A Hyperspectral Thermal Imager Based on a Low Order Scanning Fabry-Pérot Interferometer

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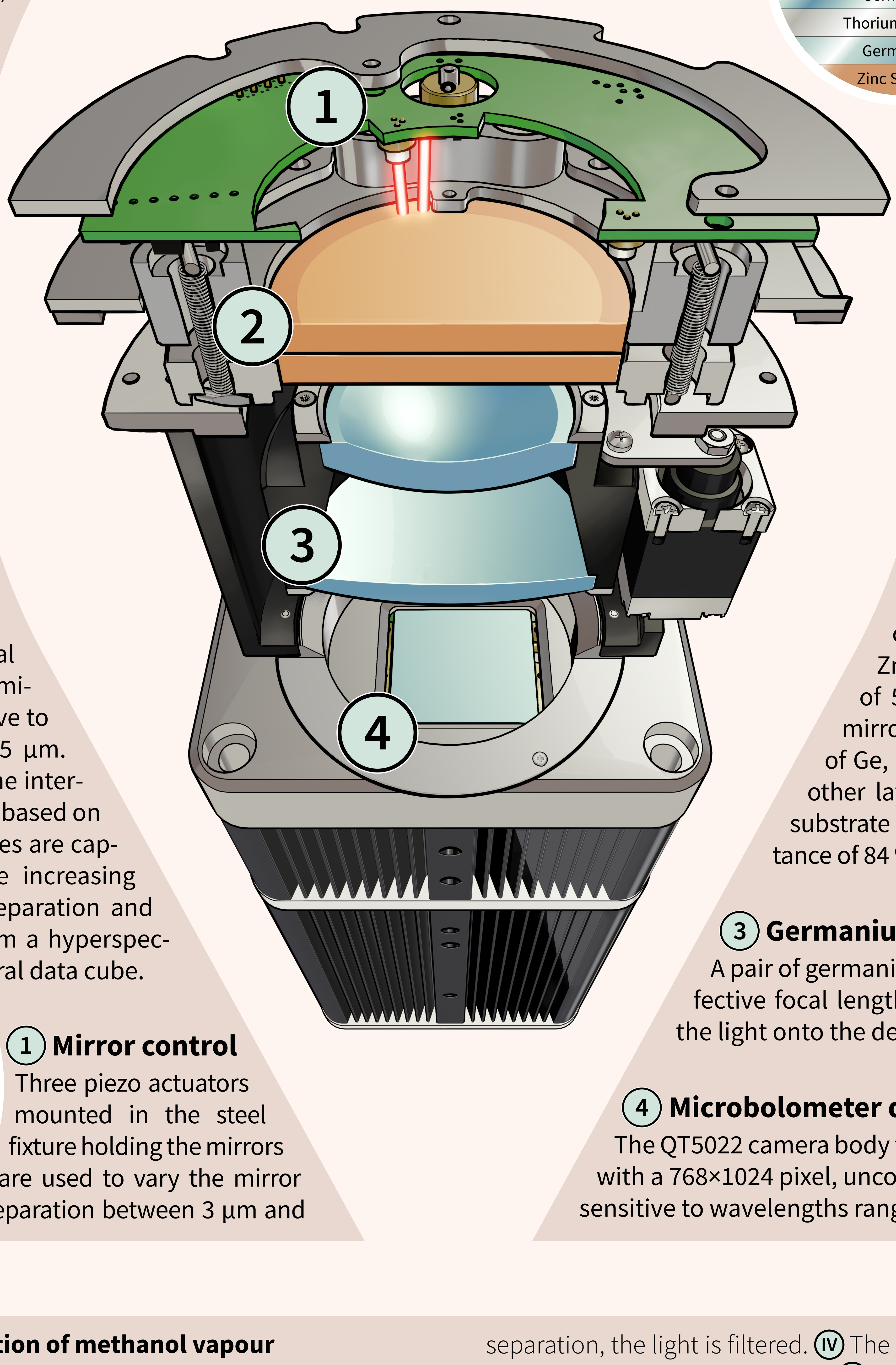
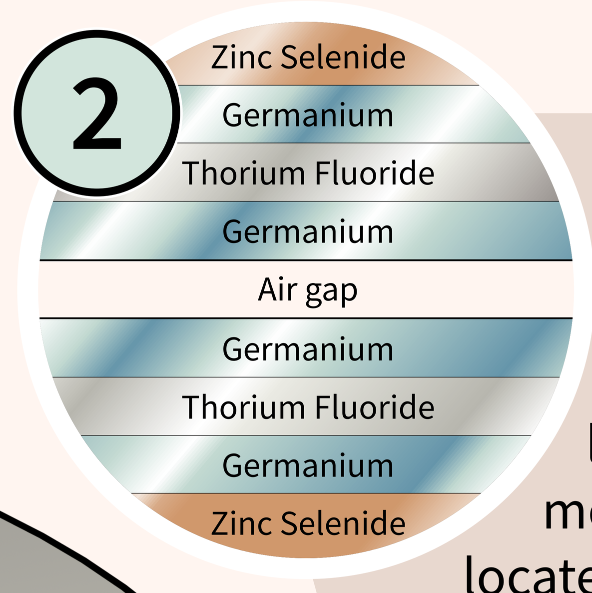
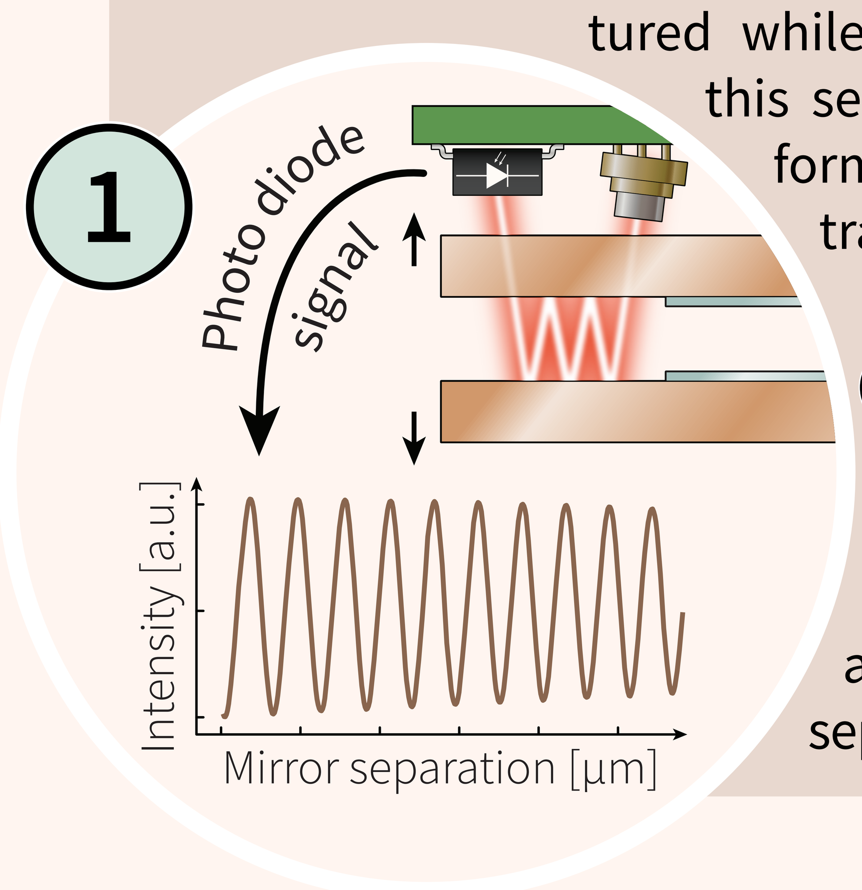




The hyperspectral infrared imaging system (8 – 15 µm)

The long-wave infrared (LWIR) regime contains material specific information which can be used for material analysis and identification. Fourier Transform Infrared (FTIR) techniques such as Attenuated Total Reflectance (ATR) spectroscopy are usually used to probe this part of the spectrum. However, most of these techniques rely on single-point measurements, which make it time consuming to acquire spatial information about the sample.

This hyperspectral imager combines a scanning Fabry-Pérot interferometer (SFPI) and a conventional thermal camera equipped with a microbolometer detector sensitive to wavelengths from 8 µm to 15 µm. The two mirrors comprising the interferometer filter incoming light based on their mutual separation. Images are captured while increasing this separation and form a hyperspectral data cube.



(1) Mirror control

Three piezo actuators mounted in the steel fixture holding the mirrors are used to vary the mirror separation between 3 µm and 13 µm. To ensure that the mirrors remain mutually parallel, three laser diodes are mounted on a PCB located in front of the mirrors and shine light into the cavity. As the mirrors are displaced, the light undergoes alternating constructive and destructive interference based on the separation of the mirrors. This is monitored by 3 photodiodes and is used to control the signal to the piezo actuators.

(2) Dielectric mirrors

Two mirrors form the SFPI cavity. Each is made from a Ø 2" ZnSe substrate with a thickness of 5 mm. A three-layer dielectric mirror coating comprised of a layer of Ge, a layer of ThF4, and finally another layer of Ge is deposited on the substrate to achieve an average reflectance of 84 % across the spectral range.

(3) Germanium lenses

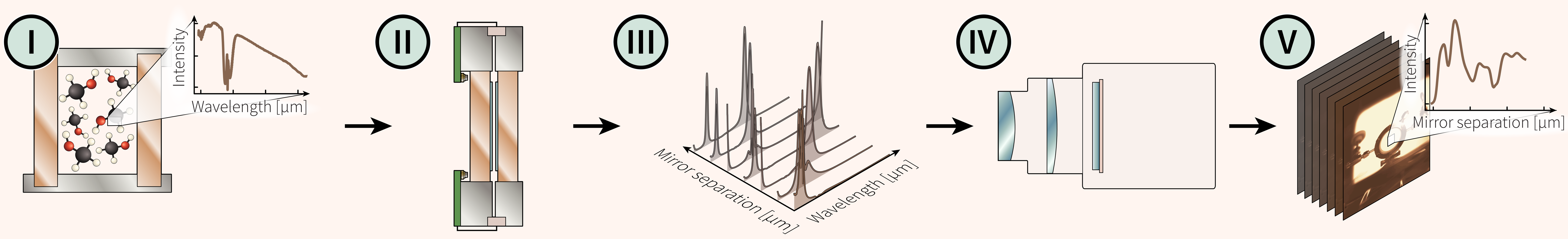
A pair of germanium lenses with a combined effective focal length of 35 mm are used to focus the light onto the detector.

(4) Microbolometer detector

The QT5022 camera body from QTechnology is equipped with a 768×1024 pixel, uncooled microbolometer detector sensitive to wavelengths ranging from 8 µm to 15 µm.

Hyperspectral image acquisition of methanol vapour

(I) The incident spectrum consists of wavelengths ranging from 8 µm to 15 µm and is a combination of emitted, transmitted, and reflected light. In this case, black body radiation is transmitted through methanol vapor in a gas cell. (II) The light enters the SFPI. (III) Based on the mirror separation, the light is filtered. (IV) The light enters the thermal camera and is integrated by the detector. (V) 150 images are captured while the mirror separation is swept from 3 µm to 13 µm, forming a hyperspectral data cube. Here, a single interferogram of the methanol vapor is extracted.



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