

Laser Based Micro and Nanoscale Manufacturing and Materials Processing

Faculty:

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Research Areas:

- Development of laser based micro and nano manufacturing technologies
- Micro and Nanoscale heat/energy transfer in laser manufacturing processes, particularly, high power, ultrafast laser (pulse width ~ 100 fs) materials interactions
- Laser manufacturing of MEMS/NEMS, microsensors and microelectronics

Sponsors :

NSF, ONR, State of Indiana, DoD, IBM, Intel, Knolls Atomics, Sandia National Lab, ...

Affiliated with

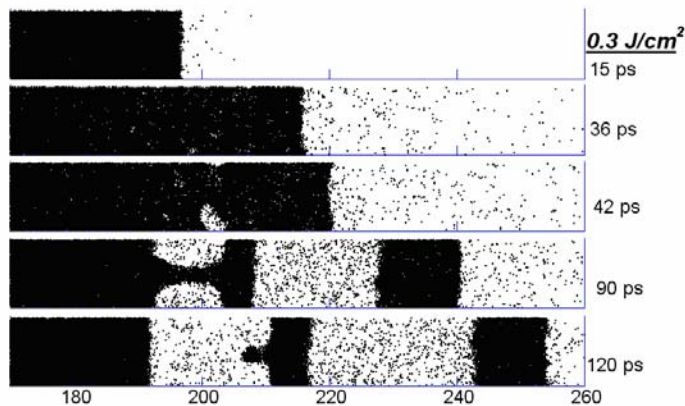
**Center for Laser Micro-fabrication, Center for Advanced Manufacturing,
and Birck Nanotechnology Center**



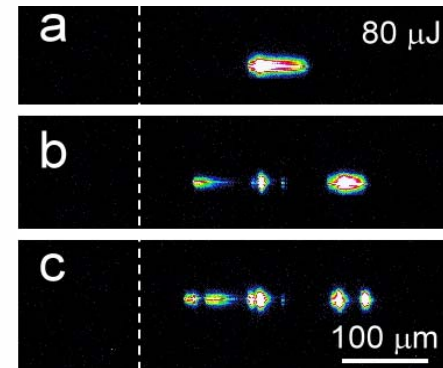
Purdue University - School of Mechanical Engineering

Fundamentals of Femtosecond Laser Interaction with Materials

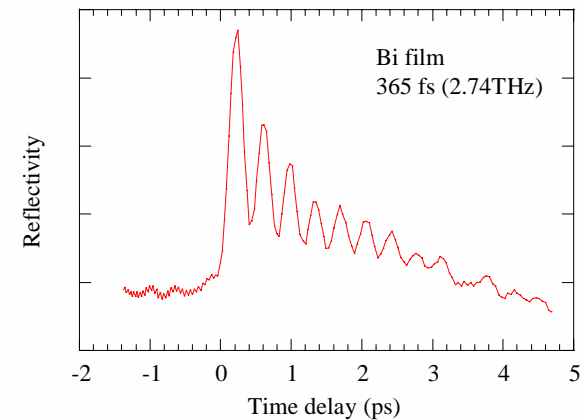
Experimental and numerical studies are being conducted to investigate energy coupling and transfer during femtosecond laser matter interaction.



Molecular dynamics simulation of femtosecond laser ablation (laser irradiates from right)



Imaging of laser induced plasma in glass



Phonon oscillation observed during laser-matter interaction

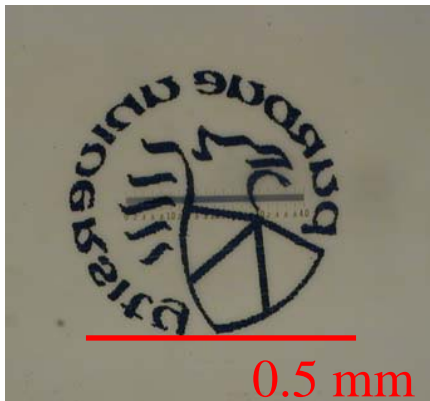


Femtosecond Laser Micro Machining

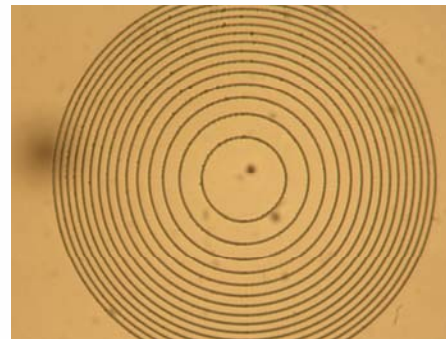
A femtosecond laser system is being used to fabricate various micro structures and components. Because of the very short laser pulse duration, heat dissipation is confined, resulting in cleaner machining results. The various non-linear and non-equilibrium processes during laser matter interaction are also utilized to machine microstructures in transparent materials (figure on right).



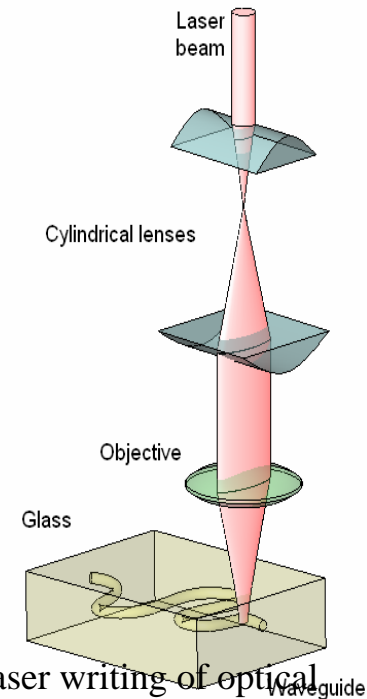
Laser fabricated 4-bar linkage



0.5mm Purdue logo fabricated inside glass



Microoptics: Fresnel zone plate

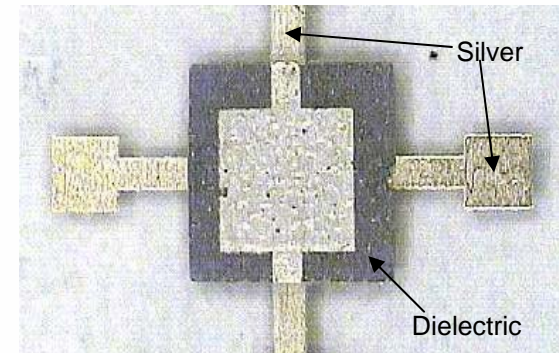


Laser writing of optical waveguides and 3D optical components.

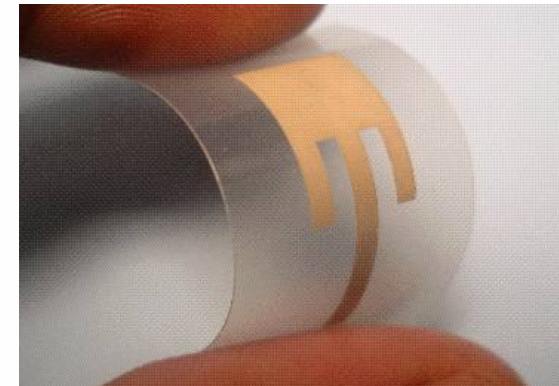


Laser Direct-Write of Microsystems

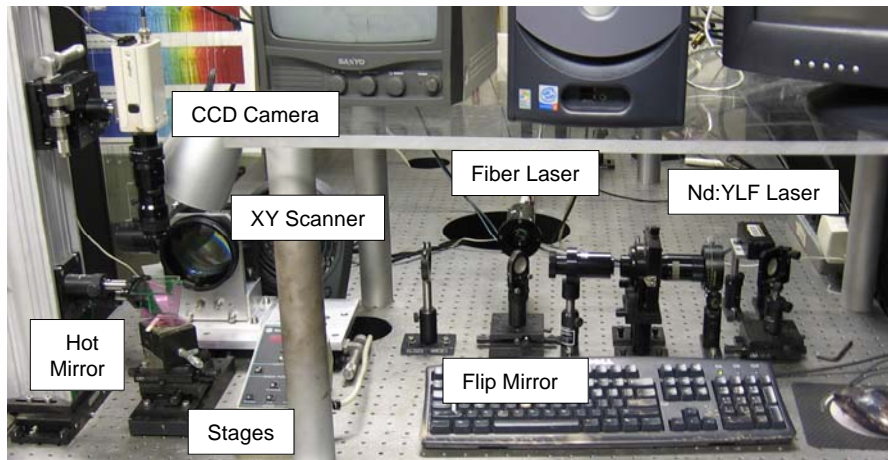
- **LDW** – Laser Direct Write and **LS** – Laser Sintering systems allow the fabrication of microelectronics with integrated chemical/biological components from a CAD file.
- **Thermal modeling** improves performance of direct-write system.
- Capable of fabricating microelectronic and energy conversion devices, and on **low-temperature, flexible substrates** that cannot otherwise be fabricated.



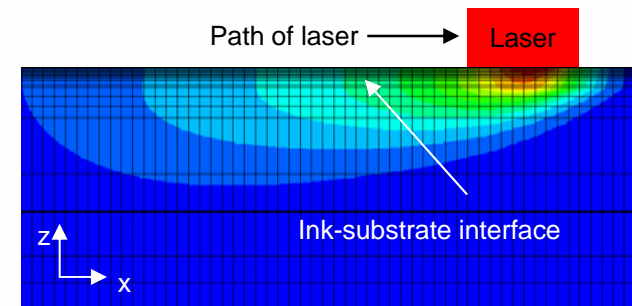
Parallel-plate capacitor on glass substrate



Patch antenna on flexible Mylar substrate



Laser Direct-Write Apparatus

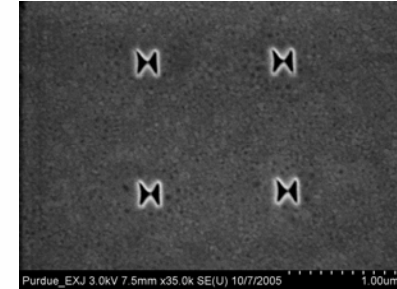


Thermal model of laser writing process

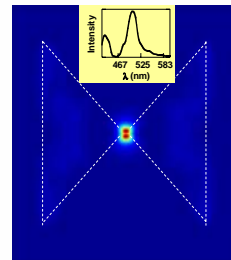
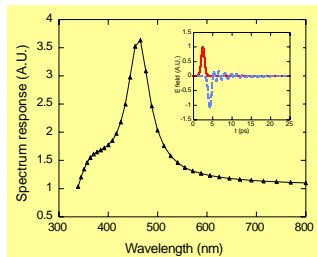
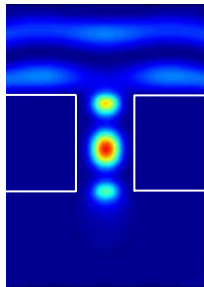


Nanoscale Optical Antenna and Its Application in Nano manufacturing

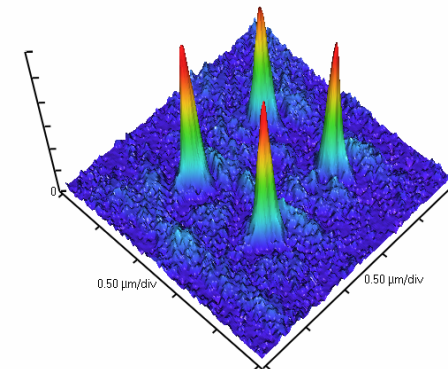
- **Objective:** to realize nanoscale confinement of light, for applications such as ultrahigh density data storage, nanoimaging, and nanomanufacturing.
- **Theory:** Nanoscale optical near-field confinement combining confined waveguide propagation and resonant optical transmission and excitation of localized surface plasmon.
- **Design:** finite-difference time-domain (FDTD) numerical computations for optimization.
- **Characterization:** home-developed near-field scanning optical microscopy (NSOM).



Bowtie nano antenna array fabricated by focused ion beam milling



FDTD calculation for design and optimization



Optical near field measurement

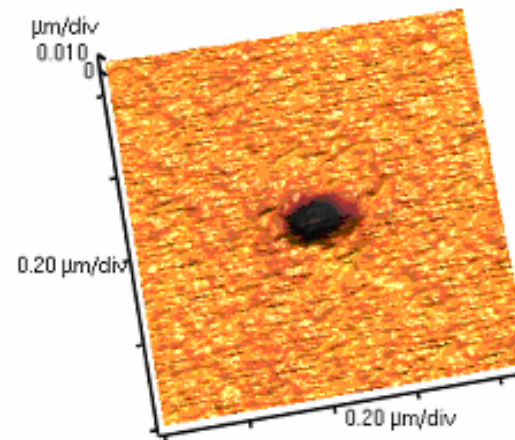


Optical Nanomanufacturing and Nanolithography

- develop nanomanufacturing technologies and understand the underlying manufacturing, control, nano-optics, and energy transfer issues



Nanomanufacturing facility, including high precision motion stages and optics housed in a clean environment



Nanometer sized holes produced by high efficiency nanoscale optical antenna developed in this laboratory

