Manufacturing Innovation

...precision instruments and automation systems.

In collaboration with Boston University, the **Fraunhofer Center for Manufacturing Innovation (CMI)** provides engineering solutions to a broad range of industries, including biotech/biomedical, photonics, semiconductor, and renewable energy. Engineers, faculty, and students at the center scale-up basic research into advanced technologies that meet the needs of client companies both in the U.S. and abroad. The primary focus is on the development of next-generation high precision automation systems, instruments and medical devices.

During 2007, CMI worked on a number of systems, including an automated high-precision casting system for the fabrication of cymbals, a metrology and calibration system for the production of fiberoptic gyroscopes, a metrology system for fuel cell fabrication, and an automated, modular system for the production of plant-based pharmaceuticals.

Also in 2007, the Boston University – Fraunhofer Alliance for Medical Devices, Instrumentation, and Diagnostics was established to accelerate the process of taking medical innovations from the Laboratory to the patient point-of-care. The Alliance will leverage the most promising research innovations in laboratories throughout Boston University and develop them into working medical devices and instruments that can be licensed to existing companies, or deployed through the creation of new spin-off ventures. Accelerating the development cycle will have a significant impact on the way clinical medicine is practiced.

The first two projects undertaken by the Alliance comprised a "Bleed-to-Read instrument for detection of bacterial or viral infections, and an optical biopsy tool for detecting colon cancer.

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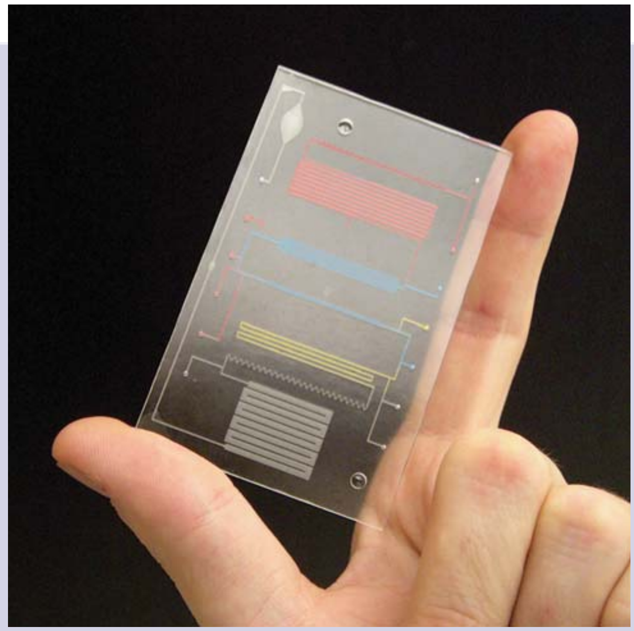


Lab on a Chip technology

Fuel Cells

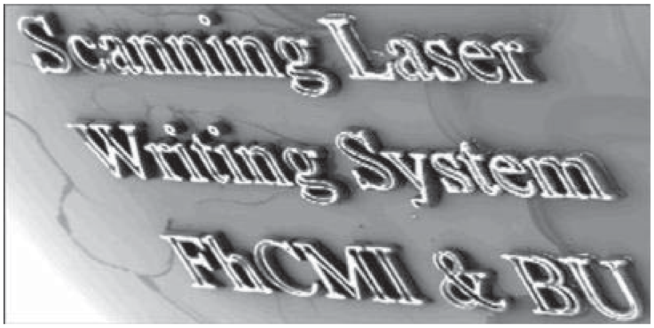
Fuel Cells have been promising to provide efficient and clean energy for some time. However, due to high manufacturing costs, they have not penetrated the market as quickly as one would have desired. Fabricating the core stack requires accurate assembly of a number of bipolar plates, gaskets, and other components. In order to align and assemble these plates, they must be first measured and characterized such that they will interface properly with the other components in the stack. The challenge is that these plates are large, thin and flexible, thus difficult to measure. CMI is developing a metrology system for Fuel Cell Energy Corporation that will accurately measure and characterize bipolar plates prior to alignment and assembly.

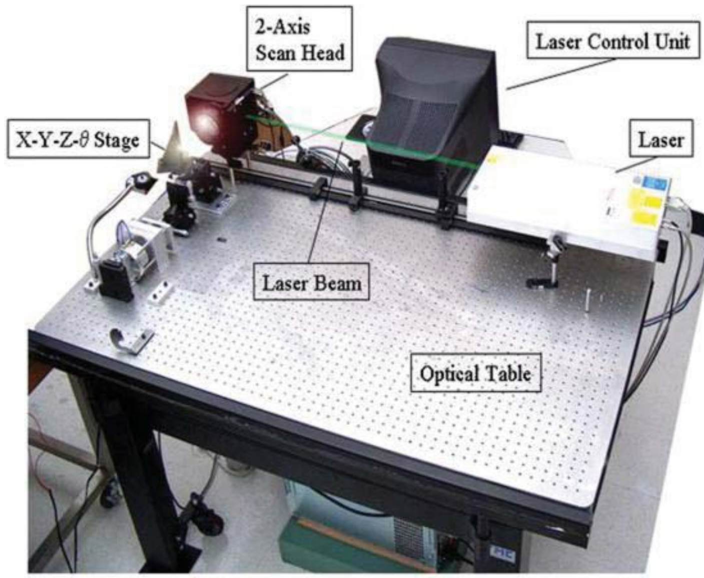
Fiber-optic gyroscopes

In the automated winding of fiber-optic gyroscope sensing coils, the process typically begins with a time-consuming setup and calibration procedure at the beginning of each coil, in order to register the empty bobbins to the machine and assure that they are within specification. CMI successfully designed and integrated an automated metrology and calibration module into a coil-winder, previously developed for a U.S. defense contractor, to facilitate faster cycle times by significantly reducing the setup time. More specifically, the setup time was shortened from 15-20 minutes per calibration to less than 3 minutes. The metrology and calibration module quickly and accurately measures all the necessary surfaces, registers the bobbins, and determines if they are within specification.

Direct 3-D Laser Writing

The Fraunhofer Center for Manufacturing Innovation and Prof. Xin Zhang at Boston University jointly developed an innovative 3D manufacturing approach to the rapid processing of freeform multi-layer microstructures using a scanning laser system. This technique combines the best features of photolithography techniques in multi-layer processing with the versatility of existing 3D prototyping technologies. It utilizes a bitmap image as an input which is then converted to a dot matrix that then ablates an SU-8 Photoresist mold with Nd:YAG laser pulsing for both in-plane and in-depth processing. With this technique, a large number of 3D microstructures with mechanical, optical, and/or biological functionalities can be achieved.

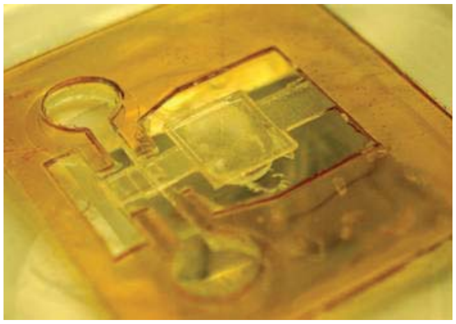




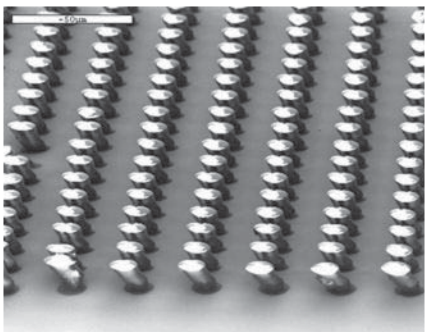
The experimental apparatus is comprised of a pulsed Nd:YAG laser (emitting at 355nm) directed through a 2-axis Scan Head. Since the pulsed UV laser is not easily visible, an auxiliary red alignment laser was used for multilevel alignment. Since light rays can be converged to a focal point, the distribution of laser intensity as a function of focal depth can be selectively exposed by varying laser doses from Gaussian-like spot.

Applications for this technology include the following:

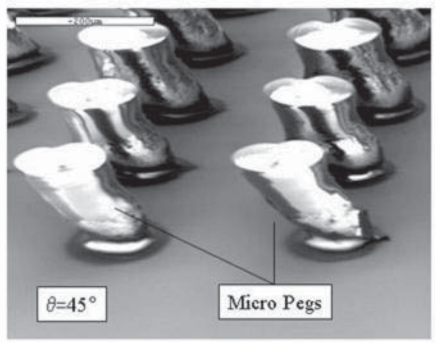
- High-aspect-ratio micro-needles can be fabricated using Gaussian-intensity laser pulsing.
- Concave and convex lenses can be fabricated using sectional laser writing instead of multi-mask photolithography processing.
- Functional micro-valves using double-clamped cantilever arrays with embedded channels can be fabricated using laser writing at different focus levels. By applying compressed air to the membranes, the valves can be opened and closed. As a result, the flow through the embedded channels can be modulated
- Other multi-layer architectures including complex micro-fluidic chips that can be used in may applications, from ink jet printing to discovery.



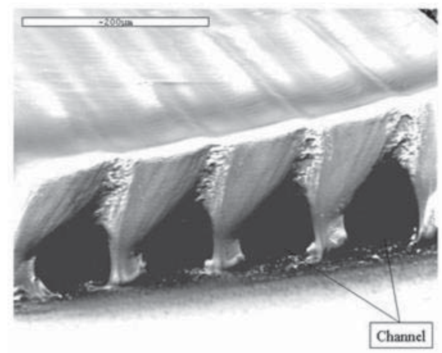
Micro-fluidic Device



Pillar Array



Micro-Peg



Embedded Channel

"Bleed-to-Read" instrument and integrated consumable for bacterial and viral diagnostics

The major challenge of point-of-care clinical diagnostics of bacteria and viruses is to provide accurate detection with automated sample preparation. The field of clinical diagnostics is moving toward molecular diagnostics (e.g. Polymerase Chain Reaction (PCR)) which are the most sensitive and specific methodologies currently available. However, PCR suffers from labor intensive sample preparation to isolate the nucleic acids and requires the physical separation of the sample preparation space in the laboratory in order to minimize contamination. Existing point-of-care clinical diagnostics (e.g. rapid strep test, home pregnancy kits, etc.) use antibody-based immuno-detection which enables simple test protocols, but lack the sensitivity and specificity of molecular diagnostic techniques. To address this challenge, CMI, in collaboration with Prof. Catherine Klapperich of Boston University, is developing an integrated lab-on-a-chip consumable and prototype instrument that automates the sample preparation for bacteria and viruses from clinical samples, amplifies the nucleic acid and optically detects the presence or absence of the target. The plastic microfluidic chip (page 21) is approximately the size of a credit card. The chip is designed to be low cost by keeping all active components in the instrumentation (valves, heating units, optics, etc.) and having a planar layout that enables low cost fabrication methods. CMI's prototype instrument automates the fluidic handling, thermal control and optical detection such that bacteria and viruses can be detected in a point-of-care setting while maintaining the highest level of sensitivity and specificity typical of a hospital's clinical laboratory.