabled this unusual characterization method and identified the seriousness of

the failure mode.

The inability to form good electrical contacts presents a frustrating challenge to those trying to take advantage of high crystalline perfection in GaN nanowires. On the one hand, the p-type doping can't be measured and optimized because the nanowires can't be contacted, and on the other hand, the contacts are poor in part because the doping is not optimized.

Adhesion layers

In the study, the team from NIST used different Ti-based adhesion layers to eliminate the delamination of the Ni/Au films after annealing, yet some degradation in the I-V response of the nanowires still occurred. XRD measurements of the Ni/Au layers before and after annealing on p-GaN films and SiO_2 with and without an adhesion layer showed that the phase formation and evolution of the crystallinity of the metal films are dependent on the substrate material.

The key to preventing degradation during annealing was the use of an adhesion layer that included Al. The alloy formation of Al with Ni and Au seen in the XRD scans inhibits the mechanisms that are responsible for the void formation. The lack of void formation at the contact/NW interface after annealing when a Ti/Al/Ni adhesion layer is used was confirmed using TEM. The resulting increase in the contact area to the NW surface is believed to be responsible for the large decrease in resistance.

This work shows that alternative contacting schemes, rather than the industrial favourite, NiAu, are critical for contacting and optimizing p-type GaN nanowires.

Full details (http://iopscience.iop.org/0957-4484/23/36/365203/) can be found the journal *Nanotechnology*.

About the author

This study was conducted by the Semiconductor Metrology for Energy Conversion project in the Quantum Electronics and Photonics Division of the National Institute of Standards and Technology (NIST) in Boulder, CO. Dr Andrew Herrero was a postdoctoral research associate from 2009 to 2012. He discovered the tape lift-off method and explored its implications for nanowire contacts. The other co-authors assisted with metal contact development, electron microscopy and GaN nanowire growth.