A. Title Page

Electron Transport Properties of Epitaxially Grown Nanostructures
Final Report

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B. Restatement of problem researched, creative work, or professional enhancement opportunity

Traditional electronic components such as *pn*-junction diodes or field–effect transistors (FET) essentially work by keeping track of the amount of charge flowing through the device. As these devices become increasingly smaller, the amount of charge (and hence the number of electrons) available to switch gates "on" and "off" is approaching a fundamental limit as described by Moore's Law (see figure 1).[1-2] One possible solution to this problem is to increase the size of the microchip to accommodate more transistors. The problem with this approach is that the increase in the number transistors results in an increase in heat that negatively affects overall chip performance.

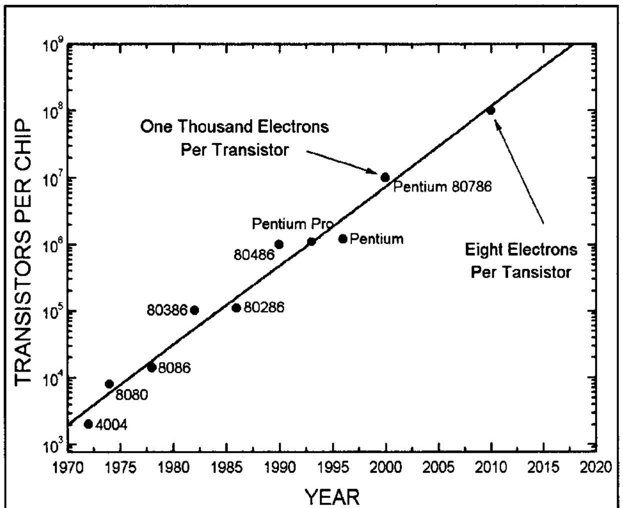

Figure 1 – A graph illustrating Moore's Law which says that the number of transistors on a chip doubles roughly every five years.

Another possible solution is the development of a novel device that not only tracks the charge of the electrons but also their spin. One proposed device, known as the spin field-effect transistor (or spin-FET) would use the precessions of a spin-polarized current to increase the gate switching speed by a factor of ten.[1-4] Additionally, it is predicted that the spin-FET would also allow for a new multi-level logic. So, instead of the computer translating "0" (off) or "1" (on) bits into commands, the spin-FET offers the possibility for higher order logic such as "0", "1", "2", etc. In order for a "spintronic" device to work it must have a long spin relaxation time, this is the amount of time an inject electron will maintain it's spin orientation. One promising material system is ferromagnetic semiconductors such as InMnAs, GaMnAs, and Mn-doped GaN.[5] These systems have been shown to become magnetic at temperatures ~ 100K.[6-7] In order for these materials to be used for devices it is necessary to measure the spin-dependent transport properties of these systems.

C. Brief review of the professional enhancement opportunity, creative work, or research procedure.

Experiments were carried out in an ultrahigh vacuum (UHV) multichamber facility [(5-8) $\times 10^{-11}$ Torr throughout] at the University of Arkansas, which contains a solid-source molecular beam epitaxy (MBE) chamber (Riber 32P) and an arsenic cell with an automated valve and controller. The MBE chamber also has an all UHV connection to a surface analysis chamber, which contains a custom integrated STM (Omicron). Commercially available "epi-ready," *n*+ (Si doped 10^{18} cm^{-3}) GaAs(001) $\pm 0.05^0$ substrates were loaded into the MBE system without any chemical cleaning. The surface oxide layer was removed and a 1.5-μm-thick GaAs buffer layer was grown at 580 °C using an As_4 to Ga beam equivalent pressure (BEP) ratio of 15 and a growth rate of 1.0 μm/hr as determined by reflection high energy electron diffraction oscillations. The samples were then annealed and transferred to the STM without breaking UHV, and imaged at room temperature. Each sample was imaged using tips from single crystal <111>-oriented tungsten wire with a sample bias of -3.0 V and a tunneling current of 0.05 – 0.1 nA.

D. Summary of findings, outcomes, or experiences had.

The primary goal of this initial investigation was to develop a growth algorithm that produced large (~ 1μm), flat terraces. Figure 2 shows a 1μm × 1μm STM image of our initial growth. The surface morphology is covered with small 3D-islands ranging in size from 1nm-5nm. These features are suspected to form because the native oxide layer was not completely removed from the surface.

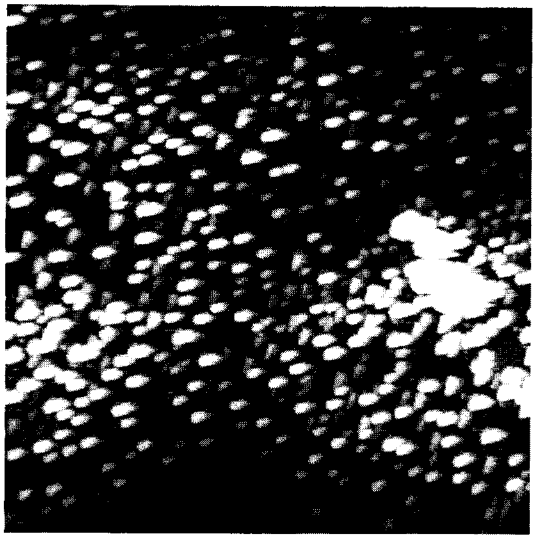

Figure 2 One-micron filled state STM image of GaAs grown by MBE. This sample still has remnants of the native oxide layer.

A second sample was grown using a slightly higher temperature during the oxide removal stage. This sample was then removed from the MBE chamber and imaged in the STM. Figure 3 shows a 1 μm × 1 μm filled state image of the sample with the oxide fully removed. This surface has larger terrace structures that are occupied by a variety of l 2D adatom islands. This can be caused by growing at an inappropriate As_4 /Ga BEP ratio.

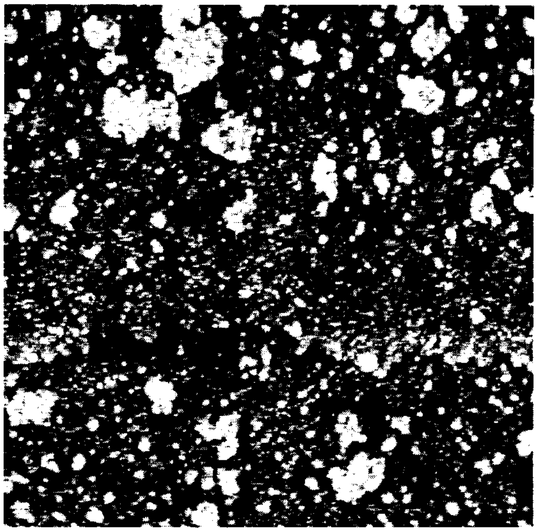

Figure 3 One-micron filled state STM image of GaAs grown by MBE. This sample was grown with the oxide layer completely removed but has an inappropriate BEP.

Figure 4 shows a sample that has been grown with a As_4 /Ga ratio of 15. In this image the terrace structures are flat and extend for almost a micron. This type of surface would be appropriate for a device structure.

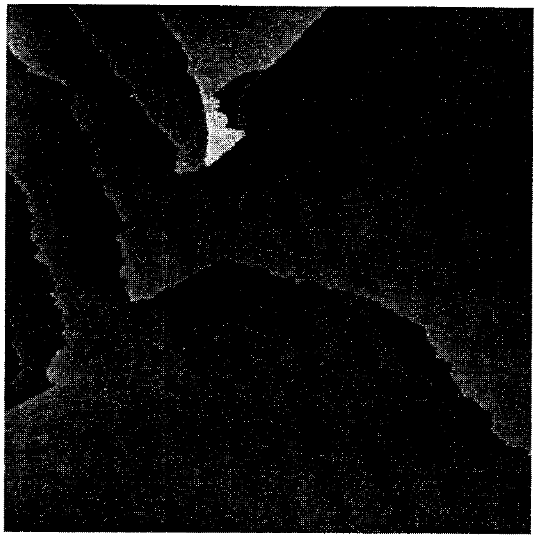

Figure 4 One-micron filled state STM image of GaAs grown by MBE. This sample was grown with the oxide layer completely removed with an As_4 / Ga ratio of 15. Notice the large flat terrace structures on the sample surface.

E. Conclusions and recommendations

In conclusion we have successfully developed a growth algorithm that produces a suitable surface for device production. The next step in this project will be to dope the sample with Mn and measure the transport properties using spin-resolved Hall Effect.

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A. Title Page

Attending a Traffic Accident Reconstruction Course for Vehicle Safety Design Research
Final Report

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B. Restatement of problem researched, creative work, or professional enhancement opportunity

Traffic accidents have become a serious social problem that threaten people and their property at an accelerating rate. In the United States, motor vehicle accidents are the leading cause of death for college age people.[1] Globally, traffic accidents are the second leading cause of death for young people between the ages of 18-25.[2] Astonishingly, road traffic accidents kill 1.2 million people each year and injure 50 million more.[2] In addition to the number of human lives affected, the financial impact on a society is significant. It is estimated that motor vehicle injuries account for 22% or $89 billion of the total annual cost of injuries in the United States.[3]

The effects of vehicle accidents can be minimized by better educating/training of drivers, engineering safer trafficways, and designing safer vehicles. Vehicle safety design has made great strides during the last 20 years. Crumple zones, air bags, anti-lock brakes, and safety data recorders were direct results of control crash test and real-world accident investigations. With changing designs in automobiles (such as introduction of hybrid and all electric models) continued research is needed to make the next generation of automobiles is safe as possible.

In this professional enhancement proposal, the PI attended a course entitled "Traffic Accident Reconstruction 2", hosted by Northwestern University. (Please note: the PI attended Traffic Accident Reconstruction 1 over the winter break and funded the project with personal funds) This course gave the PI new techniques to pursue a new area of research in vehicle safety design. Specifically, the PI would learn from this course: oblique Collisions, occupant kinetics, injury mechanisms, pedestrian accidents, pedestrian motion, vehicle damage, pedestrian injuries, braking capabilities, and speed from damage analysis. [4]

D. Summary of findings, outcomes, or experiences had.

I attended the conference April 28 – May 2, 2008 on the campus of Northwestern University and successfully completed the course (see attached certificate). Surprisingly, I met several engineers at this conference that work with attorneys and insurance companies during litigation of auto-accidents.

E. Conclusions and recommendations

In conclusion I have successfully completed a traffic accident reconstruction from Northwestern University. This professional development activity will aid in future research into vehicle safety design.

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