Infrared Emission Spectroscopy on Micro Samples

Application Note M168

Introduction

Using FT-IR spectrometers to determine materials' emission spectra in a wide infrared spectral range is an important analysis technique in many research fields. Both, thermal emission resulting from heat, as well as emission caused by quantum mechanisms (such as photo- or electroluminescence), act as a source in FT-IR emission experiments.

High signal intensities can often be reached when the materials are bulk and emit intense infrared radiation. However, detection can become a challenge for advanced emission investigations that are based on submillimeter size devices. For example:

- Film based light emitters [1,2]
- Micro infrared diodes [3]

Another challenge is to collect exclusively the emission from the area of interest of the sample itself, preventing thermal background radiation from masking the signal of interest. In this application note, we introduce a unique and comprehensive Bruker solution fulfilling these demanding requirements.

Typically, the Bruker HYPERION II infrared microscope is used to measure samples with micrometer level spatial resolution in conventional transmission, reflection, and ATR measurement modes. In these modes, the infrared radiation from the integrated Globar or tungsten source of an INVENIO or VERTEX spectrometer passes the interferometer and is finally focused on the sample located on the HYPERION II sample stage. The sample absorbs a certain amount of IR radiation while the remaining radiation will be reflected and/or transmitted, collected again by the objective and then finally sent to the microscope detectors (Fig.1).

Such a classical optical path can be smartly "inverted" for emission or luminescence measurement mode such that the light emitted from the sample on the HYPERION II sample stage is sent to the spectrometer where it will be finally analyzed in the INVENIO/ VERTEX detector compartment.

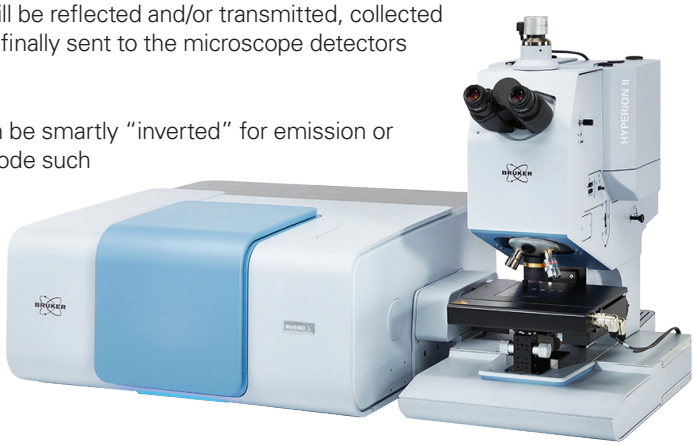

Fig. 1
INVENIO with HYPERION II microscope.

Measurements

With the motorized HYPERION II sample stage, one can easily perform microscopic emission measurements at various positions of a sample. In many cases it is required to analyze the spatial dependence of the emission over a larger sample area. This can be conveniently achieved with the automatic line- and area mapping functionalities of the HYPERION II. Fig. 2 shows the emission profile of a MIR emitter (0.65 mm²) measured using a HYPERION II microscope coupled to an INVENIO spectrometer. The 3D view in OPUS visualizes the total emission intensity distribution of the emitting area. Outstanding performance of the HYPERION II microscope combined with utmost sensitivity of INVENIO or VERTEX spectrometers deliver a perfect solution for such advanced measurement tasks. The beampath in the highly flexible INVENIO spectrometer can even be optimized for emission experiments by configuring it in such a way that the emission signal is directly guided to a highly sensitive internal detector, bypassing the sample compartment.

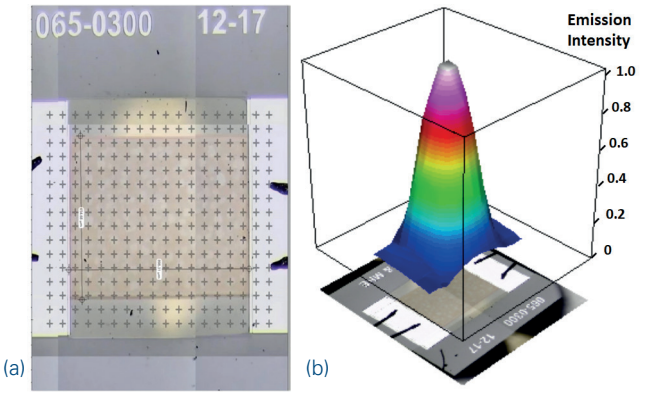

Fig. 2
(a) Photo of a 0.65 mm² MIR emitter heated by constant 6V voltage supply (up to 500°C), taken by a HYPERION II microscope. A mapping grid covering the entire emitting area has been defined with high lateral resolution. (b) 3D view of the normalized total emission intensity (0-1) over the emitter area.

State-of-the-art Bruker Step-Scan amplitude modulation (AM) technique is a valuable option for even more advanced applications such as micro-photoluminescence experiments. By modulating the excitation laser for example, the PL signal from micro samples will be modulated with the same frequency and can be amplified via a lock-in-amplifier. In contrast, the constant thermal background contribution is filtered out, which could otherwise conceal the weak PL signal. In Ref[1], Chen et al reported the MIR-PL spectra on ~30 µm dual-gate hBN/BP/hBN device measured by Bruker VERTEX+HYPERION II systems using the Step-scan AM method and proving an extraordinary achievable sensitivity.

Summary

Bruker research level FT-IR spectrometers INVENIO and VERTEX are excellent and unique tools to determine emission or luminescence properties in infrared spectral range. Analysis capabilities can be extended from bulk to microscopic samples by adaption of a HYPERION II microscope. State-of-the-art Bruker step-scan amplitude modulation technique provides in addition the possibility to eliminate the unwanted thermal background contribution and allows to amplify the weak emission signal via lock-in amplifier, further enhancing the sensitivity for micro emission measurements.

References

[1] Chen et al., Sci. Adv. 2020; 6 : eaay6134
[2] Chen et al. Nano Lett. 2019, 19, 1488-1493
[3] Bruker product brochure <INVENIO-X>, 2019

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