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Micrion

April 14, 1990

Dr. Martin Peckerar
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Dear Dr. Peckerar:

This is the third technical report on Contract N00014-89-C-2238, reporting on work done in February and March 1990. The majority of the work was on advanced column development, clear repairs using tungsten deposition, system stability, and imaging.

2.31 Advanced Column Development

The performance of the existing two-lens column is limited by the optics design and the mechanical stability and does not have the resolution to repair 0.25 um and maybe 0.5 um features on an X-ray mask. We are developing a column capable of achieving 25 pA of beam current in a 0.023 um spot, and that is more stable than the existing column. At this time, we have completed a new optics design and have chosen a mechanical concept which is more stable. We are also building a developmental test stand for advanced column development.

The proof-of-concept column that we are building is a two-lens column which will operate at 30 kV. The calculated performance will be a 25 pA beam in a 0.023 um spot, about 6 A/cm^2 current density.

We will build it in a stacked disk approach, using internal bore alignment instead of the glassing technique that is used in the existing column. This design is more stable and is flexible enough to make changes in during the development period.

The mechanical components of the test stand have been assembled from parts of existing systems: the chamber and turbopump, for example, come from dissassembled systems. It should be completed and ready to use with a column in late June 1990.

2.32 Repair Processes

We determined deposition rates of tungsten for different beams, and tested the opacity of depositions by exposing them to Perkin-Elmer's XSAR. We are trying to determine the cause(s) of absorber distortion when repairs are made in close proximity to a feature. A number of clear and opaque repairs are being made on an IBM X-ray mask - we will need this exposed to a synchrotron source in May to test these repairs.

The deposition rates of tungsten, in a non-limited gas regime, are .0025 +/.0005, .015 +/.005, and .025+/.005 um^3 for the 17, 70, and 300 pA beams respectively. The thicknesses are linear with dose.

Tungsten repairs were tested by exposure to Perkin-Elmer's XSAR. For the same thickness, the FIB tungsten achieved better contrast than the gold absorber. For this system, tungsten that is thicker than 5000 Angstroms is suffiently opaque to X-rays.

We are making a series of tungsten depositions on an IBM mask. These vary in size (0.1 to 5 um) and are done with different beams (17, 70, and 300 pA) and different doses. We need to test these repairs at a synchrotron, preferably IBM's line at Brookhaven, to determine the thickness of tungsten we will use to repair IBM's X-ray masks.

We have observed distortion of gold features when clear repairs are made close to the absorber. This could be due to redeposition of sputtered material during the process, deposition of tungsten on the gold, or even distortion due to mechanical or thermal stress on the gold. Possibly the way the ion beam scans enhances the effect.

We have begun to quantify the effect for tungsten deposition repairs. The proximity distortion is noticeable when a deposition is made with a dose of $2nC/um^2$, about 0.5 um from the feature: it can be measured at higher doses which are closer to the absorber. The distortion is proportional to the repair size.

A suggestion is that particles coming off the surface at angles(tungsten that did not deposit, molecules from the membrane that are being competitively sputtered while tungsten is deposited) hit and stick on a nearby wall.

We have not determined the surface chemistry of the proximity distortion yet. We are planning to do milling experiments to see if milling leads to similar problems. We may have to investigate different beam scanning and repair strategies.

2.33 System Stability

The stability of the FIB system is affected by mechanical and electrical contributions, and by the column. Mechanical contributions include mechanical slip, temperature effects, and barometric pressure. Thermal stability of the deflection electronics and the HV supply contribute to electrical drift. The column instabilities are caused by charging, the stability of the source, and local temperature.

We used a spectrum analyzer with FFT(Fast Fourier Transform) analyzed to determine the frequency and source of system instabilities. Vibration Engineering, a company that Alan Wilson recommended at the quarterly review held in December 1989, analyzed the two-lens ion column and the ion source fixture.

We reduced the magnetic fields which contribute 0.03 um of noise by installing a magnetic shield around the column, and by changing to DC fans. Microphonic noise in the HV power supplies was reduced by shielding the exposed dielectric with conductive tape. We improved the isolation design to reduce vibrations from the mechanical pumps and the fans.

The major source of instability left in the system at this time is from the column. It vibrates easily and dampens slowly, and is very susceptible to electronic noise. We are trying to reduce noise by sliding an o-ring around the internal glass elements and by using a better electronic filter, but we feelthe column is at the limit now. The advanced column(2.31) is being designed to be more stable.

2.34 Charge Neutralization

We grounded the IBM masks in our holders with silver paint, and this slightly reduced the charging effects we can observe at high magnification.

2.35 Imaging and Edge Analysis

A preliminary evaluation of how IBM masks image in an FIB system was done. We found that there is contrast between the gold absorber regions and the transmitting (chrome on polyimide on silicon) regions. The preliminary data show that ion imaging will be preferable to electron imaging.

The progress is according to the schedule. The second quarterly review meeting was held in March. Marty, we need your help with the following items which were brought up in the meeting:

1. We need more X-ray masks. We would like to receive two each month. We need masks with the gold absorber in spec, so we can have the masks exposed to X-rays.

2. We would like to have some X-ray masks made with the 'Gumby pattern' (a regular statistical defect pattern) that Peter Levin and Al Wagner use. This is ideally suited to do the necessary statistics for repair resolution.

3. We need to have masks exposed to an X-ray source from a synchrotron and transferred into resist to evaluate our repairs. Mac Young was supposed to get back to me on this, but hasn't. We will have a mask ready by May.

4. We should begin working with KLA, preferably having a meeting at Micrion soon.

5. POLYIMIDE?! Is this a problem? We did not get a definite answer at our review meeting, only hints that it might be a problem. KLA has seen gold melting on an X-ray mask while imaging it in a SEM. Micrion has seen odd effects imaging isolated gold dots in a SEM and the FIB system. If the thermal properties of polyimide are potentially a problem for repairing IBM masks as they exist, and if IBM knows how to avoid problems, we need to know too. This information could save the government and this program time and money.

Sincerely

Diane K. Stewart

Diane K. Stewart
X-ray Program Manager

cc: N.Economou
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