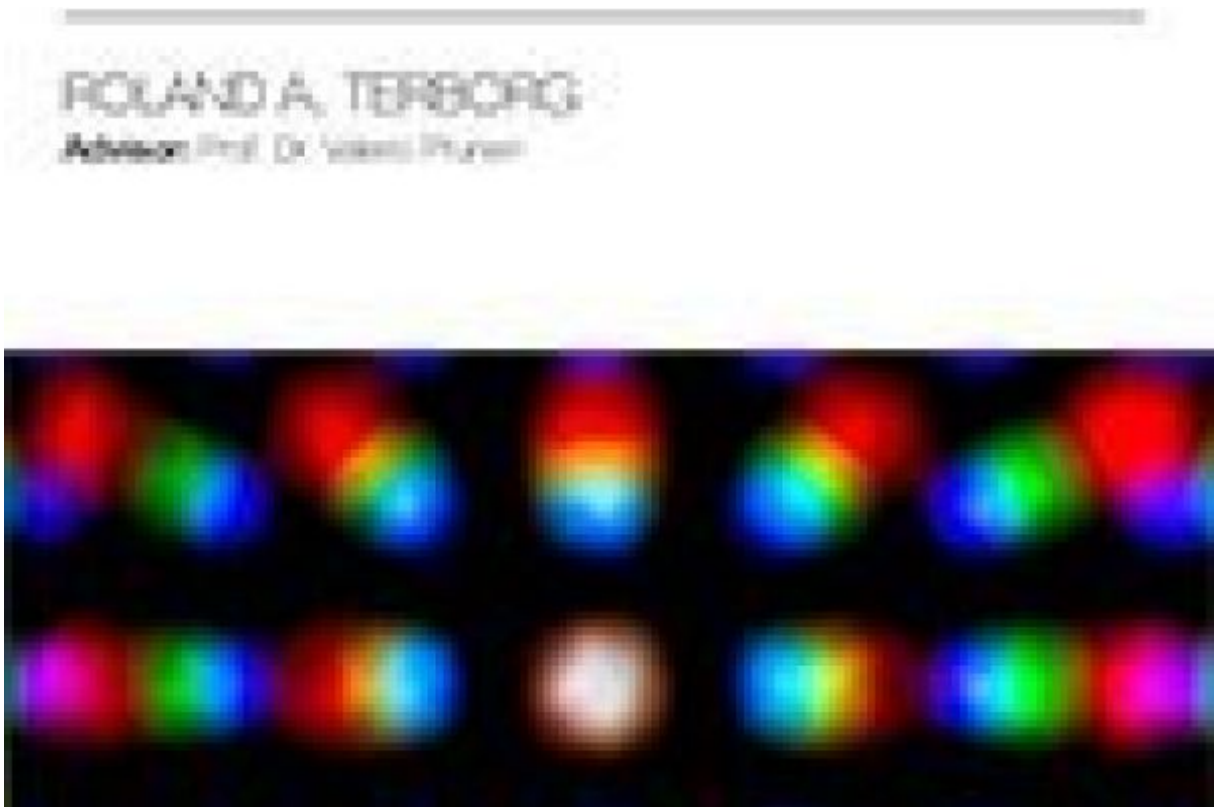

# PhD Thesis Defense ROLAND TERBORG 'Lens-Free Interferometric Microscope for Transparent Materials'

ROLAND TERBORG

October 19, 2018

Friday, October 19, 11:00. ICFO Auditorium

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As health systems fight against epidemics and infectious diseases, new forms of diagnostics need to be developed in order to meet the growing demand for services, often in locations without the necessary infrastructure. An emerging solution to this problem is point of care (POC) devices since they can provide rapid diagnostics without the need for specialized personnel or complex infrastructures.
In this thesis, we show the development of a POC platform for the rapid early detection of infection, in particular Sepsis, a whole-body inflammatory reaction with high mortality rates.

The main components of this platform are: a lens-free interferometric microscope (LIM) and a microfluidic cartridge with a functionalized plasmonic chip for the label-free detection of biomarkers. The LIM is also able to measure the phase modulation in commercial plasmonic chips.

More specifically the thesis describes:

The development of a LIM with a large field of view and depth of field showing a sensitivity of 1nm along the beam propagation axis, which allows, for instance, the measurements of ultra-thin (2nm thickness) transparent silica and protein monolayer microarrays.
The generation of periodic structured light beams, obtained using a simple configuration including the birefringent elements of the LIM. These can be applied not only to imaging and biomarker detection but also in additive manufacturing and micro-structuring of surfaces.
The phase measurement of commercial surface plasmon resonance chips for the detection of changes in the refractive index of liquids. The phase measurements provide a sensitivity for bulk refractive index changes that is about one order of magnitude larger than for intensity-based detection under similar conditions. These results show a potential enhancement of the sensitivity of standard systems used in the biomedical community.
The development of a POC device comprising the LIM as a reader of specifically designed plasmonic gold nanohole array chips. The reading of the phase signal in the LIM shows a sensitivity increased by one order of magnitude thanks to the enhanced localized surface plasmon resonance interaction. Low concentrations of proteins and bacteria (as low as a single unit) are detected in measurements that also include human samples. This platform has the potential to multiplex the signal for simultaneous detection of thousands or even millions of different biomarkers.

The LIM presented in this thesis is a very sensitive and robust imaging system with a high performance level for the detection of small quantities of transparent materials, with applications in microscopy and biomedicine.

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**Thesis Advisor: Prof Dr Valerio Pruneri**

