Marcos Dantus

Novel Applications of Ultrafast Laser Spectroscopy

Professor of Chemistry

and

Adjunct Professor in Physics

(b. 1962)

B.A. & M.A., 1985, Brandeis University;

Ph.D., 1991, California Institute of Technology;

Postdoctoral Research Fellow, 1991-1993, California Institute of Technology.

517-355-9715,
Ext. 314

Selected Publications

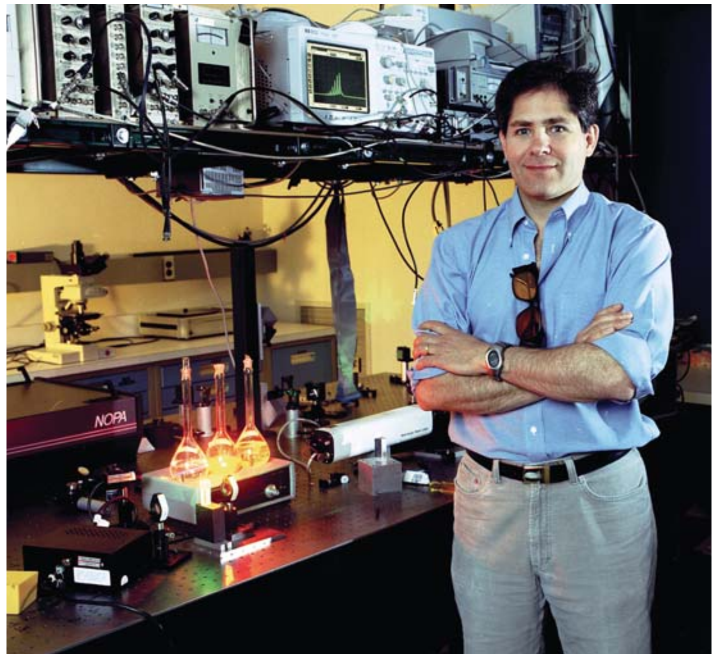
MIIPS Characterizes and Corrects Femtosecond Pulses, M. Dantus, V.V. Lozovoy, and I. Pastirk, *Laser Focus World* **2007,** *43*, 101-104.

Polarization and Phase Control of Remote Surface-plasmon-mediated Two-photon Induced Emission and Waveguiding, J. M. Gunn, M. Ewald, M. Dantus. *Nano Letters* **2006**, *6*, 2804-2809.

Advantages of Ultrashort Phase-shaped Pulses for Selective Two-photon Activation and Biomedical Imaging, L. Schelhas, J. C. Shane, M. Dantus, *Nanomedicine: Nanotechnology, Biology, and Medicine* **2006**, 2, 177-181.

Use of Coherent Control Methods Through Scattering Biological Tissue to Achieve Functional Imaging, J. M. Dela Cruz, I. Pastirk, M. Comstock, V.V. Lozovoy & M. Dantus, *Proceedings of the National Academy of Sciences USA* **2004**, *101*, 16996-17001.

Laser Control of Physicochemical Processes; Experiments and Applications, *Annu. Rep. Prog. Chem*, V. Lozovoy and M. Dantus, *Annu. Rep. Prog.* **2006**, *102*, 227-258



The scientific goal of our group is to understand and control laser-molecule interactions. We use this fundamental understanding to control molecular reactivity, and develop a number of novel applications for lasers that include biomedical imaging, molecular detection and identification and plasmonics. Five state-of-the-art femtosecond laser systems with MIIPS pulse shaping technology are used for our research.

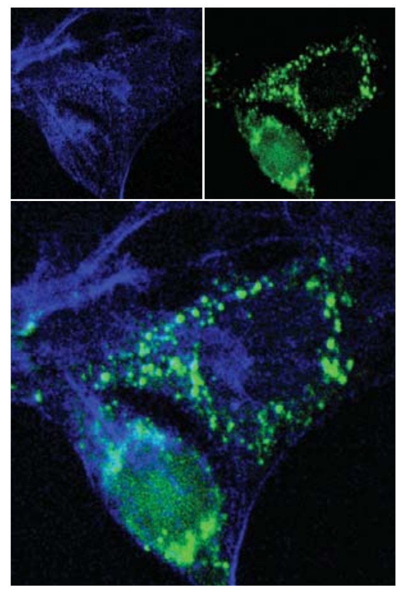
Some of our fun and challenging projects include:

- Development of multidimensional spectroscopic methods for remote identification of chemicals;
- Exploring novel biomedical applications of nonlinear photonic control for selective two-photon microscopy and imaging through tissue;
- Developing methods for selective cleavage of chemical bonds using shaped laser pulses;
- Developing a system for single molecule microscopy and spectroscopy;
- Exploring and controlling the nonlinear optical properties of nanomaterials.

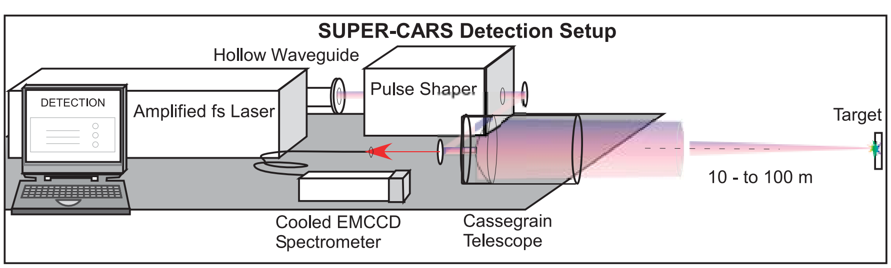
Ultrafast Lasers and Imaging. The laser pulses in our laboratory are short enough to "freeze" the motion of atoms and allow us to see chemical reactions as they take place. Using a pulse shaper, we are able to tailor the phase of the individual wavelength components. These shaped pulses can be used to control the quantum-mechanical aspects of laser-molecule interactions. For example, we can control which molecules absorb energy and which do not, an aspect we have used to achieve selective two-photon microscopy.

One of our labs is dedicated to the interaction of highly energetic lasers and molecules; the other is dedicated to imaging samples from single molecules, to single cells, to tissue. The application of "smart laser pulses" to nonlinear optical methods opens some very interesting possibilities. Among the possibilities are seeing through scattering materials such as skin, paper, and clouds.

We are also exploring the biomedical and homeland security applications of some of these laser developments. Our projects range from fundamental research to applied technology, leading to commercialization.



These images illustrate the use of ultrashort (~10 fs) shaped pulses in two-photon microscopy. Selective excitation of subcellular structures such as actin (blue) and mitochondria (green) in HeLa (human cervical cancer) cells is illustrated in the top two images, obtained without fluorescence filters. The bottom figure is a combination of the top two images.



One of the more challenging real world problems is the remote identification of hazardous molecules. Here, we couple the multidimensionality of femtosecond pulse shaping with CARS (Coherent Anti-Stokes Raman Scattering) spectroscopy to develop a fast and reliable laser-based method for remote detection of explosive materials.