Future Application of JWST Microshutter Technology for Use in Neural Implants

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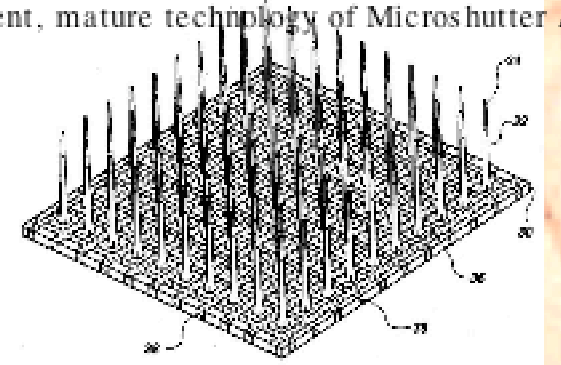
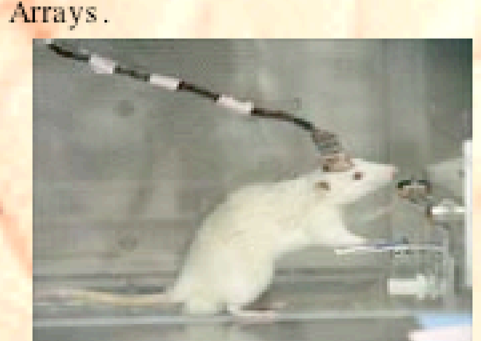
Current Application of MEMS in Neural Implants

Current research in MEMS involving neural implants is limited to fabrication of dense arrays of micro-probes, for example using LIGA technologies [1]. These technologies are limited to static sensing and probing of neurons - if a micro needle is not in contact with the target neural site, it is disregarded and left in place. While this plan of attack relieves device complexity, the long-term damage and effects are unknown.

By gaining the capacity to actuate individual probes in the array, unused probes can be removed and other probes can be periodically shifted, allowing regeneration of the neural tissue. We believe it may be possible to build an individually addressable array of micro probes based on the current, mature technology of Microshutter Arrays.

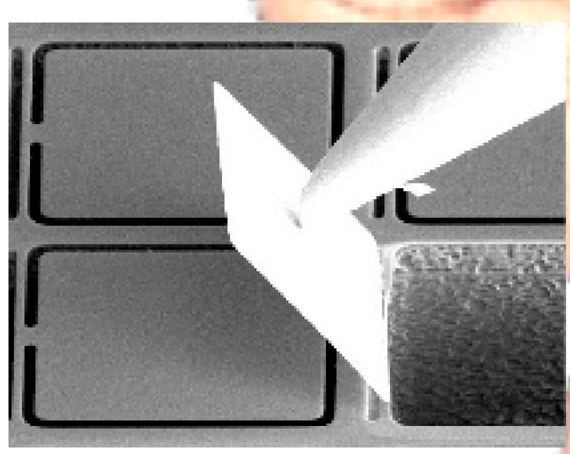




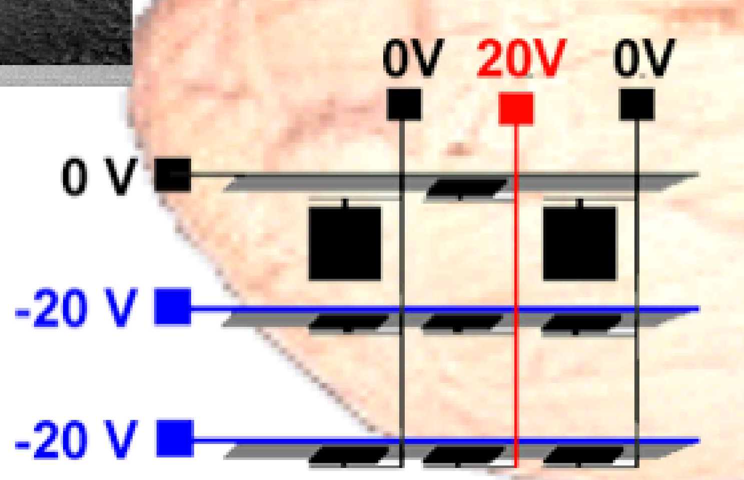
Brain implant - electrode array and rats implanted with BCIs in Theodore Berger's experiments

Microshutters project JWST [2]

Micro Electromechanical System (MEMS) microshutter arrays are being developed at NASA Goddard Space Flight Center for use as a 2-D randomly addressable field selector on the James Webb Space Telescope (JWST). Each microshutter has a hinge on one side, and includes a silicon nitride torsion bar providing the spring tension to close the shutter when opening forces are removed. Magnetic cobalt-iron strips are coated on the upper face of each microshutter element. In use, a magnet is positioned underneath the array to first open all of the microshutters simultaneously; when the magnet is removed to enable imaging, elements that need to remain open are kept that way by computer-controlled voltages that can be turned on and off selectively for each element in the grid. Shutters are actuated by a magnetic force (0.2 – 0.3 T) and latched using an electrostatic force.



A shutter in an early version of a microshutter array opened by a probe

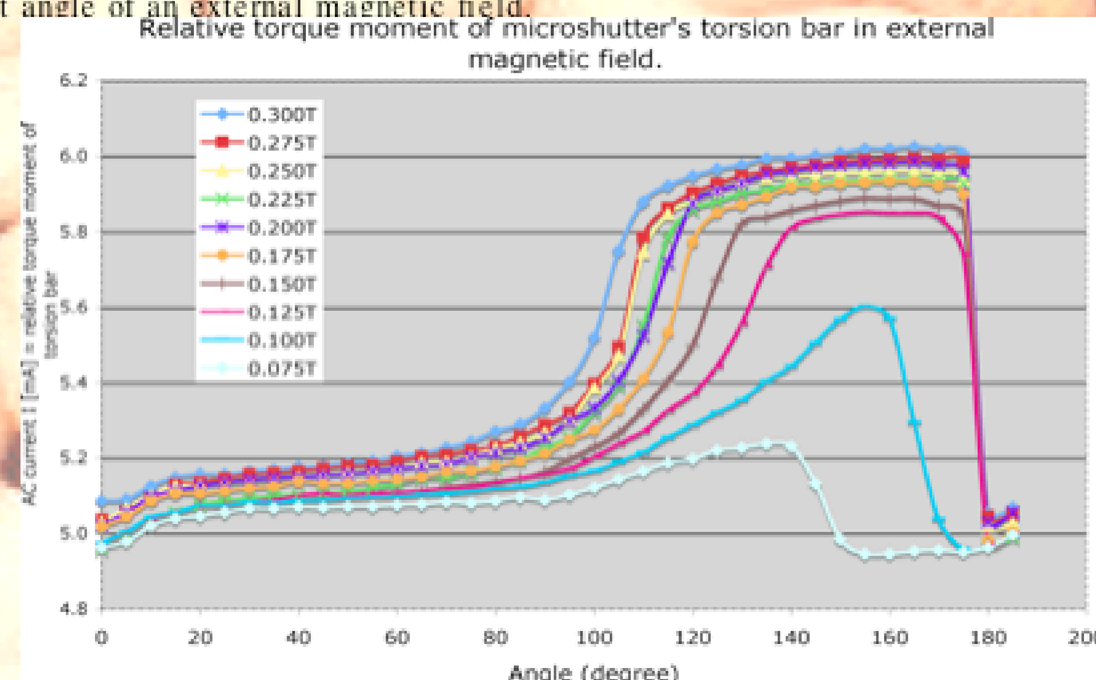


A schematic of cross-point addressing for selectively opening of microshutters

Next generation neural implants - future concept.

We can modify existing microshutters by adding pin electrodes covered by a gold layer. The Rest of implant will be covered by a thin layer of glass – SiO2. Moving electrode pins will have a density of about 45 per mm² and a length of about 100 µm.

Advantages: 1) Using this technology we can operate electrodes over long distances of about 100 µm. 2) Each electrode will be independently controlled by an electric or magnetic field. 3) Moving electrode pin arrays give the neurons a chance to return to their standard functions. If a pin electrode contacts the "weak" neurons, the electrode can be disconnected until the neurons regenerate. As comparison, static pins stimulate neurons continuously and there is no time for regeneration. 4) This technology allows for new experiments where we can excite neurons by touching them mechanically with either high or low frequency. 5) We can also gently control the contact force between electrode and neurons. On the chart below is shown torque moment of torsion bar versus magnitude and tilt angle of an external magnetic field.



There are many challenges to modify current shutter arrays. For example: 1) The implant must work in electro-conductive liquids, so insulating layer must be robust. 2) Current actuation of shutters requires a large magnetic or electric field. Possible solutions include implanted electromagnets, application of a strong electric field, a large external magnetic field combined with electrical addressing, or modification of array to reduce actuation force. 3) Individual pins must be thin to be noninvasive, but strong enough to withstand actuation and neural stimulation.

Using an array of 24 neural stimulation points, William Dobelle's second generation implant allows coarse images to be transmitted from a camera attached to the glasses to his brain.

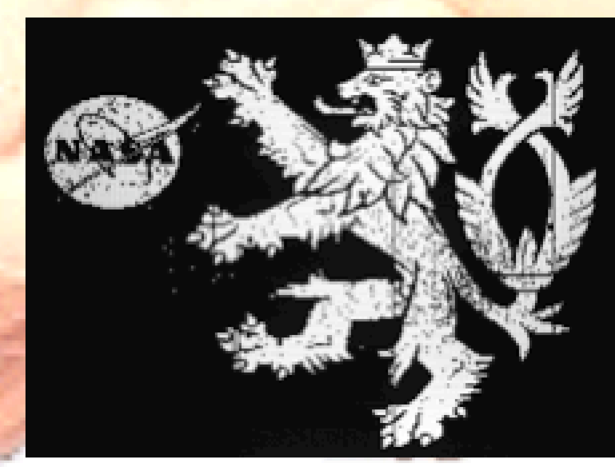
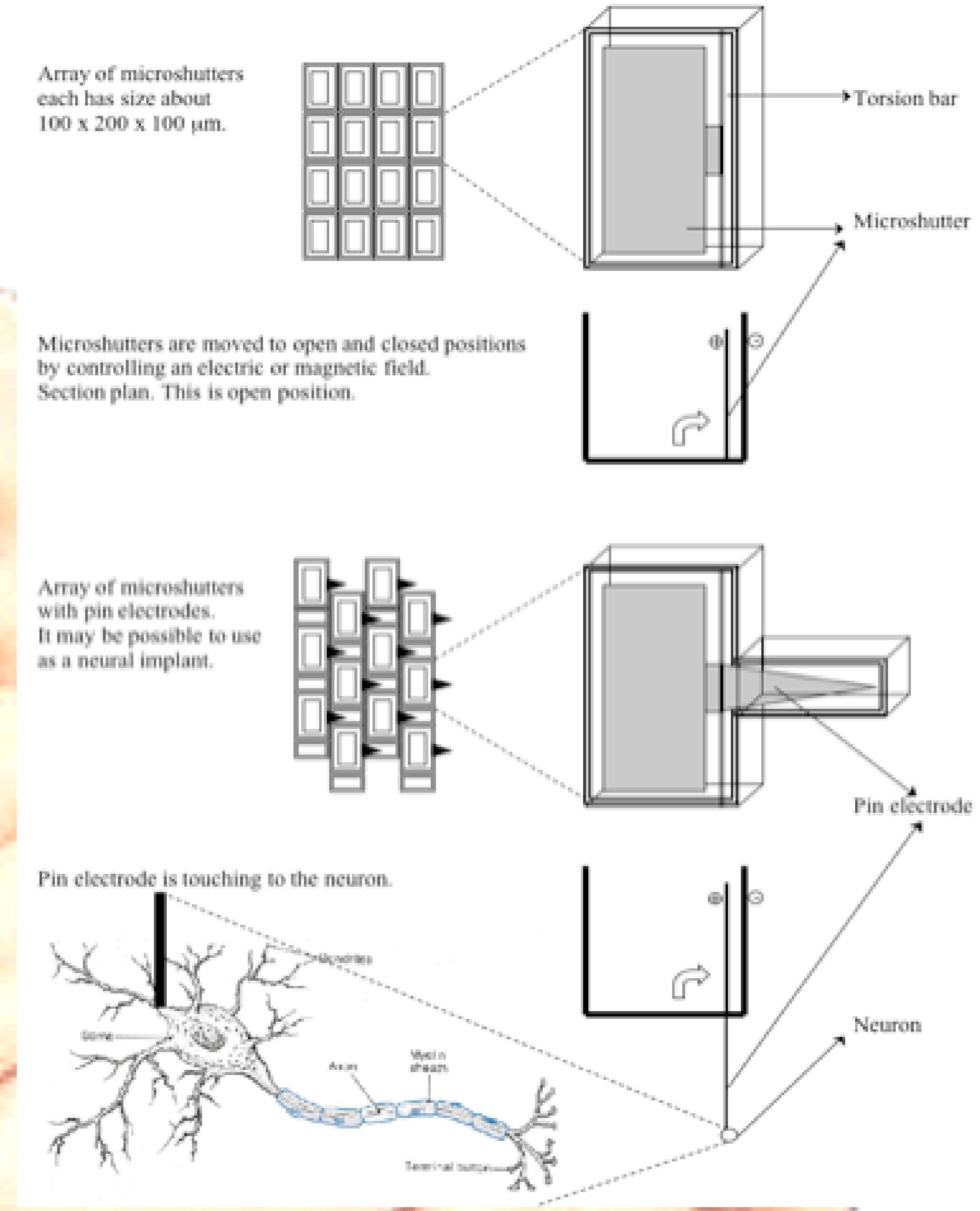
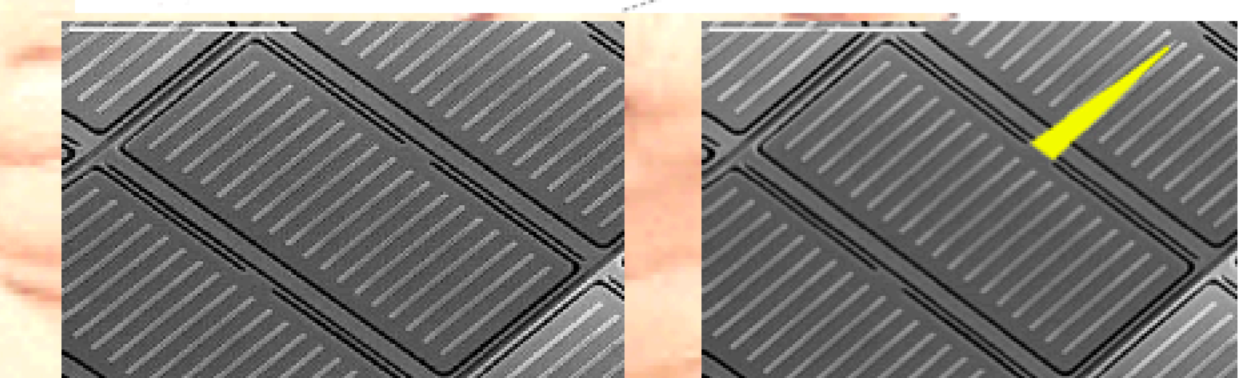


Image of Czech heraldic lion as a demonstration of 2D addressing by a microshutter array. The light pixels are open shutters, the dark pixels are closed shutters. It is possible that a blind patient with our proposed implant would see images with the same quality.





Microshutter and proposed conceptual drawing of microshutter with a pin electrode.

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