An 8 × 1 Micromachined Micro-Fresnel Lens Array For Free-Space Optical Interconnect

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We report the first fabrication of a vertical three-dimensional 8 × 1 micro-Fresnel lens array by surface micromachining technique and we also demonstrate the hybrid integration of the micro-Fresnel lens array with a passively aligned 8 × 1 vertical cavity surface emitting laser (VCSEL) array on the same silicon substrate. The fabrication and characterization of a single vertical three-dimensional micro-Fresnel lens has been demonstrated [1]. Micro-Fresnel lenses play a very important role in micro-optics because of their thin film structures and their ability to achieve various focal lengths. In addition, the micromachined vertical three-dimensional micro-Fresnel lenses are able to stand perpendicular to the substrate, which makes them attractive for integrating in a micro-chip with other active micro-optical elements such as semiconductor lasers and isolators. The VCSELs are particular suitable for integrating with the lens array using passive alignment because they have small numerical aperture. In addition, two dimensional arrays can be formed in both VCSELs and micromachined lenses. Therefore, the combination of vertical three-dimensional micro-Fresnel lens arrays with passively aligned VCSEL arrays are ideal for free-space optical interconnect and laser array packaging.

The schematic diagram of the hybrid integration and SEM picture of a vertical three-dimensional micro-Fresnel lens array and a VCSEL array are shown in Fig. 1(a) and 1(b), respectively. The VCSELs consist of AlGaAs/GaAs ¼ DBR mirror pairs and InGaAs quantum wells active layer, designed for 0.98μm wavelength. The dimensions of the VCSEL array are 2mm wide, 350μm high and 125μm thick. The optical axis is designed to match that of the lens array, and the spacing between individual VCSEL is 250μm. The L-I curve and three-dimensional beam profile of a VCSEL are shown in Fig. 2(a). The micro-Fresnel lens arrays are fabricated using a similar process as the single micro-Fresnel lens[1]. The lens array plate is supported by micro-hinges and spring latches[1][2]. During the fabrication of lens arrays, the electric contacts and alignment mounting blocks for the VCSEL array are monolithically defined on the Si substrate. Therefore, by proper design of the VCSEL dimensions, VCSEL can be mounted precisely in the designed position. The VCSELs have small numerical aperture (N.A.) and are particularly suitable for passive alignment.

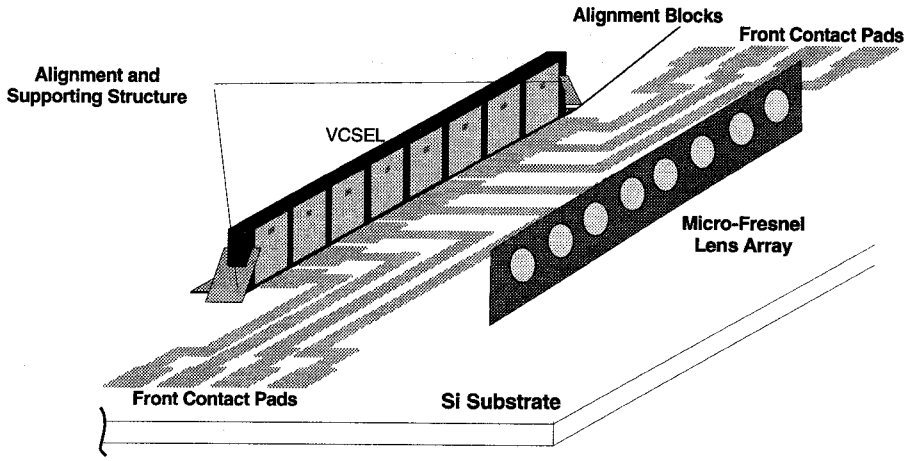
In conclusion, a micromachined 8 × 1 vertical three-dimensional micro-Fresnel lens array and its hybrid integration with a self-aligned vertical cavity surface emitting laser (VCSEL) array have been demonstrated for the first time. With there unique three-dimensional and array structures, they are suitable for integration with other similarly fabricated micro-optical components such as rotatable mirrors, gratings and beam-splitters as well as other active micro-optical elements. This new unique has great potential in free-space optical interconnect.

Reference

[1] L. Y. Lin, S. S. Lee, K. S. J. Pister, and M. C. Wu, " Three-dimensional micro-Fresnel lenses fabricated by micromachining technique" , Electronics Letter. 1994, **30**, (5), pp.448-449

[2] K. S. J. Pister, M. W. Judy, S. R. Burgett, and R. S. Fearing, "Microfabricated hinges", Sensors and Actuators A-Physical. 1992, **33**, (3), pp. 249

(a)



(b)

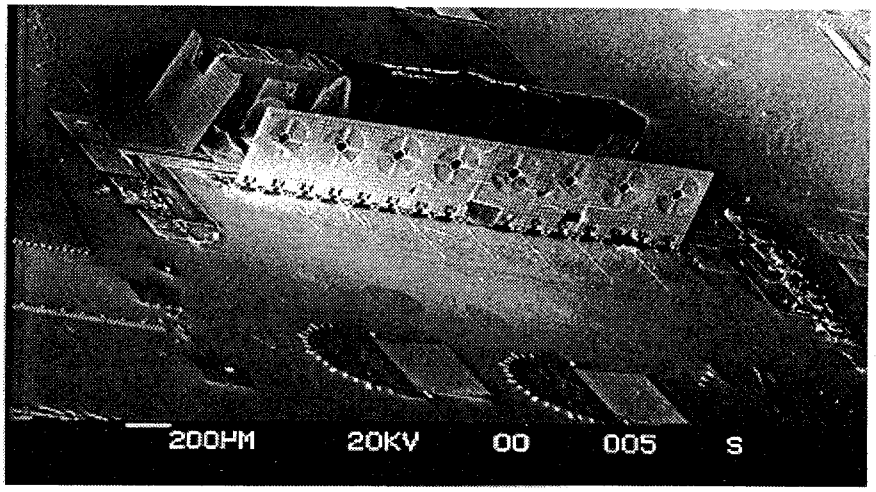
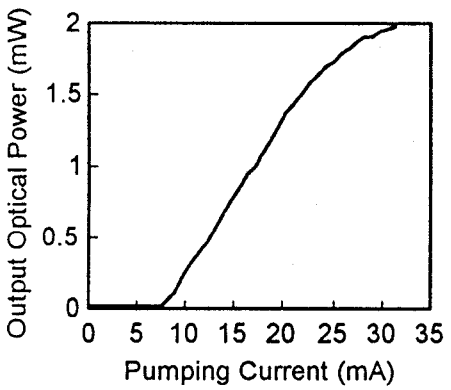
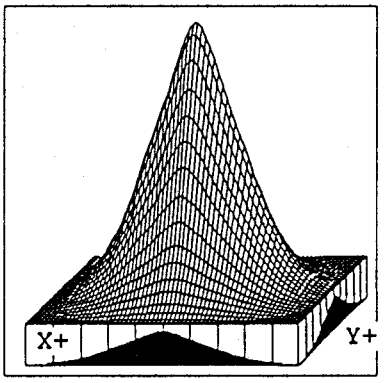


Figure 1. (a) The schematic diagram and (b) SEM picture of the hybrid integration of the 8 × 1 vertical three-dimensional micro-Fresnel lens array and the vertical cavity surface emitting laser(VCSEL) array.



(a)



(b)

Figure 2. (a)The L-I curve of a vertical cavity surface emitting laser (VCSEL), (b) 3-D beam profile of the VCSEL after it pass through the lens array.