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4. TITLE AND SUBTITLE
Quantum transport, magnetic field sensor, an integrated amplification in no el Si/SiGe Heterostrtucture devices

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6. AUTHOR(S)
Sean Washburn

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Univ North Carolina at Chapel Hill

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13. ABSTRACT (Maximum 200 words)

Studies of high mobility Si/SiGe heterostructure devices have been analyzed in light of correlations among carriers. Single-particle models fail to describe the metal-insulator transitions observed in them. Attempts to confine the carriers and create lateral tunneling structures and magnetic field sensors have revealed ambiguous results that cannot be distinguished from disorder in the devices but which show some promise for device applications.

14. SUBJECT TERMS
Si/SiGe, high mobility, heterostructures

15. NUMBER OF PAGES

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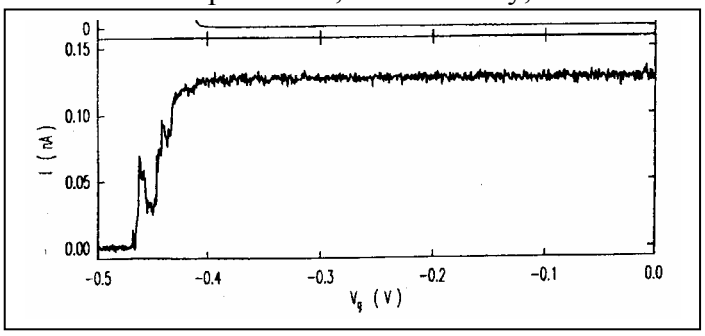
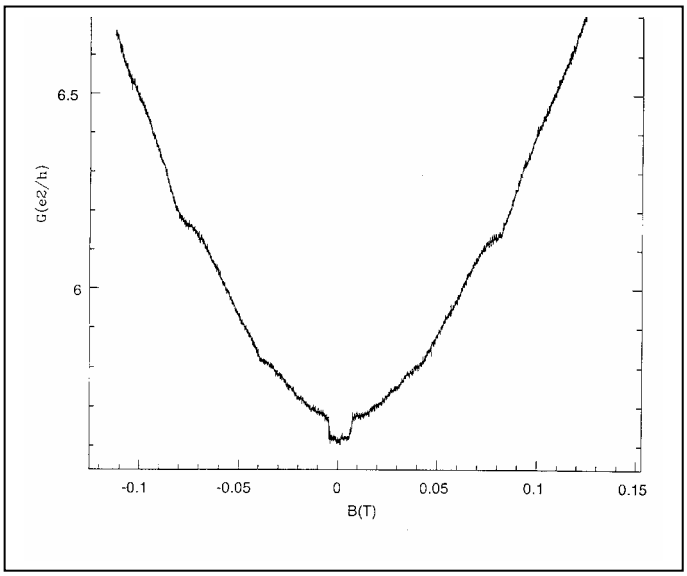
(Continuation Sheet)

Major results from research:

Experiments carried out during this grant have probed correlations among the carriers in two-dimensional systems. The original targets of the proposal to understand correlated motion of carriers through constrictions were attacked as described in previous reports. The results from the experiments, unfortunately, were indistinguishable from expected random signatures of the scattering from disorder in the material (see for example oscillations in the figure at right). In contrast, the results discovered incidentally from transport as a function of density in large structures led to startling results in the form of a magnetic field-dependent crossover from metallic to insulating behavior. Our research on this topic revealed that the behavior extends into very high mobility systems such as the SiGe heterostructures studied here; that the magnetic field dependence remains dramatic and hence potentially useful for devices. With further effort field sensing through the large magnetoresistance in this system might be manageable and more easily controlled than in the submicron structures that were targeted originally.



The experiments to discover possible use of SiGe structures for magnetic field sensing foundered on a subtle unexpected structure observed in the high temperature magnetoresistance. It turned out that simple classical Lorentz force estimates of the effect of the field were in error owing to oscillatory (see figure below) effects from focusing of carrier trajectories as the carriers were steered around the sample edges. These may have been enhanced by some quantum effects such as Shubnikov-deHaas oscillations. In any case the oscillations make use of such structures in magnetic field senseing untenable because of the calibration ambiguities that they present. The use of such structures to sense magnenetic field is therefore discouraged.



Personnel:

3 PhD Students supported in part: (KP Li, NJ Kim and K Eng), and all of them have graduated and are now emplyed -- the latter two in academic postdoc positions.

The following public dissemination was supported in part by the grant.

Refereed articles:

107. ``Absence of Localization in Certain Field Effect Transistors," Superlattices and Microstructures, **23** , 581-91 (1998). (invited) S Washburn, D Popovic, KP Li and AB Fowler.
108. ``Some consequences of chaos for quantum devices," in *Quantum Based Electronic Devices and Systems,* ed: MA Stroscio and M Dutta (World Scientific, Singapore, 1998); Int J High Speed Electron Syst, **9**, 209-22 (1998). (invited) S Washburn.
113. ``Scaling and universal behavior near the two-dimensional metal-insulator transition" Proc. 22nd Int School Theoretical Physics, Ustron, 10-15 Sept 1998; Mol Phys Rept, **24**, 150-7 (1999). (invited) S Washburn, NJ Kim, KP Li and D Popovic.
115. ``Effect of Local Magnetic Moments on the Metallic Behavior in Two Dimensions," Phys Rev Lett, **83**, 368-71 (1999). XG Feng, D Popovic, S Washburn.
116. ``A new metal in two dimensions," Phys Rev Lett, **86** (2001) 2625-8. XG Feng, D Popovic, S Washburn, V Dobrosavljevic.
113. ``Scaling and universal behavior near the two-dimensional metal-insulator transition" Proc. 22nd Int School Theoretical Physics, Ustron, 10-15 Sept 1998; Mol Phys Rept, **24**, 150-7 (1999). (invited) S Washburn, NJ Kim, KP Li and D Popovic.
115. `Effect of Local Magnetic Moments on the Metallic Behavior in Two Dimensions," Phys Rev Lett, **83**, 368-71 (1999). XG Feng, D Popovic, S Washburn.
116. ``A new metal in two dimensions," Phys Rev Lett, **86** (2001) 2625-8. XG Feng, D Popovic, S Washburn, V Dobrosavljevic.
128. "Effects of a Parallel Magnetic Field on the Metal-Insulator Transition in a Dilute Two-Dimensional Electron System," Phys Rev Lett, 88, 136402 (2002). K. Eng, X.G. Feng, D. Popovic, and S. Washburn.
131. "Phase coherence at high magnetic fields," to appear in *Semiconductors at High Magnetic Field,* edited by F Herlach (Springer, 2003). DV Khveshchenko and S Washburn.
121. ``Scaling laws, phase diagram, localized moments and Kondo effect in two-dimensional metals," Proc Localisation 1999, Hamburg, 29 July - 3 Aug 1999. Annalen Phys. **8** 569-78 (1999), (invited) S Washburn, NJ Kim, XG Feng and D Popovic,

Unrefereed articles:

111. ``Emergence of the Metallic State in Two Dimensions," *Proc Int Conf Phys Semiconductors XXIV*, Jerusalem, 1998. XG Feng, D Popovic and S Washburn.
117. ``Suppression of the metallic behavior in two dimensions by spin-flip scattering," in *Quantum Physics at the Mesoscopic Scale* , eds. DC Glattli, M Sanquer, and J Tran Tranh (Editions Frontieres, 1999). XG Feng, D Popovic, S Washburn.
119. ``A new metallic state in two dimensions," Proc EP2DS 13, Ottawa, 1999. Physica E **6**, 280-3 (2000). XG Feng, D Popovic, S Washburn, V Dobrosavljevic.
122. ``Effects of parallel magnetic field on the novel new metallic behavior in two dimensions," Proc Int Conf Phys Semiconductors 25, 2000. to appear. K Eng, XG Feng, D Popovic, and S Washburn.

Preprints:

112. ``Phase diagram and validity of one-parameter scaling near the two-dimensional metal-insulator transition," subm. Phys Rev Lett, cond-mat/9809357. Nam-Jung Kim, D Popovic, S Washburn.
130. ``Hopping conductivity near the 2D metal-insulator transition," Phys Rev B, Submitted..NJ Kim and S Washburn.

Invited Talks:

Colloquia:

U Va, Nov 1998
UCincinnati Oct 13, 1998
UClemson Nov 30, 1999
NC State Univ, Mar 2000

Meetings and Conferences:

Ustron Sept 15,1998
Hamburg Aug 3,1998
Hamburg Sept 7 2000

Contributed talks:

APS LA 1998
O11.07 Metal-Insulator Transition in small Si MOSFETs

Kuo-Ping Li, Nam-Jung Kim, Sean Washburn (Dept. of Physics and Astronomy, The University of North Carolina at Chapel Hill), Dragana Popovi\'c (National High Magnetic Field Laboratory, Florida State University)

O11.08 Effects of Disorder and Magnetic Field on a Two-Dimensional Metal-Insulator Transition

Dragana Popovi\'c (National High Magnetic Field Laboratory, Florida State University), A. B. Fowler (IBM Research Division, T. J. Watson Research Center), S. Washburn (Dept. of Physics and Astronomy, University of North Carolina at Chapel Hill)

APS Atlanta 1999

LC30.03 Suppression of the metallic behavior in two dimensions by spin-flip scattering

Xiang Guang Feng, Dragana Popovi\'c (National High Magnetic Field Laboratory, Florida State University), S. Washburn (Dept. of Physics and Astronomy, University of North Carolina at Chapel Hill)

APS Minneapolis 2000

[G20.002] Effects of a parallel magnetic field on the novel two-dimensional metallic behavior

K. Eng (National High Magnetic Field Laboratory, FSU, Tallahassee, and Dept. of Physics and Astronomy, UNC-CH, Chapel Hill), X. G. Feng, D. Popovi\'c (National High Magnetic Field Laboratory, FSU, Tallahassee), S. Washburn (Dept. of Physics and Astronomy, UNC-CH, Chapel Hill)

[G20.013] Novel metallic behavior in two dimensions

X. G. Feng, D. Popovi\'c (National High Magnetic Field Laboratory, FSU, Tallahassee), S. Washburn (Dept. of Physics and Astronomy, UNC-CH, Chapel Hill), V. Dobrosavljevi\'c (National High Magnetic Field Laboratory, FSU, Tallahassee)

APS Seattle, 2001

Y16.006 Effects of Parallel Magnetic Fields on "Non-ideal" Si MOSFETs

Kevin Eng (National High Magnetic Field Laboratory, FSU, Tallahassee, and Dept. of Physics and Astronomy, UNC-CH, Chapel Hill), Dragana Popovi\'c (National High Magnetic Field Laboratory, FSU, Tallahassee), Sean Washburn (Dept. of Physics and Astronomy, UNC-CH, Chapel Hill)

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