Self-Alignment of Folded, Thin-Membranes via Nanomagnet Attractive Forces

A. Nichol, W.J. Arora, F.J. Castaño, G. Barbastathis
Sponsorship: ISN, MARCO IFC

We are developing a thin-membrane self-alignment technique based on the attractive force between arrays of nano-patterned magnetic material (nanomagnets). The alignment scheme shown in Figure 1 will be applied in the Nanostructured Origami™ fabrication method [1], which involves first nano-patterning membranes using 2D lithography and then folding the membranes in a 3D configuration. We have shown that the scaling of the attractive force between magnets is favorable for this application. The research is moving towards a completely self-assembling, 3D nanofabrication method with better than 50-nm accuracy of feature placement for use in 3D photonics, 3D integrated circuits, and other 3D hybrid devices.

Nanomagnets with preferred magnetization in-plane can be patterned on thin-membranes with nano-scale precision using e-beam lithography, e-beam evaporation for the metallization steps, and liftoff processing. The alignment system uses a large array of nanomagnets to increase force and to average out the local errors in magnetic pole positions. A dynamic model of the system has shown a significant dependency on the number of magnets for the precision of the final alignment.

The magnetic alignment scheme is most effective when the folding takes place in an external magnetic field that holds a common magnetization direction for the nanomagnets. The addition of an external field allows the use of soft magnetic material operating at saturation. This reduces processing constraints because hard permanent nanomagnets at this scale are more difficult to fabricate than soft magnets. Furthermore, the torque due to the external field provides alignment about two axes of rotation. Using a dipole approximation along with finite element magnetic modeling (FEMM) [2], we have determined the alignment forces that can be achieved with this method. A plot of the forces between two 100 nm x 1 µm x 3 µm saturated iron nanomagnets appears in Figure 2. We are characterizing the alignment force experimentally using sensitive 300 nm-thick silicon nitride flexures that have been e-beam-patterned with iron nanomagnets.

References