NRL-Contract Monthly Report for February 1994

LOW VOLTAGE ELECTRON BEAM LITHOGRAPHY

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Progress Report for Aaron Baum

In order to measure the energy spread of electrons emitted from various negative electron affinity cathode structures, a simple apparatus using a uniform retarding field inside night vision tubes and customized tubes (all made by Intevac) was constructed and intial measurements performed. GaAs and GaAsP photocathodes with CsO activations were measured. Energy spreads as low as 100meV were observed from a low quantum efficiency GaAs cathode. An extremely sharp (30meV width) vacuum-level cutoff in the energy distribution from the GaAsP was observed. These two results show both the possible energy resolution of the technique and the energy spreads achievable from negative electron affinity photocathodes. Energy distribution variation indicated the importance of scattering in the band-bending region, and thus suggested the possibility of heterostructure and doping variation at the surface to minimize the energy spread. A design for an optimum cathode was developed.

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Progress Report for Aaron Baum

For the next round of energy spread measurements, the in-tube analyzer design was modified in two ways. First, a focusing electrode was added to parallelize the electrons, which should greatly improve resolution at low energies. Secondly, an optically flat collector coated with 50 nm of C over 50 nm of Ni was used to achieve a collector with uniform work function, as there was much evidence of work function variation in the initial data gathered. Furthermore, equipment was assembled to cool the photocathodes using liquid nitrogen and a quartz-halogen lamp was added to probe the photocathodes at a variety of wavelengths. New cathode structres, incorporating higher doping and different bandgaps, have been fabricated, as well as more standard structures. Preliminary results indicate a substantial improvement in resolution due to the refinements in tube design. Results from these tubes will be obtained in upcoming weeks.

Progress Report for Brent Boyer

We have initiated study of a novel retarding field electron optical system in which the sample lies in a field free region. Earlier work had shown that retarding field systems can have the high resolution characteristic of high energy beams along with many of the benefits of low energy systems like reduced sample damage, lower charging, and enhanced secondary electron yield [1],[2]. This previous work considered systems in which the retarding field is formed by putting a potential between an electrode and the sample; hence the sample sits in the retarding field. Practical implementation of such a system has been hampered by the fact that sample topology can cause widely varying local fields which leads to deleterious effects. For instance, these local fields may affect accurate beam placement or the collection of secondary electrons. This problem may be overcome if a second electrode is introduced to keep the sample in a field free region. Recent interest has developed for applying such a retarding field system for the high speed inspection of sub-micron features on semiconductor wafers [3]. Our study will take on two parts. We will first examine the optical properties of the system neglecting space charge. Next, we will include space charge interactions in order to predict the ultimate optical performance.

[1] Y. W. Yau, R. F. W. Pease, A. A. Iranmanesh, and K. J. Polasko, *"Generation and applications of finely focused beams of low-energy electrons"*, J. Vac. Sci. Technol., 19 (4), Nov./Dec. 1981 p. 1048.

[2] E. Munro, J. Orloff, R. Rutherford, and J. Wallmark, *"High-resolution, low-energy beams by means of mirror optics"*, J. Vac. Sci. Technol. B, 6 (6), Nov/Dec 1988 p. 1971.

[3] W. D. Meisburger, A. D. Brodie, and A. A. Desai, *"Low-voltage electron-optical system for the high-speed inspection of integrated circuits"*, J. Vac. Sci. Technol. B, 10 (6), Nov/Dec 1992 p. 2804.