# Suspended, Micron-scale Corner Cube Retroreflectors as Ultra-bright Optical Labels

Tim Sherlock[1], Azeem Nasrullah[1], Julia Litvinov[2], Eliedonna Cacao[3]
Jennifer Knoop[3], Paul Ruchhoeft[1], and Richard Willson[3]
[1]*Electrical and Computer Engineering*, [2]*Biomedical Engineering*,
[3]*Chemical and Biomolecular Engineering*
*University of Houston, Houston, TX 77204*

Many biosensors measure the presence of secondary objects, such as colored beads, fluorescent molecules, nanoparticles, etc., as they accumulate at specific sites when the target biomolecules are present. The accumulation is driven by highly selective molecular binding events, such as DNA hybridization, antibody/antigen binding, etc. In this work, we are developing a new class of reporter objects consisting of suspended, micron-scale retroreflectors. These transparent cubes have three reflective, mutually perpendicular surfaces, and, when properly aligned, return light directly to its source, making them extremely detectable using simple, low-cost optics, as is commonly observed in lane markers, reflective safety markings, and reflective clothing. Additionally, these objects do not suffer from photobleaching and can incorporate magnetic films for sample preparation.

Our cube fabrication sequence is shown schematically in Figure 1: (a) we coat a wafer with layers of PMGI, polyimide, and PMMA and (b) form a pattern of squares using ion beam proximity lithography. (c-e) A lift-off sequence converts this pattern to metal patches, which are (f) transferred through the polymide by reactive ion etching. (g) A layer of gold is evaporated at an angle to coat three sides of the cube, and (h) the cubes are released by dissolving the sacrificial PMGI layer in TMAH.

We have previously reported that we can fabricate suspended corner cube retroreflectors and are now able to image these objects in solution, both beneath the surface and at the liquid/air interface. Figure 2 shows SEM micrographs of 5 μm corner cubes on a silicon wafer surface prior to release. Figure 3a shows the cubes as imaged using a 12× optical microscope with NA $\approx$ 0.1. These cubes were fabricated using a nickel layer which allowed us to manipulate them using a standard lab magnet. We have also fabricated corner cube reflectors at fixed locations on a substrate and imaged them using the same optical system in order to compare the size and intensity of the images. Figure 3b shows these patterns imaged using the same microscope: we note that the images are very similar in size and intensity to those imaged in solution.

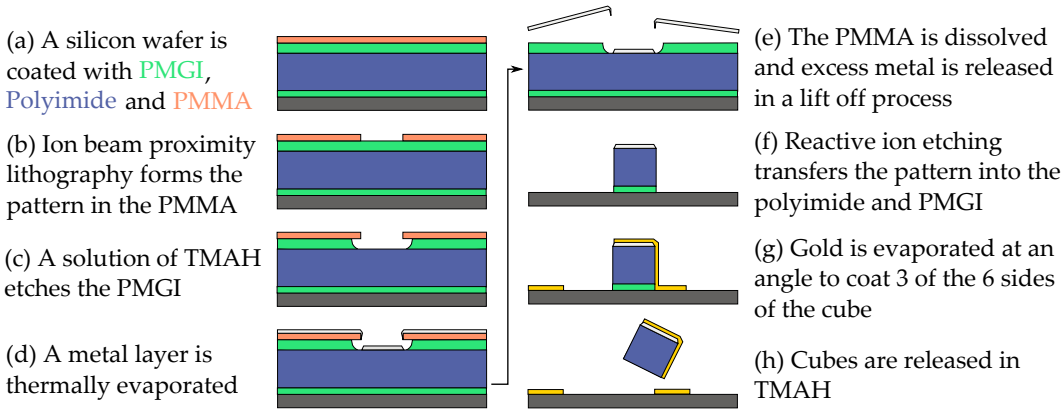



Figure 1: Fabrication sequence for suspended retroreflector cubes.

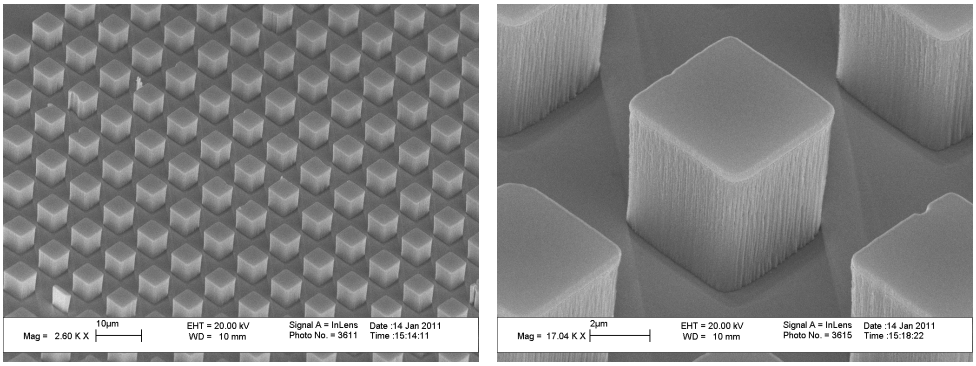
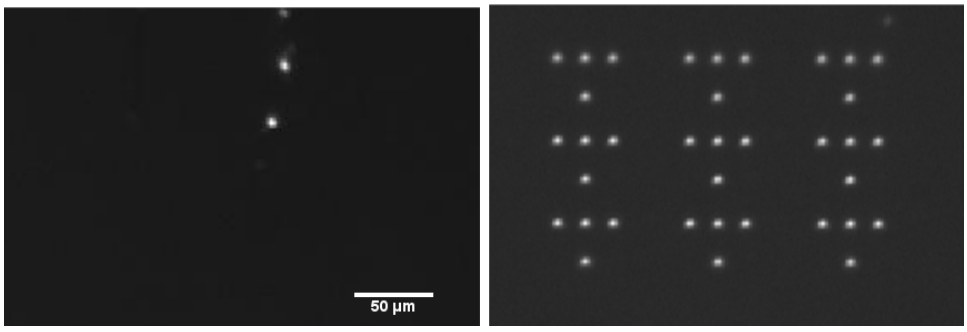



Figure 2: Scanning electron micrographs of corner cube retroreflectors.




(a) (b)

Figure 3: Retroreflecting corner-cubes imaged (a) in solution and (b) at fixed locations on a silicon wafer using 12×, 0.1 NA optical microscope.