Translume

MICRO-MIRROR STEERING OF DIODE ARRAY BEAMS

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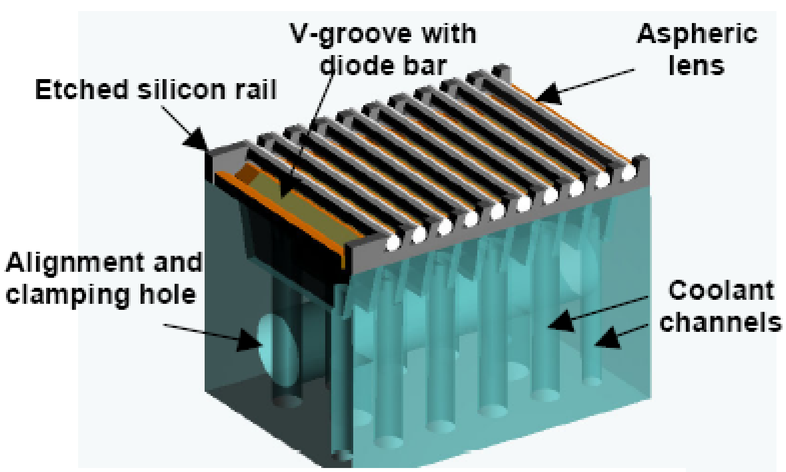

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Introduction

Femtosecond laser processing is well known for precise ablation of materials with insignificant heat effects [1]. With commercially available power of a few watts, femtosecond lasers are suited for micromachining applications. However, as innovations and hybrid processes are developed, the field of femtosecond laser applications advances and broadens [2].

Below the ablation threshold, femtosecond laser beams can be used to create nanostructural changes in transparent materials such as glass affecting the refractive index. The change in refractive index is localized and can be controlled 3-dimensionally, whereby simple straight waveguides to much more complex array of interferometric devices are fabricated. Automating the process and providing precise controls results in a higher order of flexibility to users for complex and multi-layered designs for optical devices compared to conventional lithographic techniques. Hence rapid prototyping of micro-optical and microfluidic components can be carried out [3].

Recent developments in a hybrid process utilizing femtosecond preprocessing prior to chemical etching have significantly broadened the micromachining capability. Much higher material removal rates and more complex devices can be fabricated. This work presents an example application of this new hybrid laser-aided etching technique to fabricating micro-optics at low cost for small volumes.

FemtoEtch

FemtoEtch is a Translume process that uses the femtosecond laser nonlinear capabilities to sensitize glass for etching instead of ablating the glass [4]. It is an advancement over UV photosensitization that require UV sensitive glass (www.mikroglas.com). This "micromachining" method relies on the nonlinear laser modification of the properties of the glass such that the etching rate is enhanced by several orders of magnitude compared to the untreated material. This hybrid micromachining method for transparent materials has no heat effects as the material is etched away rather than ablated (see Fig. 1). The enhanced etching enables fabrication of both micro and macro features hence enhancing the femtosecond laser processing of transparent materials. With significant capabilities over conventional laser ablation, complex 3-dimensional microfeatures can be fabricated. With transparent materials, the femtosecond beam can create changes inside the material. Hence both surface and internal features can be etched.

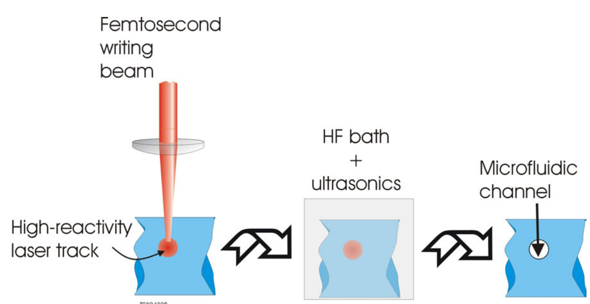

Figure 1. FemtoEtch technique.

SiMMtec Diode Array

The SiMMtec diode array is a high performance package using technology licensed from Lawrence Livermore National Laboratory. The array assembly (Fig. 2) uses several standard electronic component manufacturing techniques. It includes the etching of a silicon wafer using photolithography to form precision v-grooves for diode bar placement on top and integrated microchannels on the bottom. This silicon submount is anodically bonded to a glass block that functions as the coolant manifold. The bars are bonded to the metallized v-grooves using a thin layer of indium in a partial vacuum of hydrogen. No flux is used. The precision electronics manufacturing-based assembly technique is very reproducible and amenable to mass production.

The lens frame is also etched from a silicon wafer with notches for precision alignment of the shaped aspheric lenses. Collimation of the output to 0.5° is achieved by active alignment of the lens in the frame. Passive alignment reduces the collimation to approximately 1.5°.

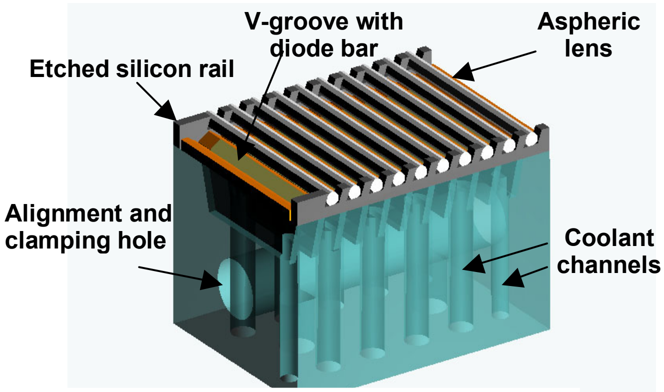

Figure 2. Schematic of SiMMtec diode array.

With the diode bars on the side of the v-grooves, the output of the array is at 35° to the horizontal unlike most other diode arrays with the output normal to the surface of the array. For more flexible applications and retrofit of existing applications, turning of the output of the SiMMtec array to normal is desired. This can be achieved by using special microlenses that have a total internal reflection surface. However, custom drawing of special lenses tend to be expensive for low volumes. Furthermore, in most diode pumping applications, collimation of the diode output is undesirable.

An alternate low cost means of turning the diode array output without collimation is then needed. The FemtoEtch technique offers the most promising solution.

Beam Steering

Translume's FemtoEtch process involves the design of the physical shape of the optical device and the translation of the physical design to a 3-dimensional femtosecond laser controlled processing of the glass. The micromirror array is etched from a thin glass plate. For the steering of the diode array beam, 10 micromirrors (optical array) are needed for the 10-bar array. Basically, the micromirror array replaces the lens array. The design of the micromirror array is shown in Fig. 3.

The micromirror array sits on top of the silicon submount with the v-grooves and the diode bars. Light from each diode bar reflects off the flat micromirror and is turned from 35° to normal as shown in Fig. 4.

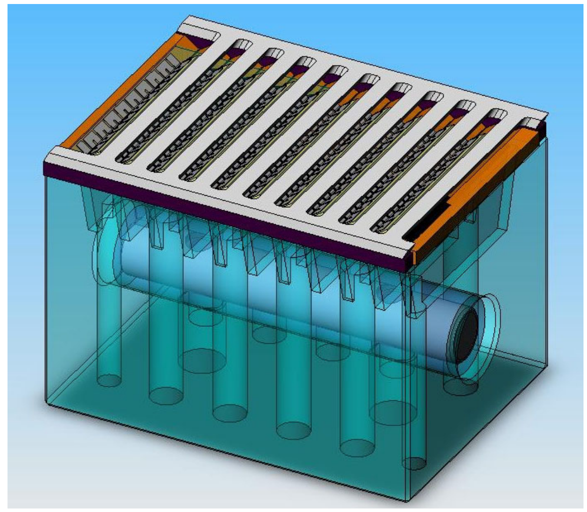

Figure 3. Schematic of micromirrors on SiMMtec diode array.

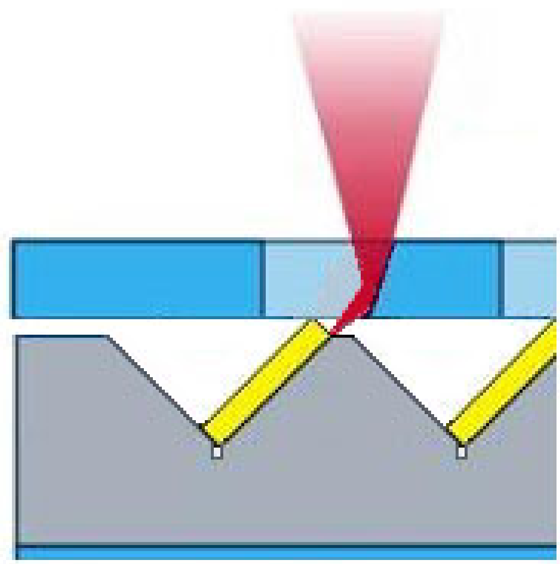

Figure 4. Schematic of diode beam steering by micromirror.

The first mirror is on the left side of the array and is tilted as shown in Fig. 4.. The 2nd mirror is on the right side of the 1st slot from the left. There are 9 slots and hence a total of ten mirrors, one for each diode bar.

Fig. 5 shows a picture of the gold coated micromirror array. The size of the array is approximately 1cm by 2 cm.

Figure 5. Micromirror array.

Performance of Array

The performance of the micromirrors is tested experimentally. The steering is controlled by the angle of the mirror with respect to the direction of emission of the diode bar. The design angle as indicated in Fig. 4 can be easily verified by examination under high magnification with an optical microscope.

The measures of the effectiveness of the mirrors are in the transmission efficiency and the beam profile normal to the diode array. The transmission is measured by comparing the power obtained at different drive currents for a diode array with and without the micromirrors.

Data obtained will be presented and discussed.

Discussion

The above work focuses on the steering of the diode array beam using micro-optics. The flexibility of the FemtoEtch technique allows the fabrication of optics with curved surfaces. With careful design and femtosecond laser processing of the glass sample, micro-optics that can condition the beam profile in addition to steering is possible. With this capability low cost custom optics that can perform many of the functions of traditional microlenses are possible. Diode arrays with more optimal or custom beam profiles can be designed at lower cost.

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