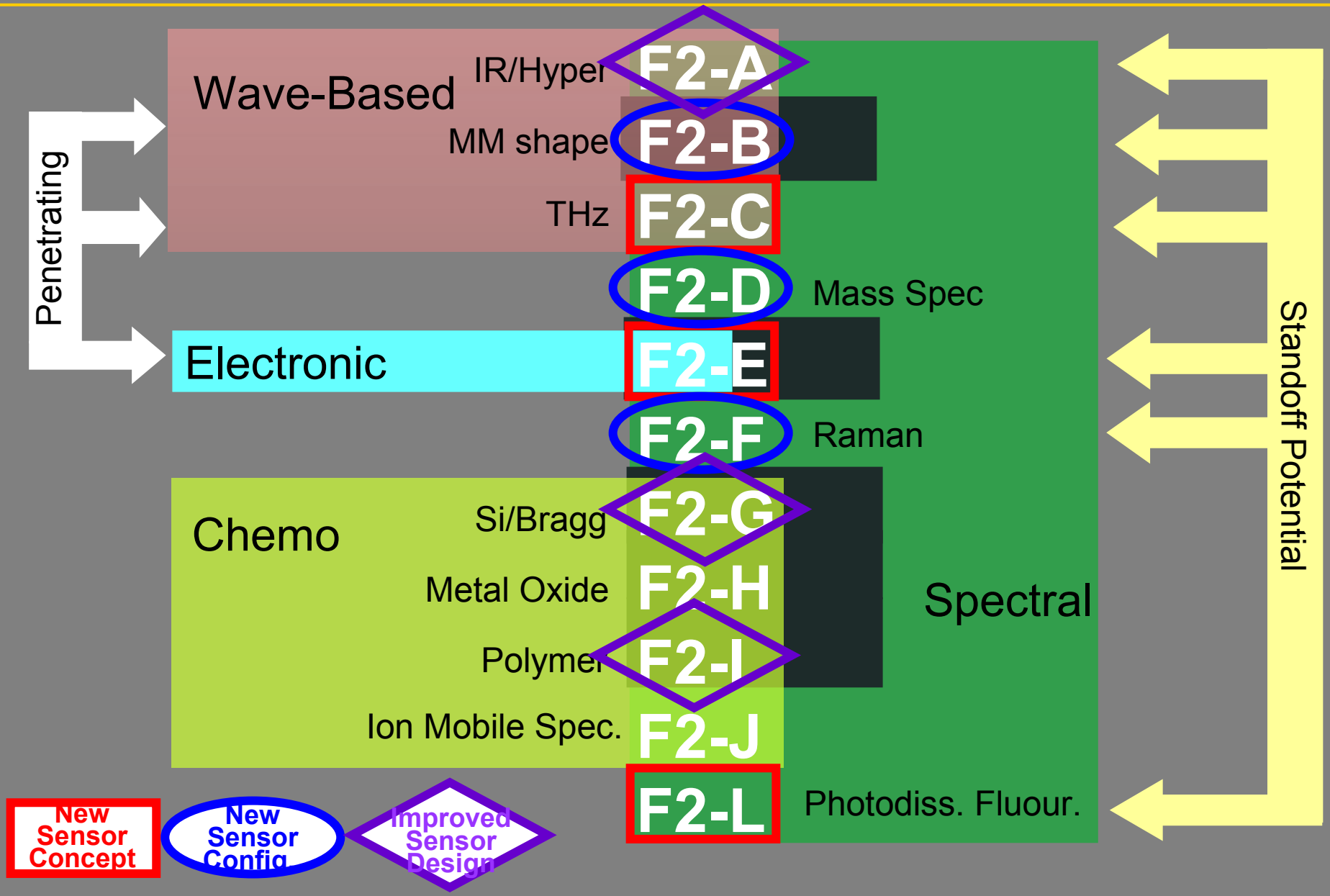
F2 Detection Sensors Overview



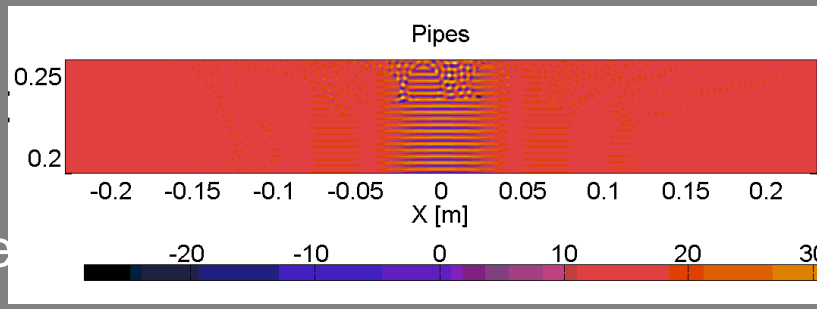
F2-A Explosive Detection using Hyperspectral Imaging
Vélez-Reyes, Santiago (UPRM), Castañón (BU)

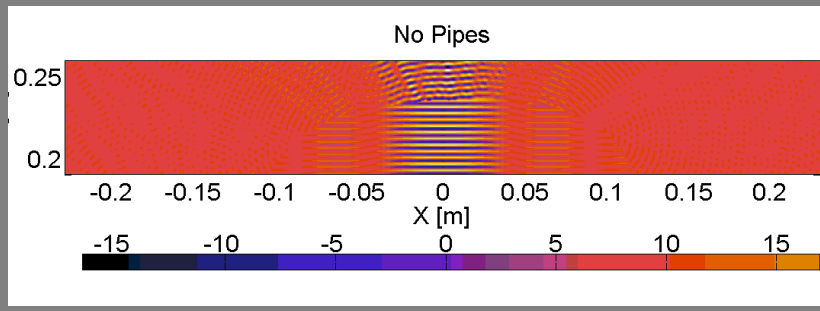
- **Motivation and purpose:**
  - Increase detection rates while reducing false positive alarms in explosive detection systems with high throughput for standoff and portal-based detection systems using hyperspectral imaging (or imaging spectroscopy)
- **Innovative Aspects**
  - New theories for detection and classification algorithms that determine when additional information is needed that work in concert with human-in-the-loop.
  - New methods for target/background contrast enhancement based on nonlinear machine learning methods and geometric PDEs
  - New unsupervised methods for hyperspectral image unmixing
  - Use of GPUs for real-time implementation of hyperspectral image processing algorithms
- **Year 1 Outcomes**
  - Unsupervised unmixing algorithms
  - Study of different geometric PDEs for hyperspectral image enhancement
  - GPU implementation of diffusion geometric PDEs for hyperspectral image enhancement
  - Processing Data from Raman Telescope work of S. Hernandez at UPRM
- **Long range impact**
  - Novel hyperspectral image processing techniques that can lead to robust and adaptive detection and classification systems for explosive detection

F2-B Millimeter Wave Standoff Detection of Concealed Explosives

Carey Rappaport and Jose Martinez, NEU

- **Purpose and Relevance:**
  - Detect foreign objects on individuals under clothing at safe distance
  - Use mm-wave radar to safely and unobtrusively screen subjects
- **Innovation:**
  - Use wide aperture antenna for narrow scanning beam and multiple views
  - Observe large phase variations due to irregularities on skin
- **Year 1 outcomes:**
  - Model wave interaction with typical explosive targets to determine feasibility and optimal frequency range / antenna size
  - Experimentally test COTS MMIC radar in array configuration
- **Long Range Impact:**
  - Fast, automatic, standoff alert of objects hidden under clothes
  - Model-based detection optimization

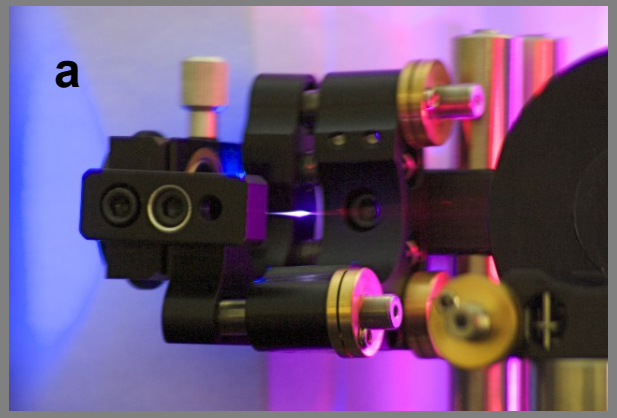


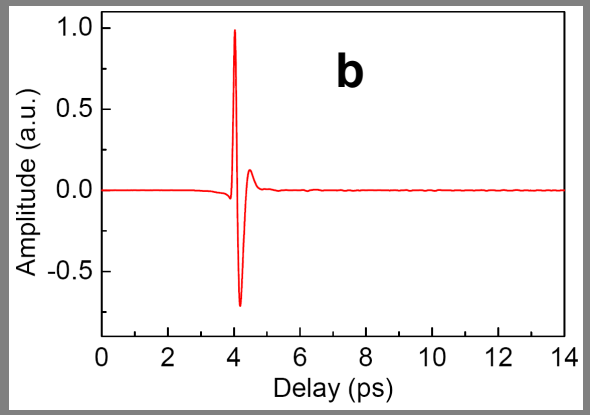


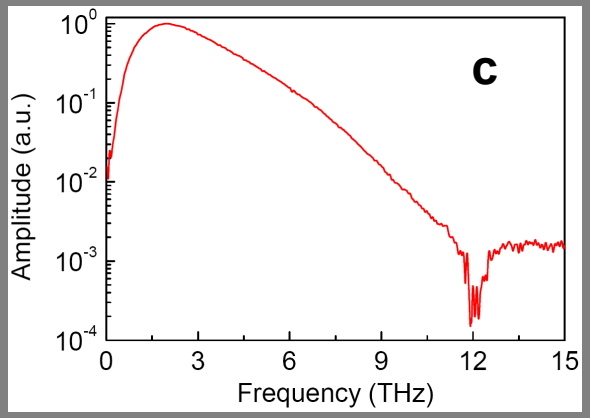
F2-C Science of broadband THz wave photonics: THz generation and detection with gases for standoff detection

X.-C. Zhang, J.M. Dai, E. Gagnon, and M. Yamaguchi, RPI

- **Purpose and Relevance: U**nderstanding the underlying science of THz wave photonics using air and gases as THz wave emitters and sensors might provide a feasible approach for the concealed items' detection at standoff distance.
- **Innovative Aspects: W**e will use a complete quantum mechanical model to fully describe THz wave generation and detection using air (gases) by solving the time-dependent Schrödinger equation; and we will experimentally verify the theory.
- **Year 1 Outcomes: I**nvestigation of the physics of intense broadband THz wave photonics in gases; exploration of the fundamental limit of standoff detection.
- **Long range Impact:** The physical mechanisms behind these effects merit further study and will both illuminate the path to providing useful information about the interaction of intense electromagnetic fields with gases and lead to improved THz systems for the detection of explosives at standoff distance.







a. Laser induced air plasma. **b**: THz signal emitted and sensed by dry air. **c**: THz spectrum.

F2-D An Intelligent Mass Spectrometer for Identifying Explosives and Chemical Weapon Threats

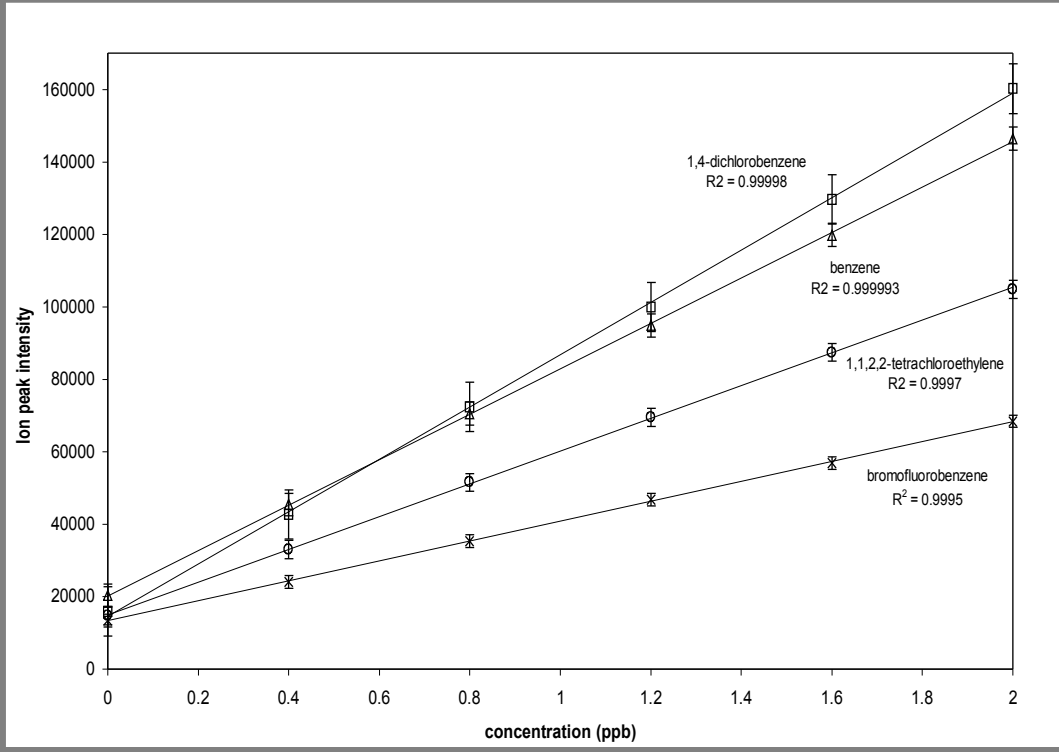
Richard Camilli, WHOI

- **Purpose and Relevance:**
  mobile explosives & chemical weapons detection

- **Innovative Aspects:**
  in-situ mass spectrometry & autonomous feature classification for determining:
  - threat type
  - location
  - magnitude
  - if multiple threats are present

- **Year 1 Outcomes:**
  detection capability for explosive agents, precursors, and breakdown products

- **Long range Impact:**
  rapid, accurate identification and localization of multiple threats across wide classes of explosives



F2-E Detection of Electronically Initiated Explosive Devices

D. Beetner, J. Drewniak, S. Grant, D. Pommerenke, Missouri Univ. S & T.

- Purpose and Relevance
  - Develop methods to detect and identify electronics commonly used in explosive devices based on their unintended electromagnetic emissions
- Innovative Aspects
  - Potentially fast, long-range detection and location
  - Detection basis orthogonal to many other explosives-detection methods, allowing effective sensor fusion.
  - Same physics used to detect devices can potentially be exploited to neutralize device without destroying forensic evidence.
  - More than 15 years of experience performing research for a consortium of 20 companies to help them *reduce* the emissions and susceptibility of their products.

- Year 1 Outcomes
  - Characterize emissions from superheterodyne receivers
  - Design algorithms to detect and locate superheterodyne receivers using *stimulated* emissions. Stimulation method is a patent-pending method that allows rapid detection and location of specific classes of devices from long range
  - Demonstrate of performance of detection technique
- Long range Impact
  - Develop firm scientific foundation for methods to detect, identify, and neutralize electronics associated with explosive devices

F2-F Remote Raman Spectroscopy Detection of High Explosives

S.P. Hernández-Rivera, Univ. Puerto Rico-Mayagüez

Purpose and Relevance:

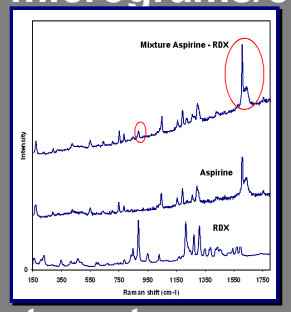
- The objective of the proposed work is to extend the existing technology of Remote Raman Spectroscopy (RRS) toward the application of explosives detection in range (greater than 100 m), in detection limits and in terms of detection of Raman signatures of realistic explosives-related materials.

Innovative Aspects:

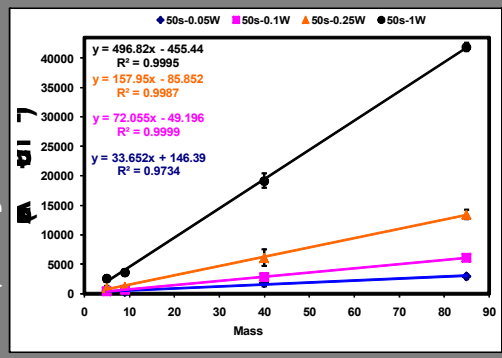
- The planned experiments include detection of HEs on test surfaces at collector to target distances of 100 m and larger. Surface loadings will be several milligrams of HEs spread with concentrations of low levels of several micrograms/cm^2.

Year 1 Outcomes:

- RRS Cross Sections/Excitation Profiles of HEs.
- Measurement of signatures of HEs on surfaces.
- Study matrix/interferences effects.
- Optimization of VIS RRS detection system.
- Discrimination studies: Mix of RDX and aspirin at 7m target-source



- Quantification studies: RDX in C4:



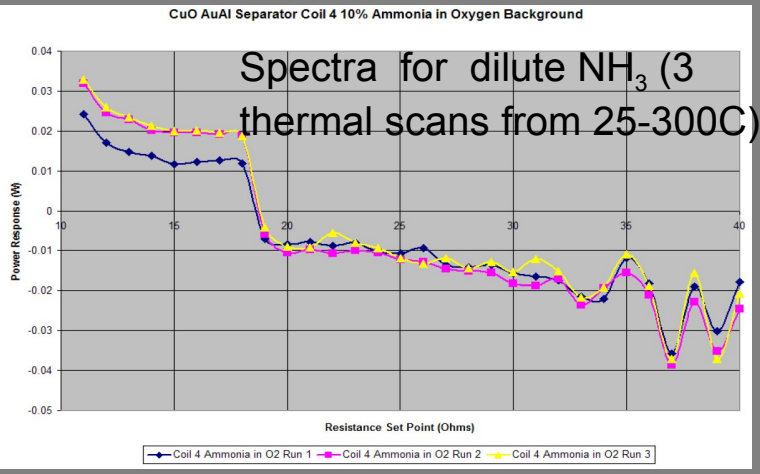
Long range Impact:

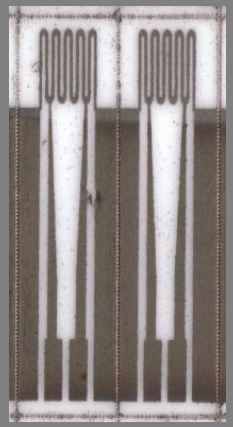
- The outcome of these studies will be a better understanding of the chemical signatures from exposed explosives and the ability to predict the performance of spectroscopic measurement techniques for measuring many different types of explosive materials.
- The results of this work will impact RRS as well as any other technique that is being considered for remote measurements of explosives or chemical threats, in general.

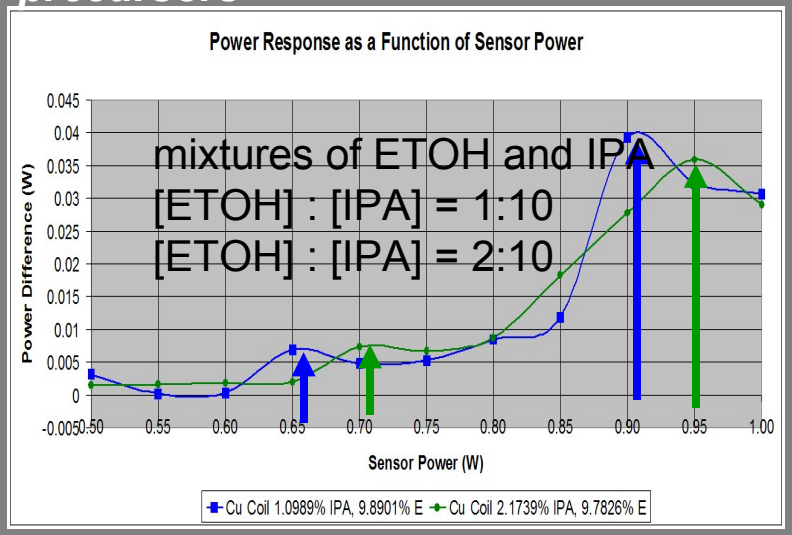
F2-H Gas Sensors for the Detection of Explosive Precursors Using Metal Oxide Catalysts

Otto Gregory - University of Rhode Island

A simple, inexpensive gas detection system using specific 3D transition metal oxides as catalysts is being developed to unambiguously detect minute concentrations of specific gas molecules..explosives / explosive precursors







Purpose and Relevance

- early detection of explosives and explosive precursors in suspected "bomb labs" and other enclosed areas where target gases can accumulate. Nearly immediate detection of specific gas molecules……

  w/o interference effects from background gases

- Small enough to be worn by ground troops yet sensitive enough to be detect minute concentrations in subways, train stations and other confined spaces where the public may be targeted

Innovative Aspects

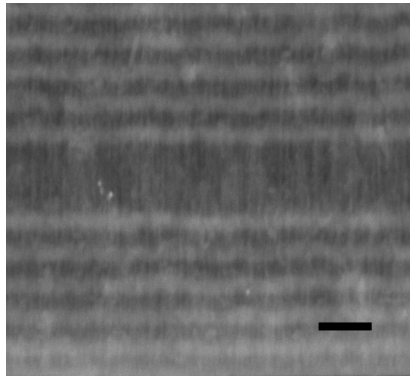
- apply combinatorial chemistry techniques to create new catalyst libraries for specific target molecules…identify optimal catalyst compounds that can be integrated into different sensor templates

- sensor templates include ceramic microheaters (above) & MEMS based microheaters (produced with Georgia Tech) sensors & signal conditioning are sufficiently developed to demonstrate technology near term.

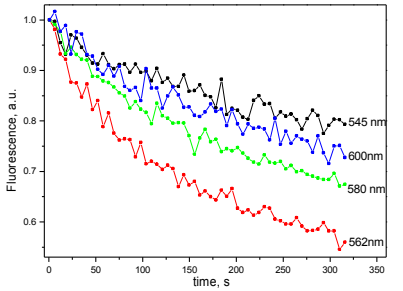
F2-G Optical Chemosensors Using Nanocomposites from Porous Silicon Photonic Crystals and Sensory Polymers

William Euler & Igor Levitsky, Jaycoda Major URI

- **Purpose**: Improved sensitivity, selectivity, and adaptability for detection of low vapor pressure explosives such as TNT, RDX, PETN, etc.
- **Innovation**: A high surface-area porous Si microcavity (Distributed Bragg Reflector), filled with sensory emissive polymers dyes
- **Year 1 outcome**: optimized pore structure and polymer filling determined
- **Long Range Impact**: Hand held detector for use by soldiers and law enforcement officers



SEM micrograph of a porous Si Distributed Bragg Reflector showing the layered pores



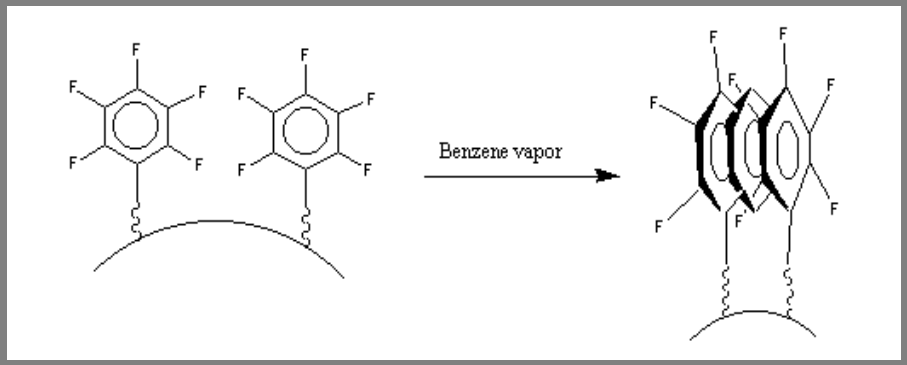
Fluorescent decay from exposure to TNT at different wavelengths with different time constants

F2-I Polymer-Aided Detection
Nathan S. Lewis, Caltech

- **Purpose:**
  Stand-off Detection Through Hybrid Sensors

- **Innovative Aspects:**
  Target Analyte Tailored Sorption Into Sensor Films

- **Year 1:**
  Synthesize Semi-Specific Nitroaromatic Sensor Films
    Use in both fluorescence and chemiresistors



- **Long range Impact:**
  Develop New Standoff Explosives Detection System

F2-J Decomposition rate constants, heats of associations, & ion lifetimes of explosives in air at ambient pressure

G.A. Eiceman, NMSU; Y. Zeiri, Z. Karpas, R. Kosloff, HUJI

- **Purpose and Relevance:**

  Determine kinetic and thermodynamic properties (*in title*) of gas phase ions of explosives at ambient pressure using a broad selection of high explosives and improvised explosives.

- **Innovation:**

  These will be the first ever such studies using newly developed methods and instrumentation where kinetic values and thermochemical constants can be measured at ambient pressure. No measurements or understandings of these properties are reported for explosives and yet these properties underlie the fundamentals of response in trace detectors of all kinds where atmospheric pressure ionization is employed (API MS, IMS and DMS).

- **Year One Outcomes:**

  The construction of a refined instrument on mobility-mass spectrometry for kinetic studies and the determination of properties (*in title*) of peroxide-based substances in positive ion mode.

- **Long Range Impact:**

  Knowledge of these title properties will inform both the design and use of the next generation of trace detectors and provide background data for innovations on their deployment or philosophy of use.

F2-L Remote vapor enhancement

Talya Arusi-Parpar, NRC Soreq, Yanve 81800 Israel

- Purpose
  - Understand and optimize the process of remote enhancement of explosives' vapor for increasing explosives stand-off detection capabilities
- Innovative Aspects:
  - Experimental results show for the first time a 100-1000 fold increase in explosive vapor concentration leading to dramatic increase in stand-off detection capabilities by PF (Photodissociation Fluorescence)
- Year 1 outcome:
  - Study of enhancement process
  - Setup of dedicated laboratory
  - Development of diagnostic tools
- Long range Impact:
  - Basis for further improvement of this method, and its efficient implementation in future stand-off detection systems for explosives or any other illicit material

F2 Detection Sensors Overview