VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Artem Shcheglov**

The public defense will take place on **Wednesday 8th February 2023 at 4:00pm** in room **D.0.08** (Building **D**, Brussels Humanities, Sciences & Engineering Campus)

To join the digital defense, please click here
Meeting ID: 324 863 446 947
Passcode: LzVYnj

NEXT-GENERATION MINIATURIZED SPECTROSCOPIC SYSTEMS

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Abstract of the PhD research

Optical spectrometers can convert substance information into readable, unique optical signals in a non-conduct, non-destructive way. Over the past decades, spectral instruments have been mainly applied in industrial or scientific applications, such as metrology and security. With the increasing health awareness of citizens in Europe, people want to know whether the substances they eat, drink, and breathe are healthy or not. Therefore the consumerlevel spectroscopic devices are to be further developed. This PhD research aims to address these needs and create novel and cost-effective methods to sense the desired analytes with high sensitivity, high reliability and sufficiently compact and portable devices so that spectroscopic measurements can be used as a consumer electronic product.

The research performed in this doctoral thesis gives potential solutions to the abovementioned needs from several perspectives: (1) optical design of a spectrometer, (2) fabrication of diffractive optical elements and (3) image reconstruction algorithms. In this work, I propose two novel optical configurations of miniaturized spectrometers based on dispersive optical elements capable of covering both the visible and short-wave infrared ranges of the electromagnetic spectrum. Both spectrometers have been realized by studying the optical and mechanical designs, fabrication, and proof-ofconcept demonstration.

The first spectrometer is fully based on commercially available optical components to demonstrate the capabilities and limitations of a design without custom optics. The second one utilizes a designed concave diffraction grating that combines the functionality of a dispersive grating and an imaging mirror in one optical component, giving an additional possibility for further spectrometer miniaturization. In addition, we also investigate state-of-theart technologies suitable for sub-micron periodical structure fabrication. We choose two advanced fabrication techniques: diamond-tooling and twophoton polymerization, which are utilized to manufacture a master mold with a desired structure. The fabricated mold is used afterwards for replication using hot embossing technology, ensuring a cost-effective fabrication of micro-scale grating structures.

With the assembled prototypes, we investigate and propose digital reconstruction algorithms for post-processing captured spectral images. These algorithms allow to design an optical system with certain residual aberrations and then correct them digitally by image post-processing. It alleviates the requirements for the imaging quality of an optical system and provides additional flexibility to ensure compactness, high performance and cost-efficiency in one device.