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Employing Hyperspectral Imaging for Temperature Determination in Laser Materials Processing

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Laser materials processing techniques have gained a lot of interest particularly in R&D over the past years. Admittedly, the process understanding of many of those techniques is still very limited. In order to broaden the process understanding, correct temperature information becomes very valuable. The reason being that correct temperature information can be used to describe numerous of the occurring physical phenomena in laser materials processing, such as heat conduction/convection, formation of stress/distortion, solidification behavior, etc. Furthermore, it also helps to improve current process simulation approaches as well as to compare experiment and simulations.

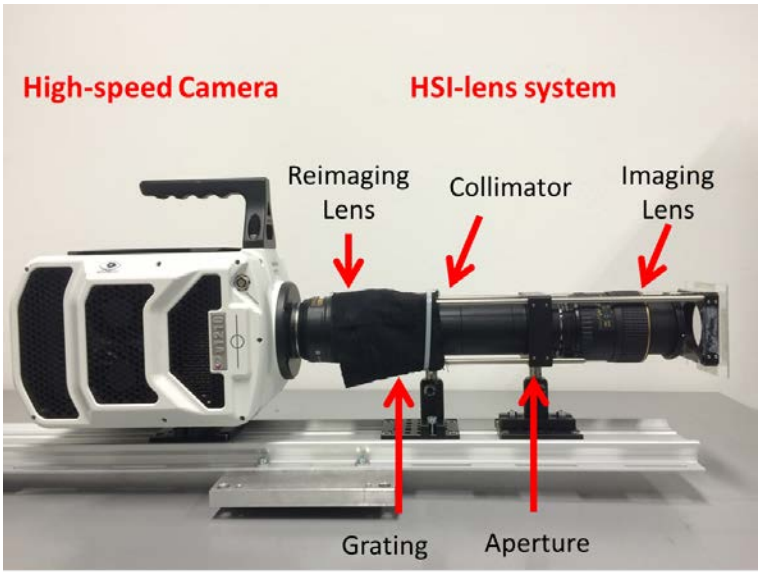

Fig. 1. Picture of the hyperspectral camera setup comprising a high-speed camera and a self-designed HSI-lens system.

For this reason, we propose a novel approach for temperature determination based upon hyperspectral imaging (HSI). HSI allows to simultaneously acquiring spectral as well as spatial information upon the investigated target which makes it an already very popular and well-established tool in biomedical imaging, agriculture, food quality control, surveillance, astronomy and remote sensing. The acquired three-dimensional dataset includes two spatial and one spectral dimension – most commonly in the range from ultraviolet to near-infrared. This information can be used for instance to reveal the chemical composition of specimens, for pathogen detection or for early detection of diseases. However, most appealingly for

monitoring purposes in laser materials processing is the possibility to retrieve temperature information as well.
Our developed HSI system comprises a high-speed camera and a self-designed HSI-lens and is inspired by the work of Habel [1]. The high-speed camera features a full frame, one megapixel CMOS sensor spectrally sensitive from 350 nm to 1100 nm. The developed HSI-lens system comprises standard photography lenses and a dispersive element that separates the incident process emissions into its constituent wavelengths. This spectrum is then detected by the high-speed camera's sensor. Interpreting the resulting spectrum as a gray-body spectrum, correct temperature information upon the investigated process can be retrieved without a priori knowledge of the emissivity. The HSI-system is capable of capturing up to 240,000 fps falling far below typical time resolutions of current state-of-the-art technologies, e.g. pyrometers. In this work, we show a proof of concept of high-speed temperature determination based upon HSI-derived spectra and present initial process observation results.

References

[1] HABEL, Ralf; KUDENOV, Michael; WIMMER, Michael. Practical spectral photography. In: Computer graphics forum. Oxford, UK: Blackwell Publishing Ltd, 2012. S. 449-458.