Investigating the Atomic Layer Structure of Manganese Atoms on Nitrogen-polar Wurtzite Gallium Nitride Surface

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The investigation of magnetic or spintronic structures on wide band-gap semiconductors is important for future novel device applications. Gallium nitride is interesting because of its band-gap (blue-UV spectral range) and robust optoelectronic properties. And while the possibility for room-temperature dilute ferromagnetism in this system - as predicted by Dietl *et al.*[1] - is still intriguing, we have shown previously that ferromagnetic manganese gallium (MnGa) is almost perfectly lattice-matched to *c*-plane wurtzite GaN.[2]

In the current work, we find that Mn atoms themselves form an ordered monolayer (ML) on N-polar wurtzite GaN.[3] We deposit sub-ML quantities of Mn on the GaN (000$\bar{1}$) surface and monitor the structure using reflection high energy electron diffraction (RHEED). By monitoring the RHEED diffraction streak intensities versus time, we deduce the surface ordering as a function of coverage. Within a fraction of a ML, the surface shows 3× structure along [1 0 $\bar{1}$ 0] but only 1× structure along [$\bar{1}$ $\bar{1}$ 2 0]. In addition, the 1/3rd- and 2/3rd-order diffraction streaks differ in intensity by about a factor of three. The structure is optimized at a deposition of ~ 0.86 ML Mn. These observations rule out the simple hexagonal 1/3rd ML $\sqrt{3}\times\sqrt{3}$ R30º reconstruction.

To explain the RHEED periodicities and intensities, we postulate a Mn linear chain-type reconstruction having 2/3rd ML Mn coverage with a spacing of $\sqrt{3}a/2$ along the chains and 3a/2 between chains, and a surface sticking coefficient of ~0.78. The arrangement of the Mn chain reconstruction on the *w*-GaN surface is also suggestive of an atomic template for MnGa film growth on *w*-GaN surfaces. This work is supported by the U.S. Dept. of Energy, Office of Basic Energy Sciences (Grant No. DE-FG02-06ER46317) and the U.S. National Science Foundation (Grant No. 0730257).

[1] T. Dietl, H. Ohno, F. Matsukura, J. Cibert, and D. Ferrand, *Science* **287**, 1019 (2000).
[2] E. Lu, D. C. Ingram, A. R. Smith, J. W. Knepper, and F. Y. Yang, *Phys. Rev. Lett.* **97**, 146101 (2006).
[3] A. Chinchore, K. Wang, W. Lin, J. Pak, and A. R. Smith, Appl. Phys. Lett., *in press* (2008).