Special section on

Optical Sensors

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Background

Optical sensing has been used for numerous years, and optical measurement techniques are central to many measurement systems sold worldwide. The apparatus cover areas such as medical diagnostics, food analysis, and industrial process monitoring. The background for the intensive deployment of optical technology is the well-known advantages of measuring non-contact combined with ultra-high precision. Also, sensing can be directed against exactly the specimens that need to be measured.

The current development in the field of optical sensors is primarily directed against more low-cost compact sensors that measure several parameters simultaneously. This is the scope of this special section on optical sensors.

State of the art

Optoelectronic components (e.g., semiconductor lasers and detectors) are central to all optical sensor systems and development in this field is progressing rapidly. The development is, and will be, driven by the needs from the telecommunication and entertainment industries. The compact disc pick-up and digital cameras being prominent examples of products emerging from the rapid development of optoelectronics.

Parallel to the rapid development in optoelectronics, massive efforts are being directed into fabrication of micro-optical elements. This is a multi-disciplinary field and requires in-depth knowledge of, e.g., materials science, micro structuring, polymers, replication, and evaluation techniques.

Combining the novel optoelectronic components with the micro-optical elements provides a basis for low-cost miniaturized optical sensors. However, it is not trivial to combine the optical components, which calls for an optical design tool that allows for trade-off analyses. Extensive software packages are constantly being updated with new features, but very often much simpler approaches are more than sufficient.

Content of the special section

With this special section on optical sensors the reader might expect a broad review of state-of-the art within optical sensing. In light of the introduction given above I have chosen a somewhat different approach that I hope will be appreciated. I will present some state-of-the art components and techniques involved in the realization of miniaturized optical sensors and also present a few applications.

First, it is my pleasure to present a paper on Vertical Cavity Surface Emitting Lasers (VCSEL's) by Jim Guenter from Honeywell (US). With Honeywell as a major player, VCSEL's have really emerged over the last years and it is a very hot topic in semiconductor laser research. Primarily, the VCSEL's were launched for local area network (LAN) applications, but due to its superior beam properties, it is likely that a few years from now, the main application is for optical sensing.

Shaping the light from the light source and directing it towards the measurand require a design tool that not only can determine the beam processing, but also include important effects such as diffraction and interaction with matter. René Skov Hansen and Steen Hanson from Risø National Laboratory have developed novel analytical design tools based on a simple ray-matrix formalism. After reading the paper it will become apparent that using the complex *ABCD* matrix formalism is a bit like eating presliced cheese. Someone else has got greasy fingers!

Aimed now with a novel laser source and a strong analytical design tool, the micro-optical element can be designed and manufactured. Carsten Dam-Hansen, Kamstrup, and Henrik Pedersen from Risø National Laboratory have worked extensively with the many disciplines involved with replication of micro optics. Their paper describes the entire process including master fabrication in photoresist, tool fabrication, replication techniques, and lists some potential optical materials. Finally they show some novel examples of replicated diffractive optical elements.

After the light has been processed by the optical elements it is directed towards a detector. Most readers are familiar with the CCD based image sensors that have been around for years – and some have had the struggle of finding a CCD that suits a compact sensor! Therefore it is a pleasure for me to present the paper on new smart image sensors based on pure CMOS technology. The paper is written by Peter Seitz, CSEM (CH), who represents one of the leading research groups in this field. The exciting technology is illustrated with two optical sensor examples utilizing not only "smart image sensors" but also "smart pixels".

Hanson *et al*. presents some novel optical displacement sensor applications based on the laser-speckle principle. The applications utilize VCSEL's and have been designed using the *ABCD* matrix formalism. One of the applications, an angular displacement sensor, has been realized using a CCD image sensor. It will be apparent to the reader that this application would benefit dramatically from using CMOS-based "smart image sensors"!

Finally, Lars Lading presents a compact bio-optical sensor based on intracavity sensing. Besides presenting a novel sensor application Lading discusses various ways of implementing the optical sensor in light of the so-called value chain. The need for these considerations is often underestimated, and focus is primarily directed towards basic physical understanding of the sensor. Lading stresses the need for mastering a number of technologies in order to bring the basic principle to a commercially viable product. Clearly, this point is fully in line with the scope of this special section on optical sensing.

Before wishing you a pleasant time reading this special section, let me take this opportunity to thank all the authors.