

Catalyst-Free Gallium Nitride Nanowire Nucleation

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2:30 p.m. – 4:30 p.m.

C103 Engineering Research Complex

Abstract:

Extensive research on nanowire devices and applications has unleashed exciting possibilities in a quest for smaller, faster electronic equipment, more sensitive detectors, and new devices that take advantage of the quantum mechanical world. One of the roadblocks to these new technologies is a clear understanding of how nanowires are formed and how to control their growth. Nanowire growths can be grouped in two broad categories: catalytic growths and catalyst free growths. Catalyst free nanowire growths are useful in applications where catalyst particles are not desirable.

This thesis deals exclusively with gallium nitride catalyst free nanowire nucleation and growth mechanisms. GaN nanowires are of particular interest because of GaN's unique optical and electronic properties. This thesis contributes fundamental understanding of the formation mechanisms of catalyst free GaN nanowire growth through investigations of the matrix from which the nanowires grow and through novel use of the nanowires themselves as a diagnostic of their own growth mechanism. This work shows that nanowire orientation changes as a function of growth temperature and investigates this orientation change in terms of availability of nucleation sites and constituent adatom materials.

Journal Publications

B. W. Jacobs, **K. McElroy**, R. Al-Duhaileb, M. A. Crimp, R. E. Stallcup, A. Hartman, M. A. Tupta, V. M. Ayres, "Cross-Section High Resolution Transmission Electron Microscopy and Nanoprobe Investigation of Gallium Nitride Nanowires," *International Journal of Nanomanufacturing*, in press 2009.

B. W. Jacobs, M. A. Crimp, **K. McElroy**, and V. M. Ayres, "Nanopipes in Gallium Nitride Nanowires and Rods," *NanoLetters*, **8** (2008) 4353-4358.

B. W. Jacobs, V. M. Ayres, M. A. Crimp, and **K. McElroy**, "Internal structure of multiphase zinc-blende wurtzite gallium nitride nanowires," *Nanotechnology*, **19** (2008) 405706.

K. McElroy, R. C. Davis, and A. Hawkins, "The effect of contact length on adhesion between carbon nanotubes on silicon dioxide," *Applied Physics Letters*, **91** (2007) 233119.

B. W. Jacobs, V. M. Ayres, M. P. Petkov, J. B. Halpern, M. He, A. D. Baczewski, **K. McElroy**, M. A. Crimp, J. Zhang, and H. C. Shaw, "Electronic and Structural

Characteristics of Zinc-Blende Wurtzite Biphase Homostructure GaN Nanowires,” *NanoLetters*, **7** (2007) 1435-1438.

Refereed Proceedings Papers

B. W. Jacobs, **K. McElroy**, R. Al-Duhaileb, M. A Crimp, V. M. Ayres, “Cross-Section High Resolution Transmission Electron Microscopy Investigation of Internal Structures of Gallium Nitride Nanowires”, 6th International Symposium on Nanomanufacturing, 12-14 November 2008, Athens, Greece, CD-ROM Proceedings paper 1.A.1

Contributed Conference Proceedings and Presentations

K. McElroy, B. W. Jacobs, T. R. Bieler, M.A. Crimp, V.M. Ayres, J.B. Halpern, and M. He, “Temperature Evolution of the Matrix for a Vapor-Solid Gallium Nitride Nanowire Growth,” *American Physical Society March Meeting*, Pittsburgh, Pennsylvania, March 2009.

J.M. Callahan, B.W. Jacobs, **K. McElroy**, M.A. Crimp, R.M. Ronningen, A.F. Zeller, and H.C. Shaw, “Carbon Nanomaterials Under Highly Energetic Heavy Ion Irradiation,” *American Physical Society March Meeting*, Pittsburgh, Pennsylvania, March 2009.

J.B. Halpern, A. Bello, J. Gilcrease, G.L. Harris, M. He, B.W. Jacobs, **K. McElroy**, V.M. Ayres, M.A. Crimp, R.A. Stallcup, and M.A. Tupta, “Biphase GaN Nanowires: Growth mechanism and properties”, European Materials Research Society (E-MRS) Annual Meeting, Strasbourg, France, 26-28 May 2008.

J. B. Halpern, B. W. Jacobs, V. M. Ayres, M. A. Crimp, M. He and **K. McElroy**, “Growth and properties of multi-phase gallium nitride nanowires”, PHYS 712, 235th Spring National American Chemical Society Meeting, 6-10 April 2008 New Orleans, LA.

K. McElroy, B. W. Jacobs, V. M. Ayres, M. A. Crimp, J. B. Halpern, M. He, Q. Chen, and Y. Fan, “AFM, STM and SPRM Investigations of Multiphase GaN Nanowires and Nanocircuits” Materials Research Society Abstracts Spring Meeting, 24-28 March 2008, San Francisco CA, Abstract O7.9, page 334.

B. W. Jacobs, **K. McElroy**, V. M. Ayres, M. A. Crimp, J. B. Halpern, and M. He, “Electronic, Mechanical and Cross-Section TEM Analysis of Zinc-Blende/Wurtzite Multiphase Gallium Nitride Nanowires” Materials Research Society Abstracts Spring Meeting, 24-28 March 2008, San Francisco CA, Abstract O6.5, page 332.

B. W. Jacobs, **K. McElroy**, V. M. Ayres, M. A. Crimp, M. He, and J. B. Halpern, “Structural and Mechanical Properties of Novel Multi-Phase Gallium Nitride Nanowires,” Materials Research Society 2007 Fall Meeting November 26-30, 2007, Boston, MA Abstract HH11.28 p.746 (2007).

K. McElroy, B. W. Jacobs, A. D. Baczewski, V. M. Ayres, J. B. Halpern, M. He, M. P. Petkov, M. A. Crimp and H. C. Shaw, "Formation and Applications of Biphasic GaN Nanowires as a Function of Growth Parameters," Materials Research Society Abstracts 2007, Spring Meeting, April 9-13, 2007, San Francisco, CA

J. B. Halpern, I. C. Bell III, M. He, V. M. Ayres, B. W. Jacobs, A. D. Baczewski, **K. McElroy**, M. A. Tupta, R. E. Stallcup II, A. Hartman, and M. A. Crimp. "Coaxial GaN nanowire structure, properties and applications", Poster Presentation PHYS 437, 233rd American Chemical Society National Meeting, Chicago, IL, 25-29 March 2007.