

A miniature solid-state spectrometer for space applications – Field tests. W. D. Smythe¹ and E. Johnson², ¹Jet Propulsion Laboratory, 4800 Oak Grove Drive Pasadena, CA 91109, wsmlythe@lively.jpl.nasa.gov, ²Ion Optics, Incorporated, 411 Waverly Oaks Road Suite 144 Waltham, MA 02452 Ejohnson@ion-optics.com

Introduction: A solid state infrared spectrometer has been developed under the Planetary Instrument Definition and Development Program PIDDP to implement a small rugged spectrometer principally for landed applications. The instrument uses the high index of refraction and waveguide properties of a silicon slab to achieve good spectral resolution and high throughput in a small instrument footprint (less than 25 cm). Light enters the silicon slab and is reflected off a grating (Ebert configuration), utilizing the silicon index of refraction to achieve high dispersion. An array of microthermopiles is used to measure the amplitude of the dispersed light. Input optics are typically utilized to focus light on the input aperture and a chopper is used to compensate system drift.

The current spectrometer hardware build has concentrated on balance-of-system issues which address identified performance artifacts. Program effort has been oriented toward system engineering, integration, test and performance validation.

On the arrays which are being integrated into the current hardware build, the measured NEP is roughly $5 \times 10^{-11} \text{ W Hz}^{-1/2}$. Our effort has been directed towards fabrication, packaging, and readout improvements, which will allow these detector arrays to perform

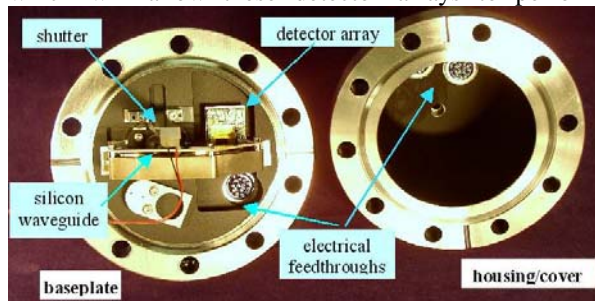


Figure 1: A laboratory model of the spectrometer. The spectrometer consists of the silicon waveguide and the detector array. The remainder of the hardware is vacuum packaging to improve the throughput of the detector arrays. Future implementations will include hermetically sealed arrays to remove the need for vacuum packaging.

at or near their laboratory noise and drift limits in a fielded system. The ultimate noise floor for this PIDDP project is dictated by the available microthermopile arrays. For these arrays the instrument model predicts the spectrometer can resolve 10% albedo contrast changes in the MWIR band.

Field tests: Our first field tests have been performed on active lavas. Spectra were collected at night

from active lava fields in the eastern rift zone of Kilauea. In these measurements, successive pixel readings were logged at roughly 10 Hz, with the integral shutter to open and close at 10 second intervals. A post-processing routine extracts shutter-closed readings

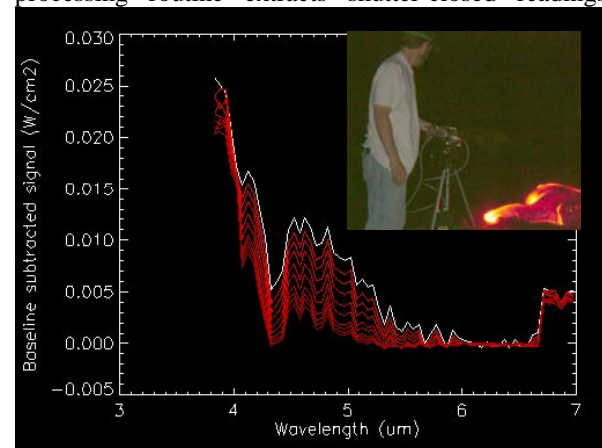
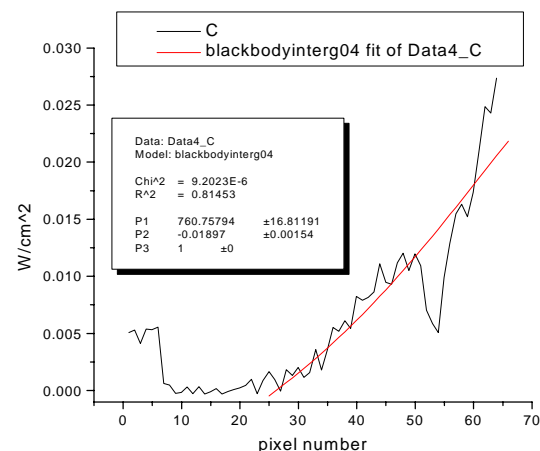


Figure 2: Thermal observations at Kilauea, Hawaii. The spectrometer and lava are shown in the inset on the upper right. The spectra show a time history of the cooling lava.

for each pixel and uses these readings to fit a baseline for each pixel reading over time. This baseline is then subtracted, for each pixel, from that pixel's time history.

To estimate the temperature for each spectrum, we



performed a parametric fit to the slope of the short wavelength pixels (pixels 25 through 64) with a Planck function, using temperature as an adjustable parameter. As a check on the post-processing procedure, we also allowed a second adjustable scaling parameter to repre-

sent possible changes in target emissivity. This parameter had a negligible effect on the temperature estimates for successive spectra. Similar fits were performed on the blackbody data (measurements in the lab with the blackbody source.) The single parameter fits worked well, producing reliable temperature estimates over the range 300 C to 900 C. Subtracting the blackbody function from the corresponding lava signals, we recover an emissivity spectrum for the target scene. There is modulation at the longer wavelengths (pixels 25 through 50) and a clear absorption peak caused by atmospheric CO₂ in the measurement. We did not observe an obvious change in the level of the CO₂ absorption over the available range of lava temperatures logged. The CO₂ band is the only unambiguous atmospheric absorption signal in this wavelength range.

This work was supported at JPL and Ion Optics under contract to the NASA PIDDP program.