Nanostructured Origami describes a new idea for manufacturing 3D nanostructures on a silicon wafer. Nanometer-scale structures are best fabricated with various 2D lithography techniques. This project addresses the problem of how to build 3D structures using only 2D lithography. The general method of the Nanostructured Origami approach involves three steps: (1) lithographically define micrometer-scale membranes and hinges; (2) lithographically pattern nanostructures on these membranes; and (3) release the membranes and actuate the hinges to fold into a 3D shape.

We have developed a process to fold thin membranes of silicon nitride using stressed chromium hinges. The chromium is deposited with high tensile residual stress by vacuum evaporation, and the membranes are subsequently released with a KOH underetch. As the membrane is released, the chromium hinges self-actuate due to their stress. Figures 1 and 2 show experimental results of the folding process. For a given value of residual stress in the chromium, the hinge will curl with a predictable radius [1]. Therefore, the angle to which the membrane folds is proportional to the length of the chromium hinge (Figure 1). We have also demonstrated 180° folds (not shown).

Our current work is focused on nano-patterning the silicon nitride membranes with electron-beam lithography prior to releasing them. In addition, we plan to reduce the hinge radius of curvature by selectively thinning the silicon nitride at the hinge area. With these improvements, Nanostructured Origami becomes a tool well-suited for the fabrication of 3D nano-devices, including 3D photonic crystals and 3D ICs.

REFERENCES: