

Final Reports

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"Laser Microfabrication in Glasses: Mechanisms and Applications"
Defense University Research Instrumentation Progress (DURIP)

and

~~(F49620-97-1-0152)~~

**"Laser driven microfabrication in glasses: Applications to rapid prototype
and micro-optical and submicron features"**

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13. ABSTRACT (Maximum 200 words)

Using DURIP funding the laser fabrication system was developed and constructed. A similar more compact system was also constructed using a diode-pumped frequency doubled Nd:Yag laser as the source.

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These grants were focused on the development of a compact and highly automated workstation capable of directly writing submicron features in semiconductor doped glasses. This equipment grant was in parallel to a research grant entitled "Laser driven microfabrication in glasses: applications to rapid prototyping and micro-optical and sub-micron structures (F-49620-97-1-0152).

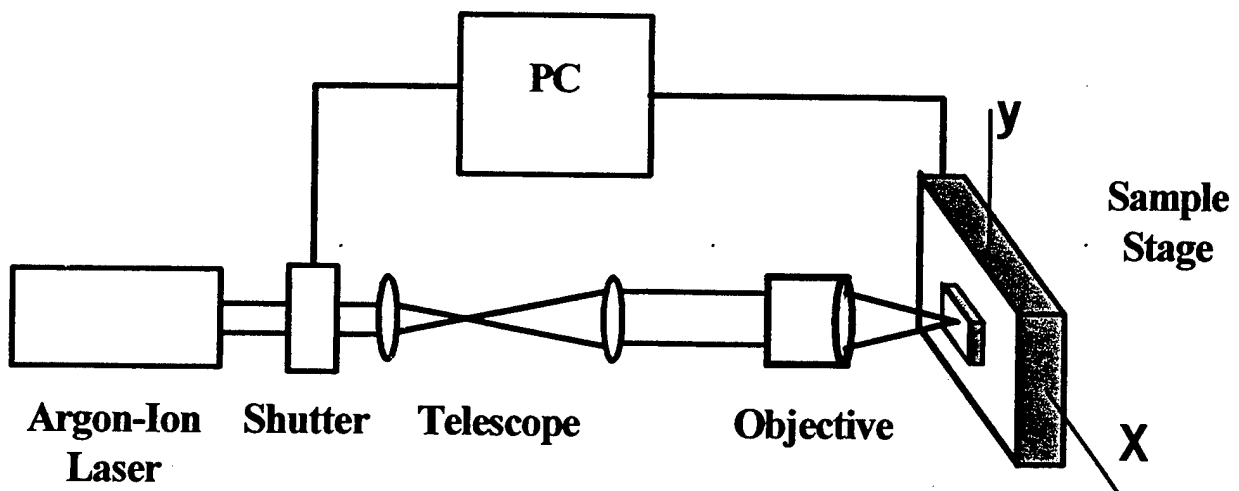
The equipment grant was used to support the work of two graduate students, Joel Firehammer, and Andrei Smuk. Mr. Firehammer has graduated with a PhD in electrical engineering as is currently employed at Comtec Information Systems. His work focused on the possible uses of the technology for micro-fabricating display optics. Mr. Smuk is scheduled to graduate in April of 2000 with a PhD in physics. His work has focused on the physics of creating arrays and compound structures, taking into account the interaction of topographic features and overall array symmetries.

Using DURIP funding the laser fabrication system shown in Figure 1. was developed and constructed. A similar more compact system was also constructed using a diode-pumped frequency doubled Nd:Yag laser as the source.

Figure 1.

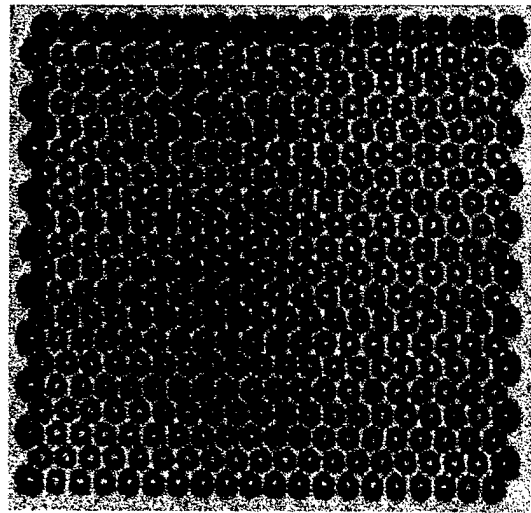
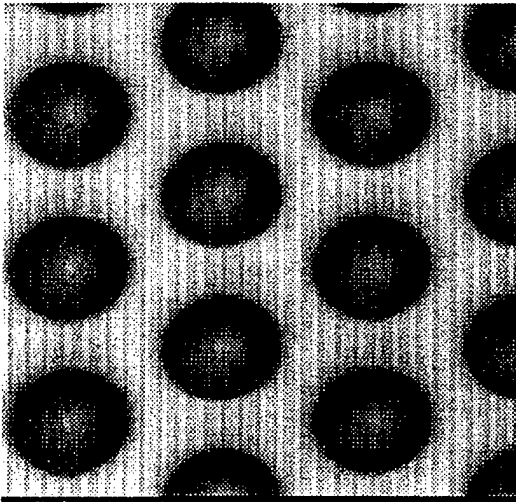
Serial Array Fabrication

Precise X-Y translation stage and computer controlled shutter allow rapid fabrication of arrays of lenses.



Using this basic setup, along with data from the basic grant, different array structures were fabricated. Figure 2 shows atomic force microscope images of hexagonal arrays of microlenses fabricated using the system.

Figure 2.



300 msec/lens
Transmission 495nm - 1.8 μm
Period 50 μm (mag.50x)

Experiments were performed to understand the dynamics of interaction between features during the writing process. This was done for various symmetry lattices including cubic and hexagonal. Particular emphasis was placed on cubic systems as they match the symmetry of current state-of-the-art detectors arrays.

Figures 3a and 3b show how lenses interacted in array formation as the proximity between lenses was reduced.

Figure 3a.

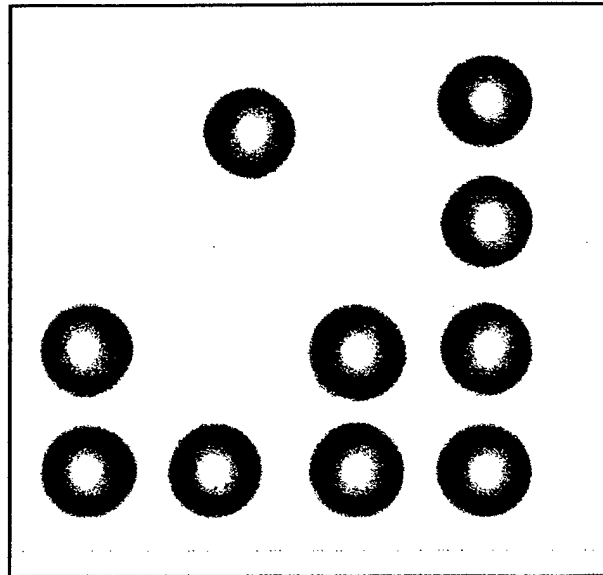
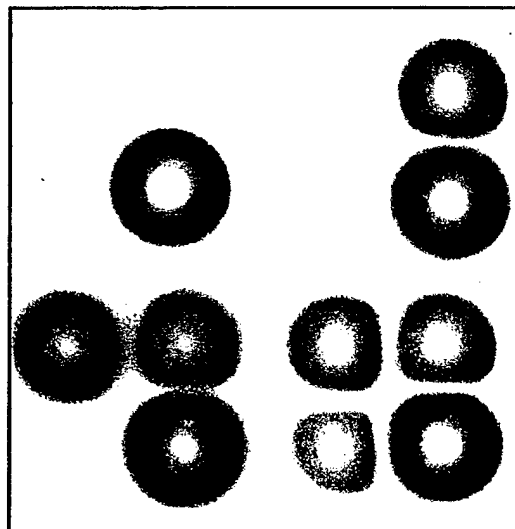


Figure 3b.



The results of the work showed that dense arrays can be constructed using this process if the parameters of time and distance between lenses were properly accounted for.

The basic work produced from this research has resulted in a number of publications and conference proceedings that have received significant attention in the literature. Based on our work, Dr. Mike Fritze of MIT

Lincoln Lab has begun a project in this area and continues to develop the technology for microfabrication of optical elements.

List of publications:

"Direct Laser Writing of Diffractive Optics in Glass" Smuk, A.Y., Lawandy, N. M., Optics Letters 22(13), 1030 (1997)

"Direct Laser Writing of Diffractive Optics in Glass" Smuk, A., Lawandy, N. M., CLEO'97, Paper No. C-01172, Baltimore, MD, May 1997

"Direct Laser Fabrication of Microlens Arrays", Smuk, A. Y., Lawandy, N.M., CLEO'97, Paper No. C-01171, Baltimore, MD, May 1997

"Selective Etching in Laser Written Semiconductor-Doped Glasses", Smuk, A.Y., Lawandy, N.M., Optics Communications, 156/4-6, 297-299 (Nov. 1998)

"Selective Etching in Laser Written Semiconductor-Doped Glasses" Smuk, A.Y., Lawandy, N.M., CLEO/QEC'98, Anaheim, CA, May 1998

"Direct Laser Fabrication of Dense Microlens Arrays in Semiconductor-Doped Glasses", Smuk, A.Y., Lawandy, N.M., Submitted to Journal of Applied Physics, Oct. 1999, set for publication April-May 2000.