# Diamond machining of blazed grating on curved substrate

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**Abstract**

The monitoring of $CO_2$ emissions is one of the central aspects for evaluating the goals of the Paris Agreement. Different missions are currently in preparation or ongoing to establish a spaceborn monioring of $CO_2$ sources. A concept for an instrument for measuring localized CO2 emissions [1,2] is based on an optical design of a three-mirror anastigmat (TMA) telescope combined with an Offner-type spectrometer which relies on metal based mirrors and a convex curved grating, see Fig.1. As alternative design using refractive elements, a Dyson spectrometer is proposed [2] that also requires a reflective, concave grating.

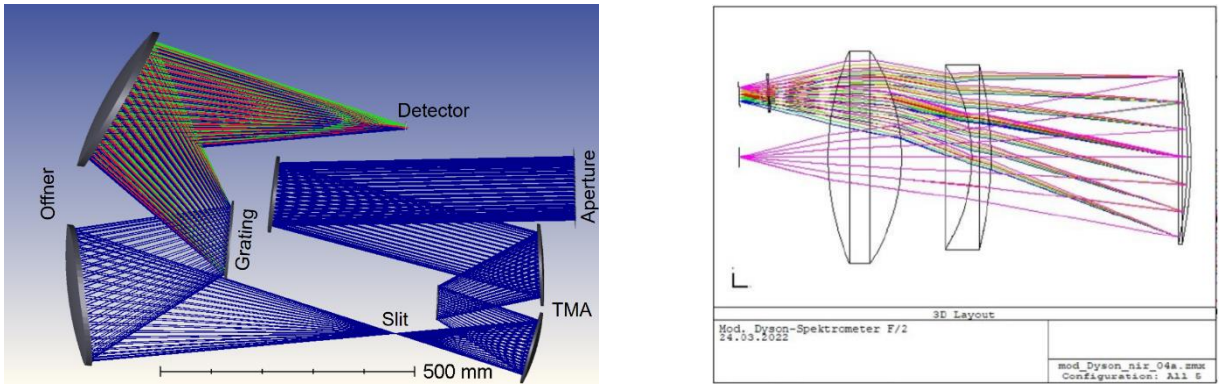


Figure 1: Optical design of TMA and Offner-type spectrometer [1] (left) and Dyson Spectrometer (right) [2]

During a Phase A study, the curved grating had been identifiyed as one of the critical components of the system, since the diffraction efficency of the grating is crucial for the throughput of the instrument. The manufacturing of the blazed grating structure on a curved surface is not possible with most traditional lithographic tools which are limited to planar substrates. A potential alternative method is the ultra precision (UP) diamond machining [3].

For the proposed Dyson design, a blazed grating structure with a grating period of 30 µm and a depth of 317 nm on a spherical concave substrate with a radius of 75 mm and a clear aperture of 48 mm was manufactured by UP diamond ruling. The setup of the UP machine uses multiple linear and rotary axis to compensate for the necessary changing position between tool and substrate surface. To characterize

the grating, measurements by microsopy and white light interferometry as well as stray light and efficency measurements are perfomed.

**References:**

[1] Strandgren J, Krutz D, Wilzewski J, Paproth C, Sebastian I, Gurney K, Liang J, Roiger A and Butz A 2020 Towards spaceborne monitoring of localized CO2 emissions: an instrument concept and first performance assessment *Atmospheric Measurement Techniques Vol. 13* pp 2887–2904 (https://doi.org/10.5194/amt-13-2887-2020)

[2] Krutz D et al. 2022 CO2Image: the design of an imaging spectrometer for CO2 point source quantification *Proc. SPIE 12233*, Infrared Remote Sensing and Instrumentation XXX 1223306 (doi: 10.1117/12.2635250)

[3] Steinkopf R 2023 Optimization of diamond machined gratings for low light scattering and highest diffraction efficiencies *euspen's 23rd International Conference & Exhibition* (Copenhagen DK)