Objective: Creation of a comprehensive understanding of the interaction science of ultrafast fs laser pulses including self-channelled pulses with energetic materials, surrogates, substrates and background materials to support the development of LIBS and other potential SO sensing technologies.

Scientific Challenges: Reliable modelling of the complex chemical and molecular kinetics.
Interpretation of spectra. Detailed understanding of fs interaction in all modalities under consideration.
Detection and determination of chemical interactions occurring within the plasma.

Major Accomplishments
• Progress in understanding early-stage fs pulse interaction. Studies of double fs pulse irradiation.
• Thin film experiments by all program participants.
• Advances in understanding chemical kinetics.
• Development of advanced chemometric analysis of complex spectra, for PCA and ROC curves.
• Detailed spectra from full range of explosives and other materials with ns and fs pulses.

Army Relevance: Program will provide DoD with the strongest fundamental science assessment for development of next generation sensing technologies for explosives and other agents, in point- and stand-off detection modes.

Funding profile:
FY06 $443K, FY07 $826K, FY08 $837K, FY09 $805K
Grant # W911NF-06-1-0446

PI Contact information: mcr@creol.ucf.edu
Objective: To develop theoretical understanding of ultrafast laser material interactions expressed in physical models that are rigorously grounded by experimental characterization and detailed observations.

Scientific Challenges.
• Nonequilibrium model that describe femtosecond laser interaction with solid materials.
• Connection between nonequilibrium interaction model with plasma development model.
• Experimental analysis of LIBS spectra of organic and inorganic samples.

Major Accomplishments:
• Developed the first model to describe ejection of ions from femtosecond laser irradiated Cu target at 2 ps.
• Continued LIBS experiments on representative organic samples, and investigated correlations between plasma imaging and time-resolved spectroscopy observations.
• Conducted initial experiments on LIBS spectra of thin films deposited on a controlled substrate.

Army Relevance: A full understanding of the interaction of ultrafast laser light with materials is critical to achieving LIBS for stand-off explosive sensing technology that can be deployed to the field.

Funding profile: FY08 $95K
Grant # (MURI sub): W911NF-06-1-0446

PI Contact information:
Department of Mechanical Engineering
University of California at Berkeley
Berkeley, CA 94720
Objective: Remote FLIBS requires that the delivery of laser beam energy be optimized to the target.

Challenges:
- How should collinear dual pulses be delivered to enhance FLIBS signal?
- What is the role of nanoparticles in the enhancement of FLIBS signals?
- Can you form a plasma mirror to enhance LIBS? Hitting ejected aerosols and the timing

Major Accomplishments:
- Given 250 µJ of energy, it is better to deliver in 125 µJ pulses.
- First femtosecond transient electromagnetic scattering code for aerosol interactions
- First dual pulse dual focus FLIBS

Personnel Supported:
- Faculty (1) 0.083 FTE, PhD (2), 2FTE, Undergraduate (1), UCARE

Army Relevance:
- Enhanced standoff detection capabilities of explosives, B&C
- Pulse propagation in aerosols

Funding Profile
- FY: 2006 = $50,000  FY: 2007 = $120,000
- FY: 2008 = $120,000

Contract #: 104226, UNL Subcontract

Dennis R. Alexander, dalexander1@unl.edu, 402-472-3091
Objective: Develop chemical kinetic model to describe the chemistry and electronic excitation processes in laser-induced plasmas and integrate with hydrodynamic models of the plasma.

Scientific Challenges:

- Understand processes leading observable atomic and molecular spectral signatures.
- Relate decomposition of irradiated materials to expected emission spectra.

Major Accomplishments

- Development of kinetic model for chemical and electronic excitation processes in laser-induced plasmas in air, including excitation of emitting N and O atomic levels.
- Validation of kinetic model by comparison with laser-induced breakdown spectra in air.
- Development of kinetic model to describe decomposition of small organic molecules in air.

Personnel: Postdoc (0.30 FTE), graduate student (0.10 FTE), faculty (0.08 FTE)

Army Relevance: Work will help determine the optimum conditions for recording LIBS spectra of residues (explosives etc.) on surfaces and will help quantify emission intensities from modeling of the plasma.

Funding profile: FY06 $28K, FY07 $67K, FY08 $67K, FY09 $39K

Grant # W911NF-06-1-0446 (MURI sub to JHU)

PI Contact information: pjdagdigian@jhu.edu
Objective: Experimentally study laser interaction with sample in the multi-pulse fs and ns regimes, to determine conditions to maximize remote explosive materials detection.

Scientific Challenges

• Study the optimum focal position to minimize ambient oxygen and nitrogen contribution which critical for the detection of most explosives.
• Investigate and demonstrate the remote detection of explosive residues using self-channelled LIBS.

Major Accomplishments 2008:

• Began study of atmospheric oxygen/nitrogen suppression for femtosecond (fs), nanosecond (ns), femtosecond self channelled (fs-sc), Dual ns, ns-fs, fs-ns, ns-fs-sc, fs-sc,ns modes of excitation.
• Investigate dual pulse LIBS enhancement mechanisms

Personnel: 1 Undergraduate, 1 Graduate Student, 1 Faculty Member.

Army Relevance: The Ultimate goal of this effort is to understand the relevant physics and chemistry of the use of femtosecond lasers for the remote detection of trace amounts of hazardous materials to build capable sensors for the war-fighter.

Funding profile: FY07 $122k FY08 $80k FY09 $80k
Grant # W911NF-06-1-0446 (MURI sub to FAMU)

Contact Information: Lewis Johnson, Depart. of Physics, FAMU, Tallahassee FL, 32307 (850) 599-3943, lewis.johnson@famu.edu
Objective: Experimental and theoretical studies of ultrafast laser interactions with energetic materials, background and substrate materials. Precision LIBS spectroscopy and advanced chemometric analysis and material specificity determination

Scientific Challenges:
- Reliable spectrometric measurements of thin-film traces of energetic materials on different substrates
- Detection and determination of chemical interactions occurring within the plasma.

Major Accomplishments
- Progress with multiple studies of fs interaction and LIBS analysis of thin films samples.
- Studies of emission and LIBS from self-channeling
- Development of detailed PCA chemometrics
- Plasma modeling with plasma and kinetics codes.

Year 2 accomplishment: Acquisition of One-shot filamented-LIBS of Polyisobutylene on Silicon: molecular but no atomic signal

Army Relevance: Work will help determine the optimum conditions for recording LIBS spectra of residues (explosives etc.) on surfaces and will help quantify emission intensities from modeling of the plasma.

Funding profile (including subcontracts):
FY06 $291K, FY07 $442K, FY08 $473K, FY09 $592K
Grant # W911NF-06-1-0446

Personnel: Postdoc (1.5 FTE), graduate student (3.0 FTE), faculty (0.08 FTE)

PI Contact information: mcr@creol.ucf.edu