Microshutters for James Web Space Telescope (JWST)

Spectrographic astronomy measurements in the near-infrared region will be done by functional two-dimensional microshutter arrays that are being fabricated at the NASA Goddard Space Flight Center for the James Webb Space Telescope (JWST). These microshutter arrays will represent the first mission-critical MFMS devices to be flown in space. JWST will use microshutter arrays to select focal plane objects. 2-D programmable aperture masks of more than 200,000 elements select such space objects. The use of silicon wafer material promises high efficiency and high contrast. Microshutter operation temperature is around 35K. Microshutter arrays are fabricated as close-packed silicon nitride membranes with a unit cell size of 105 x 204 μm. A layer of magnetic material is deposited onto each shutter. Individual shutters are equipped with a torsion flexure. Reactive ion etching (RIE) releases the deposit onto each shutter. Individual shutters are equipped with a torsion flexure. Magnetic materials are used to hold the shutters open (up to most of the time). Figure 1 indicates a direct correlation between the minimum voltage release and 2-D addressing to hold specific shutters open versus external electronics. (See Figure 1)

Figure 1: Magnetically activated microshutters array show distribution of the shutters that did not open during the time that they were opened. Similar distributions will be used when taking the images with JWST. Our analysis indicates that distributions of the closed shutters are indicative of the variable bowing of the microshutter membranes that translates into the stress relaxation from the wall acting against the electrostatic forces.

Figure 2: Confocal microscopy allows taking images of the microshutters at variable temperatures without preserving information about the temperature. This way the microshutters can be analyzed for degree of shape change during the cooling.

Figure 3: Diagram shows the temperature effect on the minimum voltage release of tunnel microshutters. We also included effect of length of time used to hold microshutters open (0-120 minutes).

- Latch all shutters at test voltage
- Decrease voltage, counting the number of shutters that close at each voltage
- Use results to determine the average release voltage of the array

Figure 4: Test setup for measuring the minimum voltage release included a dewar containing a window that allowed observation of the microshutters while they were released at the minimum voltage. Images above were taken by camera observing microshutters in this window while they were near liquid helium temperature.

Discussion:

Figure 3 indicates a direct correlation between the minimum voltages and degree of bowing. Data also show that the degree of bowing can be detected with larger precision if microshutters are held longer time in liquid nitrogen. The maximum time was 2 hours and is comparable with exposure times that will be used on James Web Space Telescope. We believe that the minimum voltage release measurements can be used to investigate any change of the degree of bowing as a result of exposure to the space environment during the lifetime of the JWST mission.

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The MEMS Alliance
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2008 Symposium Information

The Mid Atlantic MEMS Alliance
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