Concept of a Prism Spectrograph for Infrared Linear Array Detectors

U. Schade[1], E. Ritter[2], L. Puskar[1] and P. Dumas[3]
[1] Helmholtz-Zentrum Berlin, 12489 Berlin, Germany
[2] Humboldt-Universität zu Berlin, 10115 Berlin, Germany
[3] SOLEIL Synchrotron, 91192 Gif sur Yvette Cédex, France

***Abstract*—We discuss the concept of an IR spectrograph suitable for linear array detection. The dispersive element of the spectrograph is based on an arrangement of commercially available low-cost prisms. The dispersion is such that the whole spectral bandwidth of interest is distributed along the linear array of detector pixels in such a way to achieve an optimum for the spectral resolution. The concept is exemplarily shown for the design of a spectrograph working in the range between 5000 and 2500 wavenumbers spread onto a linear 128-pixel array detector.**

I. INTRODUCTION

TIME resolved infrared investigations on the kinetics of objects of interest can be performed by means of Fourier transform infrared spectroscopy. However, this method finds its limits for non-cyclic systems or systems with low recovering dynamics having kinetics under investigation faster than the millisecond time regime [1].

In contrast to standard Fourier transform spectrometers, dispersive spectrometers based on prisms or dispersion gratings with the utilization of linear array detectors make the single-shot operation possible. They have no moving components mechanically limiting the speed of detection which is now only determined by the signal read-out of the detector itself [2] and can be as fast as in the order of microseconds.

The spectral resolution that is possible to obtain by a linear array detector, however, depends on the number of pixels. Since most available linear array detectors with response optimized in the mid-infrared spectral region consist of either 64 or 128 pixels only, the spectrometer design has to account for the limited number in order to ensure an optimal spectral coverage.

II. RESULTS

Prism-based spectrometers have the advantage of a higher transmission compared to grating spectrometers, which even need additional filters when the elimination of unwanted orders becomes necessary.

The instrument presented here utilizes CaF_2 as dispersive medium, and is designed for the spectral range between 5000 and 2500 wavenumbers (2 - 4 µm) and for a 32-mm long MCT linear array of 128 pixels with a pitch of 250 µm (Infrared Associates). The instrument design has been optimized by ray tracing. The spectrometer optics has an F-number of 14 and images the entrance aperture on the focal plane by a ratio of 1:1. Fig. 1 displays the spectral resolution as obtained for a slit of 250 µm which corresponds to the pitch of the detector pixels.

The large F-number of the spectrometer results from the small apertures of the low-cost prisms (25x25 mm^2) but still produces a sufficiently small image optimally filling the individual detector pixels as shown in the inset of Fig. 1.

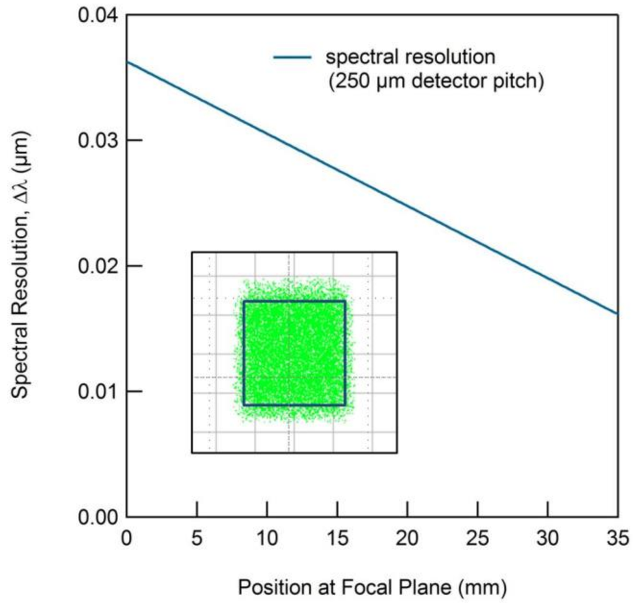

Fig. 1. The spectral resolution for a detector pitch of 250 µm as a function of the position at the exit slit of the spectrometer. Inset: 1:1 image (green) of the square-shaped entrance aperture (black square of 250 x 250 μm^2) at the detector's position for a wavelength of 3 µm as obtained by ZEMAX ray tracing.

III. SUMMARY

In contrast to grating spectrometers, prism-based spectrometers can cover a larger spectral width to the cost of a more moderate spectral resolution. Together with linear array detectors such instruments are of advantage for single-shot spectral investigations with a time-resolution in the microsecond time-scale.

The paper reports on the design, the realization and the commissioning of a low-cost spectrometer for the spectral range between 5000 and 2500 wavenumbers.

The spectrometer finds application with low throughput sources (e.g., infrared synchrotron radiation) for time-resolved investigations of small samples either under an infrared microscope or through small gasket apertures of diamond anvil pressure cells.

REFERENCES

[1] E. Ritter, L. Puskar, F. J. Bartl, E. F. Aziz, P. Hegemann, and U. Schade, "Time-resolved infrared spectroscopic techniques as applied to channelrhodopsin," *Front. Mol. Biosci.*, vol. 2, no. July, pp. 1–7, 2015.
[2] U. Schade, E. Ritter, P. Hegemann, E. F. Aziz, and K. P. Hofmann, "Concept for a single-shot mid-infrared spectrometer using synchrotron radiation," *Vib. Spectrosc.*, vol. 75, pp. 190–195, Nov. 2014.