Microshutter arrays for the NGST MOS

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NEXT GENERATION NGST SPACE TELESCOPE

ABSTRACT

We are developing a two-dimensional array of square microshutters (programmable aperture mask) for a multi-object spectrometer for the Next Generation Space Telescope (NGST). This device will provide random access selection of the areas in the field to be studied. The device is in essence a close packed array of square slits, each of which can be opened independently to select areas of the sky for detailed study.The device is produced using a 100 μm thick silicon wafer as a substrate with 0.5 μm thick silicon nitride shutters on top of it. Silicon nitride has been selected as the blade and flexure material because its stiffness allows thinner and lighter structures than single crystal Si, the chief alternative, and because of its ease of manufacture. The 100 μm silicon wafer is backetched in a high aspect ratio Deep Reactive Ion Etching (Deep RIE) to leave only a support grid for the shutters and the address electronics.

We are currently working on three key aspects: the optimization of the photolithographic micromachining process, the shutter selection electronics, and the translation mechanism required to open the shutters. Microshutter arrays of 128x128 have been produced with good reliability of the fabrication process and good quality of the microshutters. The selection circuitry is embedded in the frame around the shutters to allow individual shutter selection. It has been designed and modeled for operation at cryogenic temperatures. The element addressing is essentially a Dynamic Random Access Memory (RAM) scheme, which allows very compact design of the electronics on the array. Finally, the mechanical behavior and optical performance of the fabricated arrays at cryogenic temperature are being studied.

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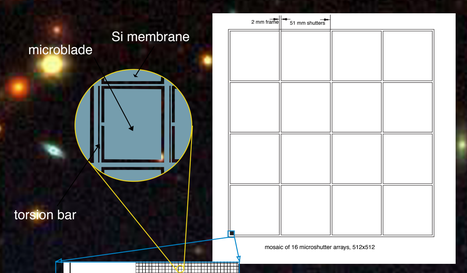
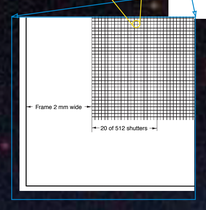
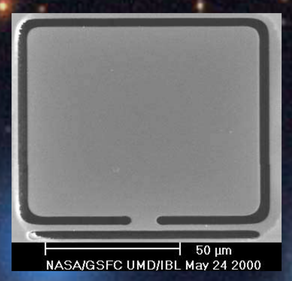
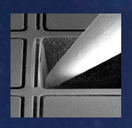
Microshutter array concept

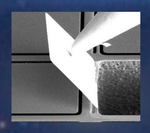


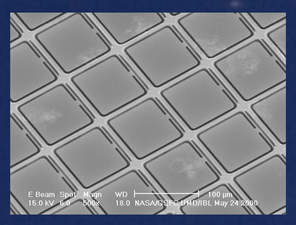




Single shutter scanning electron microscope image and layout of a 2048 by 2048 microshutter array. 512 by 512 (~ 100 by 100 microns shutter pitch) shutter arrays are arranged in mosaic on a frame with 2 mm thick ribs. Expanded views show the corner of the mosaic and single microshutter outline. Below is SEM image of photolithograpically fabricated shutters flipped out of the plane by the micromanipulator.

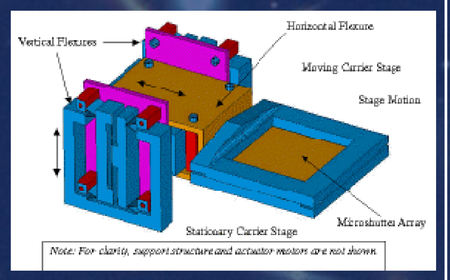




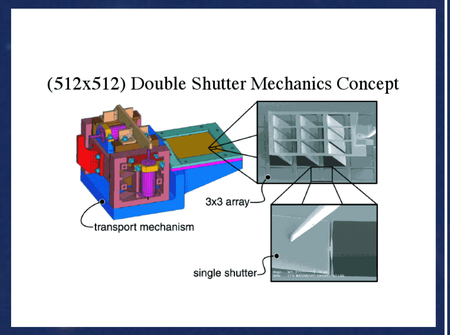


ACTUATION

The transport system consists of two perpendicular linear flexures. One of the flexures controls the vertical motion of the array stage while the other controls the horizontal motion of the stage. The flexures will be sized to limit any unprogrammed motion to less than 2 μm.



Double shutter transport mechanism with the stepper motors mounted and an insert picture showing the schematic representation of the shutter actuation. For 128x128 array tests an adapter plate will be used to mount them in the carrier designed for 512x512 arrays.



Addressing CMOS electronics

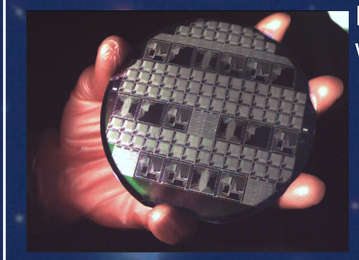
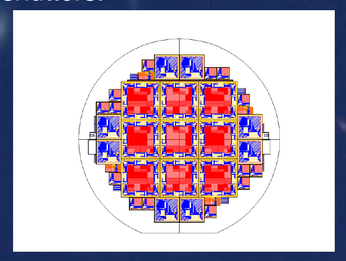


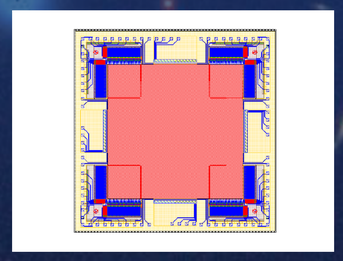
Image of a CMOS process test wafer without shutters.

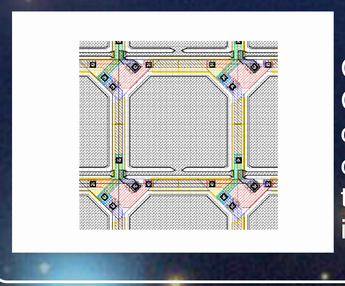


Wafer layout with nine 128x128 shutter arrays with various 32x32 CMOS addressing configurations and additional tests structures

Shutters are selected with a CMOS decoder and actuated with a single-FET unit cell that constitutes a dynamic RAM. Electronics must allow the application of a potential to any shutter.

128x128 shutters array with four 32x32 CMOS addressing circuits.



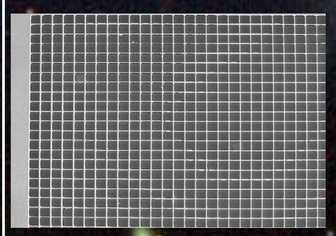
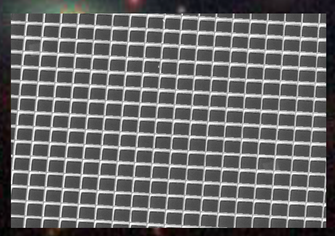
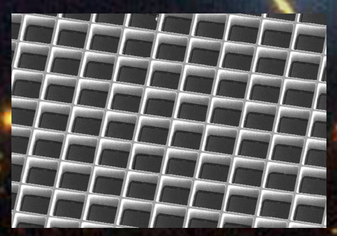
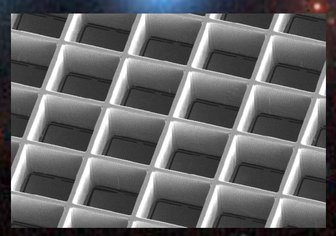
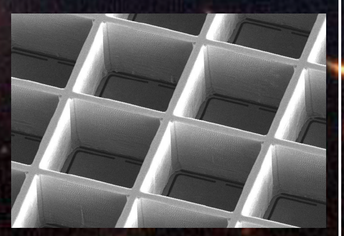


CMOS unit cell on individual shutter. CMOS transistors are located in the corners of the shutter array grid. Shutter corners will be cut out to accomodate transistors without significant reduction in the fill factor.

Current status:

- Manufactured large size (32x32 and 128x128) arrays using photolithographic process
- 32 by 32 addressing circuits similar to what will be used in microshutter arrays have been fabricated and tested.
- CMOS layout integrated into a shutter array has been finished and is in the process of fabrication.
- Mechanical flexures have been fabricated. Other parts of the support structure and actuation mechanism are being fabricated
- Materials stiffness and strength have been analyzed
- Preliminary tests of the the shutters lifetime and reliability have been carried out

Further Development (year 2001):

- 128x128 mechanical model with integrated CMOS
- Cryogenic optomechanical testing of the shutter arrays
- Double shutter suspension integration and tests
- 512x512 fully addressable array assembly and lab testing
- Lifetime and reliability tests with the double shutter
- Demonstration of the shutters in a groundbased astronomical applications

SEM images of the photolithographically produced 128 by 128 array .