



## PHD PROPOSAL:

# HYPERSPECTRAL TOMOGRAPHIC DIFFRACTIVE MICROSCOPY: RESEARCH AND APPLICATIONS

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Silicone implants are among the most widely used medical devices, implanted in pectoral muscles, calves, buttocks, testicles, or breasts. However, they may contribute to chronic inflammatory diseases. The IS2M-BioInterface group is doing pioneering work to raise awareness about these issues [1]. *One of the present challenges is to visualize and identify silicone accumulation at intracellular level (Fig. 1).*

At IRIMAS we develop a method called Tomographic Diffractive Microscopy (TDM) [2-5], imaging directly from the optical field transmitted or reflected by the object [6,7]. By varying the object's illumination conditions, it is possible to obtain a 3D reconstruction of its complex refractive index, with improved resolution compared to conventional methods [2,5,7], and rendering sample labeling optional.

These methods offer an interesting alternative to fluorescence microscopy, but presently still suffer from a lack of chemical selectivity: indeed different structures or components may have a similar refractive index, which preclude properly identifying them, apart from possible morphological peculiarities.

*This innovative PhD aims at developing new methods, to restore selectivity in tomographic images, and to investigate applications on silicone nano-microparticule ingestion by macrophages.*

Preliminary studies have shown that it is possible to access quantitative polarization information, offering structural selectivity by distinguishing non-birefringent and birefringent elements [8,9].

Dynamic selectivity is also possible: heterodyning of the detected signal allow for isolating moving structures by measuring the Doppler effect induced on scattered light [10].

Another possible approach is based on multispectral or hyperspectral imaging (spectro-imaging), another topic of this PhD proposal. In particular, it has already been proven that the variation of absorption with wavelength enables chemical species to be distinguished at the micrometric scale [11,12].

The proposed PhD therefore comprizes 3 sub-topics:

- an instrumentation part, to upgrade our instrument for hyperspectral and/or polarimetric TDM,
- a numerical aspect to develop tomographic image reconstruction algorithms using these data [13,14],
- an experimental aspect to perform acquisitions on living macrophage ingesting nanoparticles.

*For such a project, a taste for experimental work (instrumentation, microscopy imaging), as well as for computer science (acquisitions automation, image reconstruction) is mandatory. The successful candidate will have to be proficient in an object-oriented programming language (C++, Python, Matlab...).*

*You will join 2 dynamic teams, with internationally recognized scientific expertise, and benefit from their available equipment and operating resources (to attend conferences, for publication fees, etc.).*

PhD fellowship: 2390 €/month in 2026 (Depending on your situation, you may also be eligible for APL housing assistance. Starting in the second year of PhD, part-time courses are also an option).

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| 1. I. Pluvy, <i>et al.</i> , Biomaterials 317, 123025 (2025) | 8. A. M. Taddese <i>et al.</i> , Opt. Express 31, 9034 (2023) |
| 2. V. Georges, <i>et al.</i> , Opt. Lett. 34, p. 79 (2009)   | 9. N. Verrier <i>et al.</i> , J. Microscop. 289, 128 (2023)   |
| 3. B. Simon, <i>et al.</i> , J. Biophoton. 3, p. 462 (2010)  | 10. N. Verrier, <i>et al.</i> , Opt. Express 22, 9368 (2014)  |
| 4. H. Liu, <i>et al.</i> , Appl. Opt. 53, p. 748 (2014)      | 11. Y. Sung, Phys. Rev. Appl., 10, 054041 (2018)              |
| 5. B. Simon, <i>et al.</i> , Optica 4, p. 460 (2017)         | 12. Y. Sung, Phys. Rev. Appl., 19, 014064 (2023)              |
| 6. E. Wolf, Opt. Comm. 1, 153 (1969)                         | 13. T. Zhang, <i>et al.</i> , Opt. Express 26, 26093 (2018)   |
| 7. V. Lauer, J. of Microscopy 205, 165 (2002)                | 14. F. Yang, <i>et al.</i> , Opt. Express 28, 3905 (2020)     |

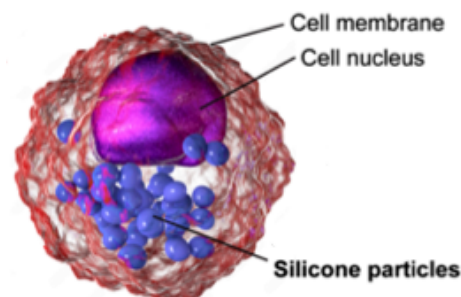


Fig. 1 Illustration of a macrophage cell having ingested many silicon nanoparticles