**Nanoscale Deposition and Etching of Silicon Quantum Dots Using**

**Field-Assisted AFM-Based CVD**

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Electric-field assisted decomposition of gas molecules near a conducting AFM tip can be used to directly deposit, etch and pattern nanometer-scale silicon structures. We used SiCl4 to deposit silicon on a poorly conducting silicon substrate and SF6 to etch silicon at room temperature and one atmosphere. Deposition and etching can be done under square wave voltage, in the frequency range of 10-50MHz. The deposition and etching rates varies with gas flow rate, and voltage and the type of tip. Deposition and etching from gas phase is relatively a clean process since the byproducts are in gas phase. It is also potentially very fast since gas molecules at 1 atmosphere have around 60 nm mean-free-path and are readily available on demand. Owing to relatively large curvature of our current AFM tip apex ~ 40 nm, the smallest feature size we could pattern was around 100 nm. We discuss kinetics of formation of these dots and propose a reaction mechanism that is being evaluated to improve the spatial resolution of this unique technique. We also discuss the role of thermal decomposition that can deteriorate the spatial resolution of tip-based CVD processing. To avoid thermal contribution and spreading, the tip voltage should be pulsed. We are also in the process of adding microwave excitation to the tip to reduce I2R heating.

The AFM-based CVD technique is being extended to include electrodes directly on the probe to eliminate any need for conducting substrate. With excitation completely contained in the tip, the AFM-based nanofabrication will become versatile and can be used as a 3-D mask-less nanofabrication on any material from polymers to diamond to clays. To demonstrate the feasibility of this approach, we have developed micro-plasma sources that are being scaled down to nano-scale for direct write and etching.

Acknowledgement: This work is supported by DARPA’s Tip-Based Nanomanufacturing program under Dr. Thomas Kenny. We acknowledge useful discussions with Profs. Mortom Litt, Carlos Mastrangelo, Mohan Sankaran and Steve Garverick. Mr. Andrew Barnes, Dr. O. Lucian Vatamano, Mr. M. Abdlatif, Mr. Mousa Souare, and Mr. Joseph Zarycki have contributed at different stages of this work.