

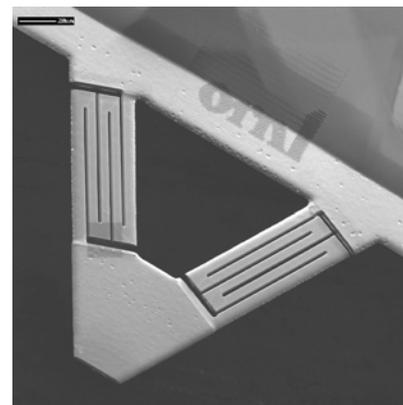


MEMS Based Calorimetric Spectroscopy (CalSpec)

{Chemical And Biological Detection}

CalSpec Concept And Background

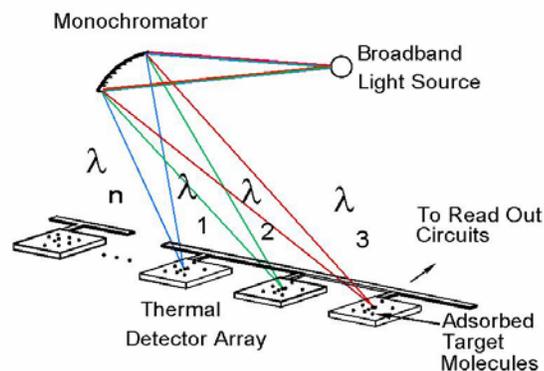
We have developed a novel micro_calorimetric spectroscopy technique that can be used for chemical and biological detection applications. This is a micro-electro-mechanical-systems (MEMS) based technique that provides detailed spectral information about the target species. However, since it is MEMS based, the device volume can be extremely small. Single chip versions have been envisioned and the components for such a detector are presently being developed. In the CalSpec approach target molecules interact with sub-femtojoule sensitive micro-mechanical thermal detectors. Thus a temperature spectrum is measured along the detector array, as a function of wavelength, for the target species. Since we are using extremely sensitive thermal detectors, a substantially smaller target sample is required compared to traditional absorption spectroscopy. Both chemical and biological species have routinely been detected. An example of a typical bi-material MEMS thermal detector that can be used for CalSpec is shown in the figure on the right. This technology has received both a US patent and an R&D 100 award.



Detailed CalSpec Detection Approach

- Target molecules adsorb onto thermal detector surfaces.
- Detector surfaces illuminated with discrete wavelengths
- Photons are absorbed and excite target molecules on selected detector elements
- Preferential detector element heating produces unique photothermal spectrum.

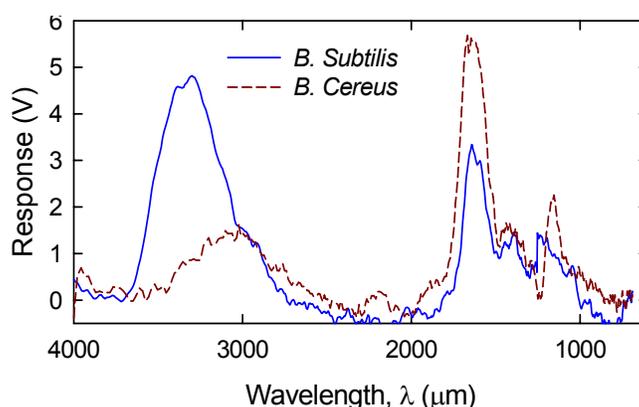
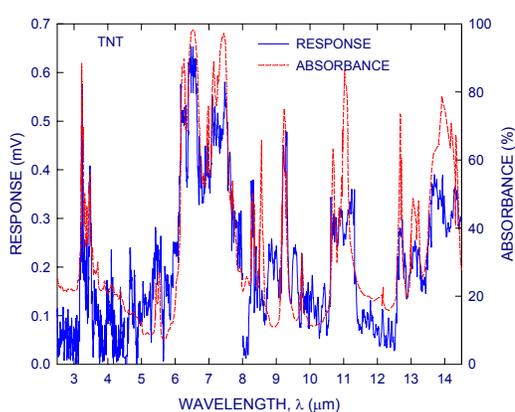
The detection of the presence and identity of target species using CalSpec can be broken down into simple steps. In the first step the sample is allowed to interact with the surface of a femtojoule sensitive thermal detector that can be coated with an appropriate chemical layer selective to the family of the target chemicals. Depending on the choice of thermal detector, the initial molecular adsorption can induce surface stress changes that provide a kind of “trigger”. However, the selectivity in our approach is primarily a consequence of the photothermal “signature”, and therefore only moderately selective chemical layers may be needed such as those customarily used to coat GC columns. In the next step, a photothermal spectrum is obtained for the molecules adsorbed on the detector surface, by scanning a broadband wavelength region across the detector array such that a narrow part of the spectrum illuminates each individual thermal detector. The



temperature changes of those particular detector elements is proportional to the number of photons absorbed which, in turn, is proportional to the number of molecules adsorbed on the detector surface. Because different detector elements will be exposed to different wavelengths, a sensitive photothermal signature response can be obtained. Photothermal spectra are very similar to conventional infrared spectra and can be used to uniquely identify the adsorbed molecules. The figure above illustrates this unique detection technique.

Representative Data

Shown below are two photo-thermal spectra taken with the CalSpec technique. Both TNT chemical and anthrax simulants biological data is presented. The typical wavelength range that we have spanned is from 2.5 to 14.5 μm . The TNT data represents less than one mono-layer of chemical coverage on the thermal detector surface. The biological data shows that two similar species can be differentiated with this technique. In fact this data was reproduced in two different sampling approaches. Both evaporation and direct application of the target bacteria onto the detector surface produced similar data. Only several hundred bacteria were applied to the MEMS thermal detector to produce the data shown



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