Metallic MEMS structures for assembly of optoelectronic components

Arunkumar C Nallani[1,2], Ting Chen[2], JB. Lee[1], Donald J Hayes[2] and David B Wallace[2]

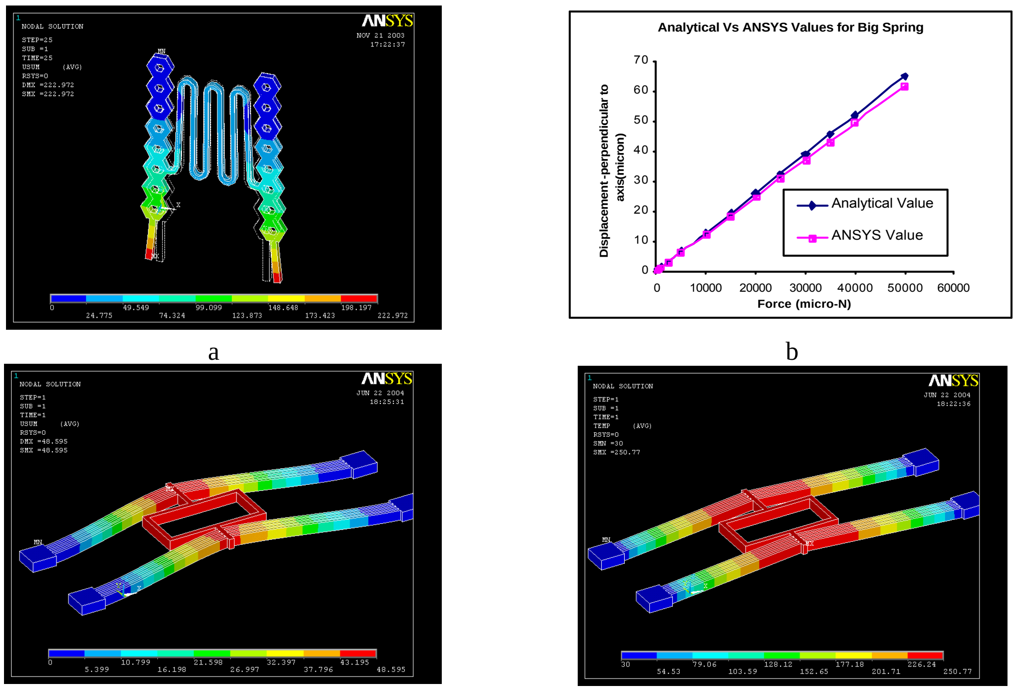
1. The department of electrical engineering, University of Texas at Dallas, Richardson, TX 75080

2. MicroFab Technologies, Inc., 1104 Summit Ave., Suite 110, Plano, TX 75074, USA

The emergence of vertical cavity surface emitting laser (VCSEL) and photo diode (PD) arrays has given scope for the development of many applications involving high speed data communication and other sensing/detection devices. Further increase in performance can be obtained by the inclusion of micro-mirrors and micro-lenses in the optical path. However, the lack of efficient assembly, alignment and coupling techniques has become a bottleneck for new products which incorporates high density arrays.

In this paper, we present development of novel metallic MEMS structures that enable alignment and coupling of these parallel components to form a single miniature package. Multiple numbers of suspended MEMS serpentine springs and electro-thermal actuators made out of electroplated nickel have been fabricated on ceramic substrates. These springs and actuators enable clamping, alignment and fine positioning of multiple numbers of optoelectronic components. Some are designed to be self-aligning with alignment accuracies of less than 3 micron after final assembly.

Finite element analysis has been carried out using ANSYS™ for optimizing the design. Figures 1(a-d) show some of the ANSYS results obtained. The optical design, based on our capability to fabricate micro-lens/ micro-mirrors of chosen diameter and radius of curvature, has been carried out using Zemax™ software.



a b c d

Figure 1. ANSYS Simulation results. (a) Displacement of Spring structure for an applied force. (b) Comparison of Force vs. Deflection results by analytical and finite element methods. (c) Displacement in an electro-thermal thermal actuator for a given voltage. (d) Temperature variation in the electro-thermal actuator for a applied voltage.

The fabrication of these structures has been performed by a two layered photolithographic process. SU-8 negative photoresist is used to make mold structures through which nickel is electroplated. This is followed by dry etching of SU8 mold using reactive ion etcher (RIE) to obtain the released structures. A few of the fabricated metallic MEMS structures are shown in Figures 2(a-d). Electrical connection between the bond pads of VCSEL's and PD's to the electrical leads on the substrate has been demonstrated earlier by molten solder inkjet printing at 45^{o} angle as illustrated in Figure 3(a). However the presence of micro-optics on top of the VCSEL and PD arrays impedes this process as shown in Figure 3(b). This problem has been fixed by inkjet printing solder into precisely designed MEMS mold structures at a much more convenient 90^{o} angle and forming the electrical interconnect by solder reflow. This process is shown in Figure3(c-d).

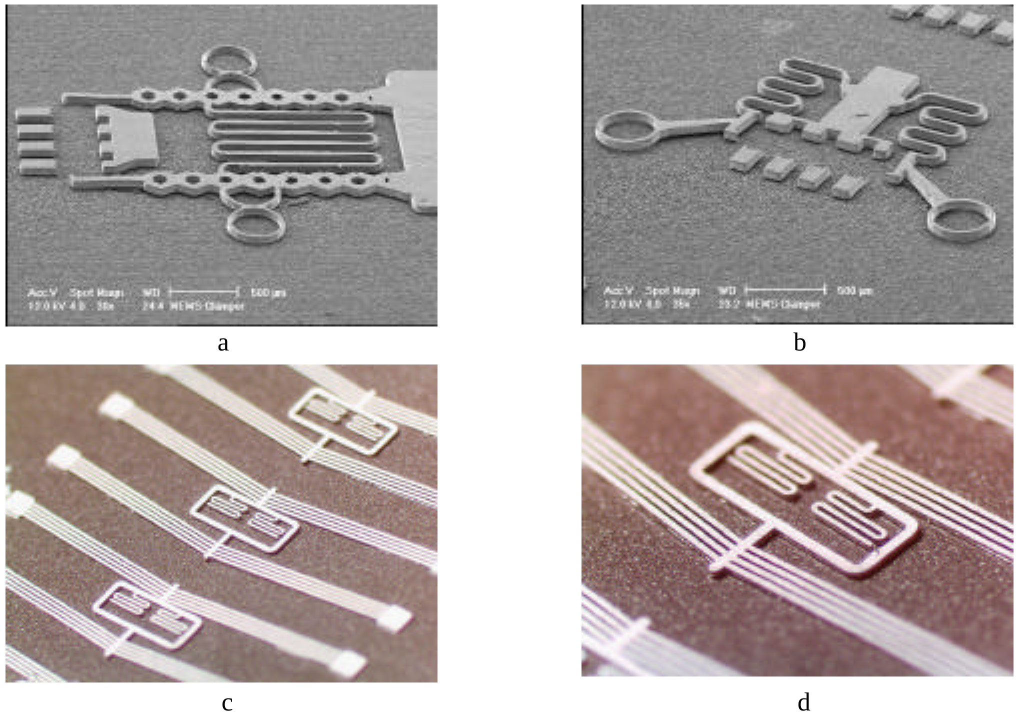


Figure 2. Fabricated metallic MEMS structures. (a) Larger design of the 4X1 VCSEL/PD array clamper. (b) Smaller design of a 4X1 VCSEL/PD array holder. (c) Electro-thermal actuator with built in structures for clamping and micro-positioning of micro-lens/ micro-mirror structures. (d) Zoomed in view of the actuator.

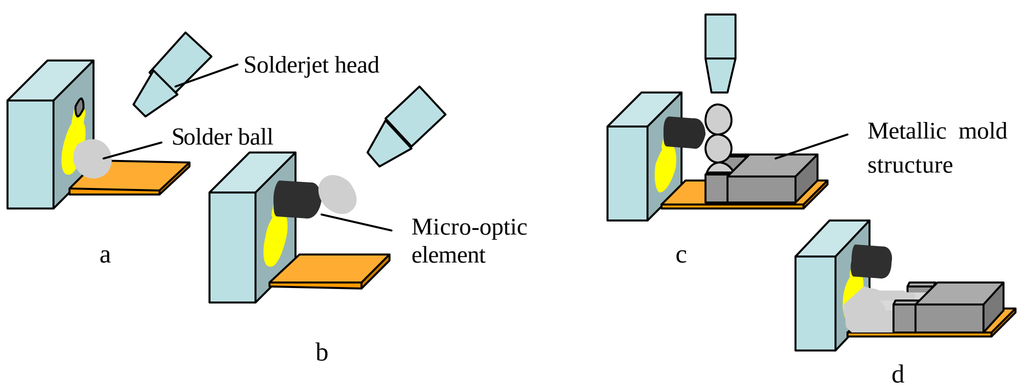
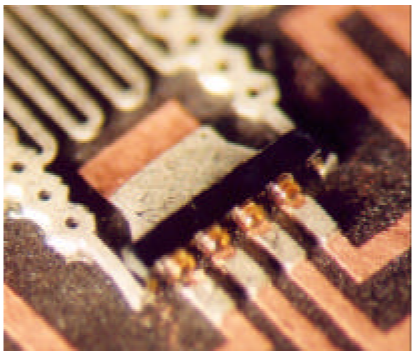


Figure 3 Schematic illustration of electrical interconnect formation. (a) 45^{o} tilt solder jet printing (b) Micro-optic Elements impeding the solder ball printing. (c) 90^{o} Solder jet printing into precisely designed metallic mold structure. (d) Electrical interconnect formation after solder reflow.

Figure 4(a) shows a 4X1 VCSEL array being held by a MEMS clamper and Figure 4(b) shows one of the VCSEL being fired up emitting 850 nm wavelength laser beam. This novel massively parallel assembly process is substrate independent and relatively simple. This technique will provide reliable assembly of optoelectronic components and miniature optical systems in a low cost mass production manner.



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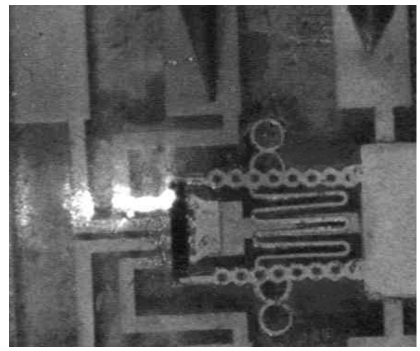

b

Figure 4 (a) 4X1 VCSEL array positioned in the arms of a MEMS clamper. (b) Fully assembled 4X1 VCSEL array with one of the VCSEL fired up and emitting 850nm laser beam through the top mounted micro-optics.