Using Nano Polystyrene Beads as Dampers in Micro-Scanning Mirrors for Photodynamic Therapy

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A scanning micromirror is not only a crucial component for telecommunications but it also can be applied to biomedical laser-scanning devices for photodynamic therapy.

Photodynamic therapy treats cancer by exposing cancer cells to powerful light at a particular frequency. The cancer cells have been selectively dosed with photosensitizing drug by intravenous injection. When doctors deliver this laser light through an optic fiber, the micro-scanning mirror allows the doctors to control the laser spot to a specific cancer site (in the case of mesothelioma, the pleura). As the agent in the treated cells absorbs the light, an active form of oxygen destroys the surrounding cancer cells and leaves the healthy cells. The scanning angle and controllability of the micromirror is important to this operation.

In our previous research [1], we presented the floating slider mechanism for the electrostatic scanning mirrors (shown in Figure 1) to achieve low voltage and large angle scanning (Figure 2). The mechanism can amplify the mirror angular displacement from the movement of bimorph electrostatic actuators. It has reliable performance after 6.9 billion cycles under continuous operation. However, the combination of restoring spring and floating slider causes long settling time, which limits the switching speed and controllability of the mirrors.

In this work, we integrate nano-polystyrene beads into the slider mechanism. The process includes nanobead trapping (Figure 3) and CO_2 super critical point dry. After redundant bead removal and critical point drying, the device is ready for the test. The testing result shows that the nano polystyrene beads work as significant dampers which effectively decrease the scanning mirror's settling time from 1.5ms to 0.8ms. (Figure 4).

Reference: [1] Kerwin Wang, Mike Sinclair, Karl F. Böhringer, "Low-voltage large angular displacement electrostatic scanning micromirror using floating slider mechanism", IEEE MEMS 2004.

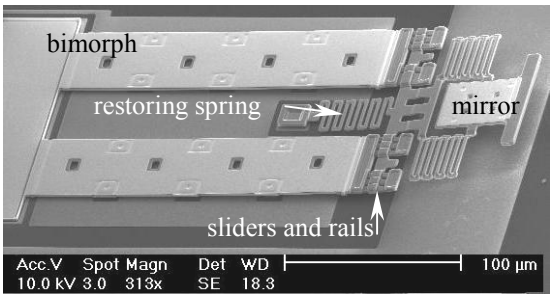

Figure 1: The mirror is attached to the substrate via a restoring spring, which is driven by two curved gold-polysilicon bimorph electrostatic actuators through the sliders. When voltage is applied, the electrostatic force of the flexures pulls the mirror downward.

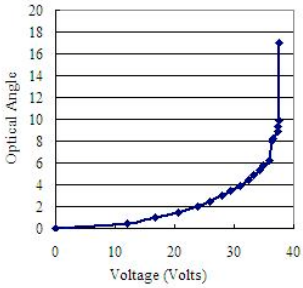

Figure 2: The mirror can achieve large scanning angle and low driving voltage with floating sliders.

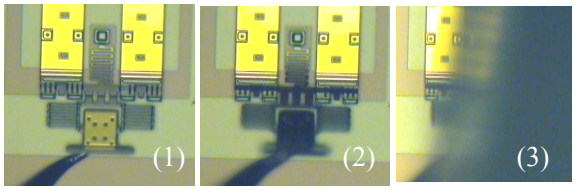

Figure 3: To imbed nanobeads into the slider, we first pull the slider away from the rail by probe with a micro-manipulator (1)-(2) that yields a gap around 20µm, then we apply colloidal solution (290nm polystyrene beads) to the top of the device (2)-(3). After releasing the probe, the slider will be put back onto the rail, which will mechanically trap some beads inside the mechanism.

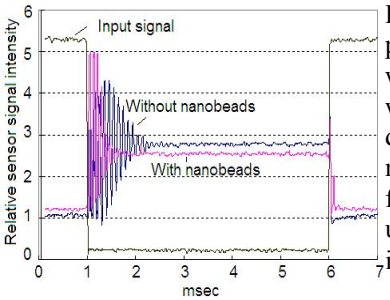

Figure 4: the nano polystyrene beads work as dampers which effectively decrease scanning mirror's settling time from 1.5ms to 0.8ms under 100 Hz square input.