Design and Fabrication of Nano-Tweezers

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Since the invention of atomic force microscopes (AFM) that provided researchers with a convenient tool to observe objects at nanoscale, manipulation tools at nanoscale have been in high demand. There have been several attempts to create nanomanipulation devices, such as nano-tweezers, to address this challenge. Most such attempts have amounted to single proofs of concepts rather than a practical, readily producible manipulation tool. The goal of this project was to further the current state of nanomanipulators, by producing nano-tweezers that are consistently producible, using batch microfabrication processes. In addition, given the regularity and practicality of the AFM as a nano-scale research tool, the nano-tweezers were intended to also serve as a scanning probe for the AFM. This way, the same tool can to be used to both image and manipulate samples, and the utility of the devices is increased.

A two-fold approach was used to tackle the problem. First, using complete batch fabrication methods, a process was created to generate nano-scale tweezer tips separated by a nano-scale gap. This process uses standard micron scale batch lithography to define pyramidal walls in silicon. It then produces an extremely thin cut that self-aligns to the apex of the pyramid. Thus far, tip separations of 358nm and tip widths of 50nm have been repeatably produced. The alignment of the process is within 35nm and is much smaller than that of the lithography tool. The second phase was to create free standing, protruding structures that can serve as the tweezing arms and move with nano-scale resolution. Cantilevered flexural members, coupled with electro-static actuation, were successfully fabricated. These slender cantilevered flexural components measure only 1-2 um in width. A novel process was developed that overcomes problems due to surface tension, and protects the released devices all the way through die separation.

The devices have shown actuation behavior that is consistent with theory and design intent. Resolution of motion of 40nm has been verified using SEM through the entire working range of the device. Resolution of less than 10nm is expected based on data but has not been verified due to the limits of this SEM.