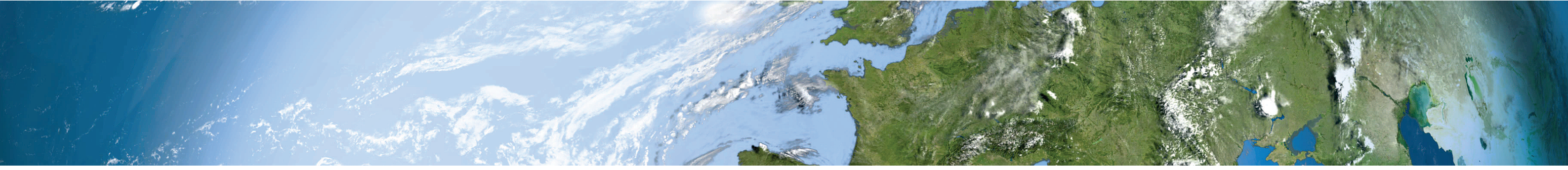

Characterization of Liquid Crystal on Silicon-SLMs for close-up remote Laser Beam Steering enabling RAMAN Imaging

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Roundup

Enabling non-mechanical Raman point mapping using light sharping - to improve system reliability. An approach to characterize Spatial Light Modulator (SLM) is shown.

1. Motivation

Application background

- 3D printing of moon regolith for In situ resource utilization
- Evaluation of silica based glass content on the surface of 3D printed parts sintered from moon regolith using Raman spectroscopy for quality assurance

Benefits

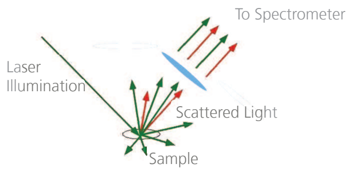
- Reduction of mechanical risks due vibrational and thermal stress
- On-mission adjustments of optical parameters of a laser spectrometer

Objective

- Raman Instruments like the Raman Spectrometer for MMX (RAX) [1] by the German Aerospace Center (DLR) selected for JAXAs Martian Moons eXploration (MMX) [2] mission are suggested to be extended by scanning units to map the characteristics of a sample spatially.
- Mechanical scanners for Raman point mapping as used on SHERLOC [3] replaced with non-mechanical SLM

Raman Basics

- Raman spectroscopy is an optical spectroscopic technique to inspect inner molecular frequency modes exited by laser light to determine material properties e.g. for minerals.



2. Approach

Goal

- Modelling of the LCoS optical characteristics for the given application

Modelling

- Laboratory characterization setup with wavefront simulation of the setup in comparison

Laser Spot Generation

- Focusing and deflecting the wavefront of a collimated continuous wave laser with Liquid Crystal on Silicon (LCoS) using dynamically adjustable Fresnel zone plates
- LCoS is a reflective liquid crystal microdisplay that is able to shift the phase of coherent light pixel-wise.
- Laser spot size is an important parameter in Raman spectroscopy influencing the spatial resolution and signal-to-noise ratio (SNR)

Parameters settings

- Applied laser wavelength 532 nm (referring to RAX)
- Driven by the application and mission

Holoeye Pluto2 reflective LCoS (HOLOEYE Photonics AG)

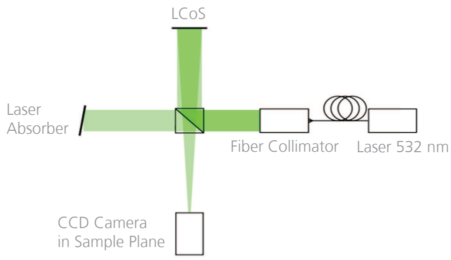
3. Workflow

- Determination of the spatial resolution necessary to evaluate the glass content of sintered moon regolith
- Analysis of spectrometric parameters: optical bandwidth, spectral resolution, SNR etc.
- Characterization of the focused laser spot using laboratory setup according to the identified parameters
- Modelling of the LCoS optical behavior using Wave Propagation Simulation (Angular Spectrum Method (ASM))

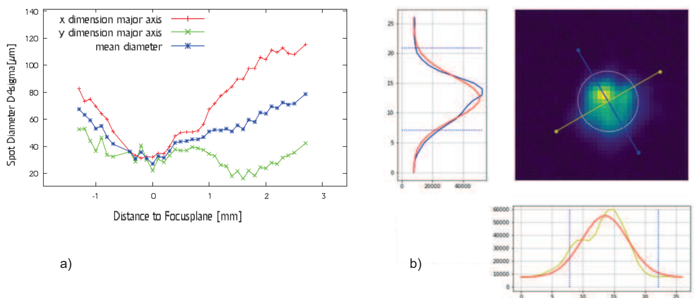
4. Challenges

- Analysis of the LCoS parameters that influence the optical performance
- Quantization effects caused by the pixel grid and the discreet phase level
- Degradation effects due to radiation under space conditions and the influence on the optical performance
- Higher diffraction orders besides the intended laser focus are analyzed

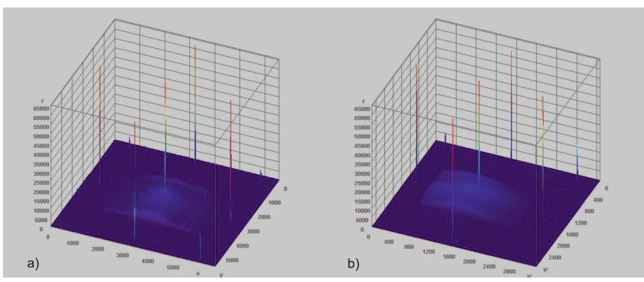
5. Characterization Setup



6. Results



Analysis of focused beam for different focal lengths a) spot size along the propagation axis b) Profile in focus (D4σ Method)



Wavefront in sample plane, spikes mark the intended focus and other diffraction orders a) raster scan b) Wavefront propagation simulation (Angular Spectrum Method)

Further characterization objectives

- Optical flatness
- Focusing efficiency
- Deflection increment accuracy
- Degradation simulation with failed pixel areas

Conclusion

It can be shown that a laser spot can be dynamically adapted to the requirements of Raman spectroscopy and point mapping using LCoS.

By examining the spot characteristics at different focal lengths and deflections, two-dimensional scanning can be optimized in terms of measuring distance, area and taking the Raman spectroscopy into account also the integration time and SNR.

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