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13. ABSTRACT (Maximum 200 words)  
  
The enclosed list of 12 publications contain papers on Silicon Carbide, Scanning Probe Microscopy, Fowler-Nordheim Field Emission, and Nanofabrication that were made possible by this grant.

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## Novel Nanostructure Fabrication and Their Characterization By STM and AFM

The main thrust of this work has been to develop a methodology for fabricating and characterizing of nanometer-scale structures and to use it for a variety of applications. In particular, we have analyzed the role of adhesion in tapping-mode atomic force microscopy and analyzed its kinetics by comparing it to the dissipation vs. phase of a lossy, grazing impact oscillators

We have developed a conducting tip atomic force microscope that utilizes a dual feedback system to measure the dielectric properties of nanostructures. Also developed were v-shaped metallic-wire cantilevers for combined atomic force microscopy and Fowler-Nordheim imaging. Using these techniques, we were able, for the first time, to (a) fabricate silicon nitride nanostructures on a silicon substrate, and (b) to measure their current-dependent growth and dielectric strength. Another application of this system was to analyze (a) the effect of copper contamination from HF and APM on the integrity of a 3 nm gate oxide, and (b) the effects of moisture on Fowler-Nordheim characterization of thin silicon-oxide films. This work lead to a comparative study of doped, oxidized silicon by AFM, STM, and TAFM. Accompanied work included the measurement of stability and superstructure of squarylium dye TSQ Langmuir-Blodgett films and nano-patterning and single electron tunneling, both using STM

The students involved in this work where R. K. Workman, D. Iams, T. G. Ruskell, J. P. Hunt, C. A. Peterson, B. Vermeire, D. de la Cruz, and A. Nagarur. The Postdocs involved in this work were V. Weissenberger, J. Chen, T. Chen, D. Chen, G. E. Jabbour, X. Yao, and X. Hu. The rest of the authors are collaborators across campus, other universities, and companies. As the publications attest, the funding had a major impact on our capability to teach students and generate new physics, for which we are thankful.

The enclosed list of publications was made possible by this grant.

J. L. Pyle, T. G. Ruskell, R. K. Workman, X. Yao, and D. Sarid, "Silicon nitride growth during scanned probe lithography," *J. Vac. Sci. Technol. B* **15**, 38 (1997).

T. X. Zhong, R. K. Workman, X. Yao, G. E. Jabbour, C. A. Peterson, D. Sarid, C. W. Dirk, D. de la Cruz, and A. Nagarur, "Stability and superstructure of squarylium dye TSQ Langmuir-Blodgett films," *Thin Solid Films* **315**, 294 (1998).

D. Sarid, J. P. Hunt, R. K. Workman, X. Yao, and C. A. Peterson, "The role of adhesion in tapping-mode atomic force microscopy," *Appl. Phys. A* **66**, s283 (1998).

J. P. Hunt and D. Sarid, "Kinetics of lossy grazing impact oscillators," *Appl. Phys. Lett.* **72**, 2969 (1998).

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- C. A. Peterson, T. G. Ruskell, J. L. Pyle, R. K. Workman, X. Yao, J. P. Hunt, and D. Sarid, "Multi-step process control and characterization of scanning probe lithography," *Appl. Phys. A* **66**, s729 (1998).
- D. Sarid, C. A. Peterson, and Xiaoming Hu, "Dissipation vs. phase in nearly harmonic grazing impact oscillator," *Proc. of the 10<sup>th</sup> International Conference on STM/STS and Related Proximal Probe Microscopy* Seoul, Korea, 19-23 July, (1999).
- C. A. Peterson, R. K. Workman, X. Yao, J. P. Hunt, and D. Sarid, "V-Shaped Metallic-Wire Cantilevers for Combined Atomic Force Microscopy and Fowler-Nordheim Imaging," *Nanotechnol* **9**, 331 (1999).
- C. A. Peterson, R. K. Workman, D. Sarid, B. Vermeire, H. G. Parks, D. Adderton, and P. Maivald, "Effects of moisture on Fowler-Nordheim characterization of thin silicon-oxide films," *J. Vac. Sci. Technol.* **8**, 2753 (1999).
- C. A. Peterson, Xiaoming Hu, and D. Sarid, "Comparative study of doped, oxidized silicon by AFM, STM, and TAFM," *Proc. of the 10<sup>th</sup> International Conference on STM/STS and Related Proximal Probe Microscopy*, Seoul, Korea, 19-23 July, (1999).
- B. Vermeire, C. A. Peterson, H. G. Parks, and D. Sarid, "The effect of copper contamination from HF and APM on the integrity of 3 nm gate oxide," *IEEE International Reliability Physics Symposium Proceedings*, pp. 315-318, San Diego, CA, 23-25 March 1999.
- R. K. Workman, C. A. Peterson, and D. Sarid, "Current-dependent growth of silicon nitride using conducting tip AFM," *Surf. Sci.* **423**, L277 (1999).
- X. Hu, D. Sarid, and P. von Blanckenhagen, "Nano-patterning and single electron tunneling using STM," *Nanotechnol.* **10**, 209 (1999).