NRL Report - January, February and March 1995

**Low Voltage Electron Beam Lithography**
**Contract No. N00014-92-J-1966**

**Aaron Baum**

January 1995

Finished constructing tube for complete analysis of electrons emitted from a negative electron affinity photocathode -- energy spectrum, angular spread, spot size, and current density. Began experiments with tube. Demonstrated energy spreads of 60meV at room temperature, lower than the lowest ever reported.

February 1995

Continued work with new tube. Found extremely low angular spread -- 50% of electrons have lateral energy of 40meV or less. Used electron optics to image the photocathode surface onto a phosphor with magnification. In this way an emission area of 1.74±0.4 micron diameter was demonstrated, two orders of magnitude smaller than any previously reported spot size.

March 1995

Maximum current drawable from micron-size spot was measured — up to 20microamps were drawn, translating to current densities of up to 841A/cm$^2$, an order of magnitude higher than the best $LaB_6$. This higher current density was expected for micron-scale spot sizes because of the possibility of increased lateral movement of trapped electrons, which cut off emission in large-area-emission photocathodes.

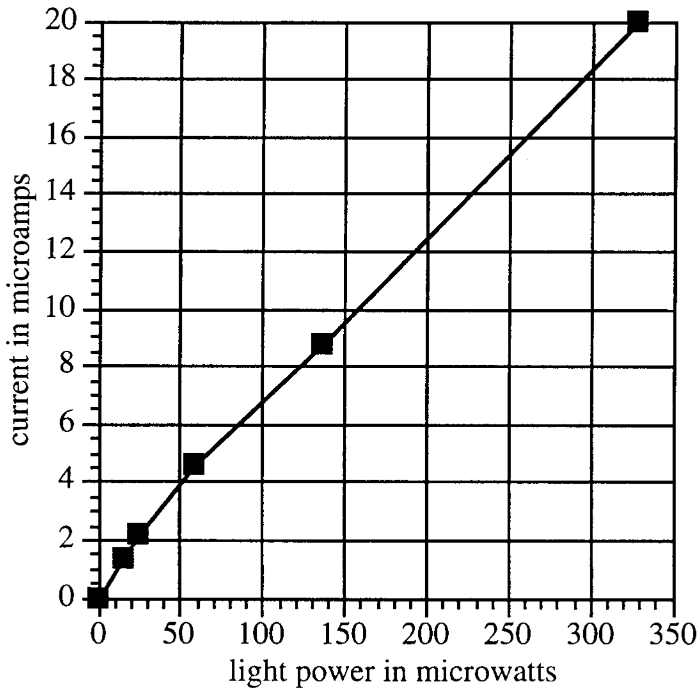


Figure 1. Current vs. 633nm light power for 1.74μm diameter spot

The maximum possible current is possibly much higher, as 20 microamps represents the limit of the current optical system; as can be seen in the figure, the current was increasing almost linearly with the light powert up to the limit of the system. In conjunction with the low angular spread of the electrons, this translates to a brightness on par with field emission.

Began design and construction of a new tube intended to explore more fully the limits of brightness of NEA photocathodes at sub-micron spot sizes, as well as the issue of change in emission area with current. Began 3D simulation of movement of electrons in a photocathode, to investigate the possibilities of cahnges in spot size and surface voltage with emission current.

## Weidong Liu

January 1995

Using our specially designed apparatus on a SEM stage, we have demonstrated that the surface potential of the resist irradiated by electron beam doesn't cause any significant deflection error under current lithography conditions. We also have shown that the resist surface potential increases exponentially as the beam voltage goes down from 10KV to 2KV. In order to get results of charging effect for low voltage electron beam lower than 2KV, the voltage source has been calibrated. New samples were prepared, 400nm SAL601 on chrome on quartz.

February 1995

Carried out the experiments on resist charging due to low voltage electron beam irradiation. Preliminary result shows a decrease of surface potential with decreasing beam voltage after surface potential reached the maximum value at a beam voltage between 1KV and 2KV. The surface potential stopped decreasing when the beam voltage is below 0.5KV. New samples were prepared to confirm the results and find out the peak charging potential and the beam voltage it occurs.

March 1995

More experimental results were obtained for resist charging due to low voltage electron beam irradiation. See Fig. 1. The magnitude of surface potential reaches the maximum value of 75V at 1.6KV beam voltage. Then it reaches a minimum value of 5V at about 0.5KV. The charging behavior of this thin resist film is different from that of normal bulk insulating material, for which the surface potential is positive when the secondary emission coefficient is larger than one at certain beam voltage. In order to understand this, more experiments were designed to measure the secondary emission coefficient and beam induced conductivity for the resist film.

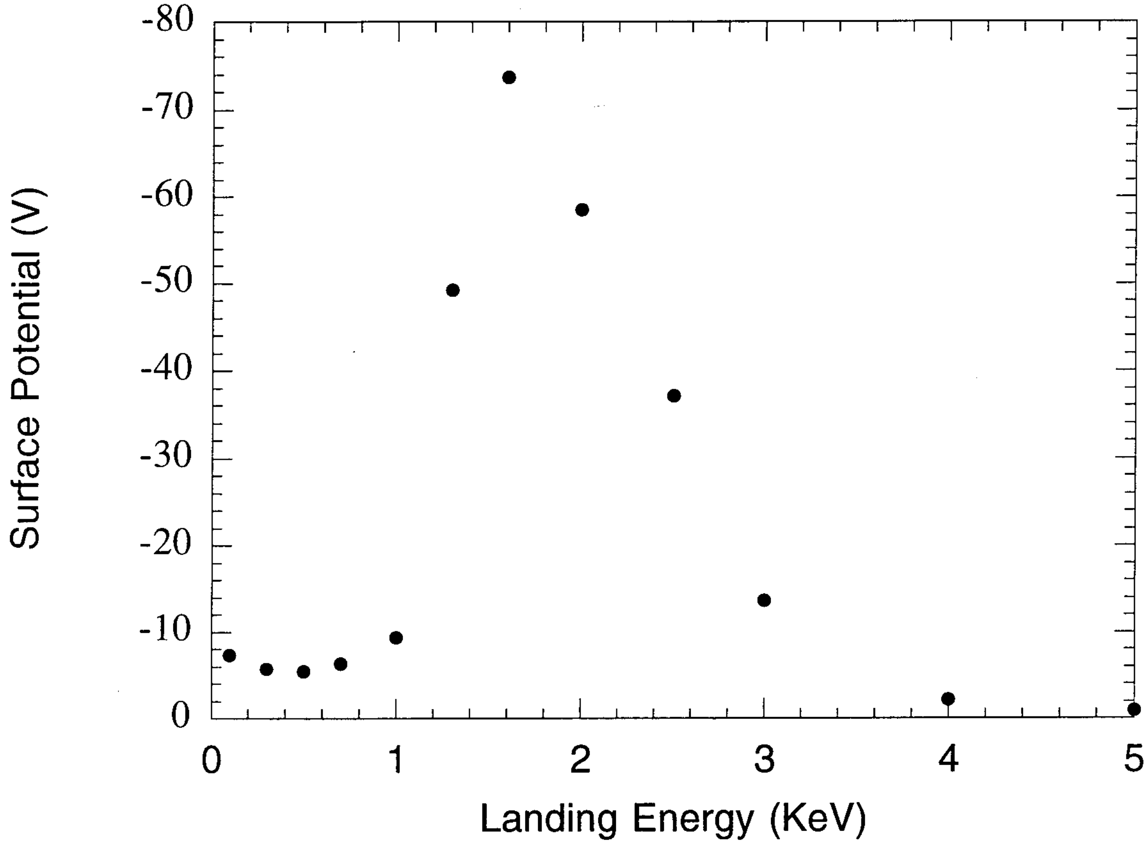


Fig. 1. SAL601 Surface Potential vs. Electron Energy
The resist thickness is 0.4μm. The exposure is 30nA on 4cm$^2$. The dose is about 10μC/cm$^2$.