Applied Mathematics Seminar

UCC
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Modelling of magnetic-field and photonic-crystal biosensors

We investigate two types of biosensors suitable for mobile and point-of-care applications. Portable magnetic-field sensors require a compact setup as well as room-temperature operation in an unshielded environment. We investigate magnetic-field sensors based on resonant magnetoelectric cantilevers of strain-coupled magnetostrictive, piezoelectric, and substrate layers. A linear material model is used to calculate the small-signal behavior of sensors at the working point. The resonance line shape at the first bending-mode resonance shows a Fano line shape in finite element method (FEM) simulations as well as in experiments. This line shape is explained by the co-existence of a direct and a resonance-assisted pathway inducing voltages of equal or of opposite sign. These findings are particularly important for the case of an inhomogeneous magnetic excitation field [1]. Simulation results will be discussed in comparison to experimental results.

Point-of-care screening of multiple molecular biomarkers from a single sample is an essential next step in early disease diagnosis as well as infectious disease identification. We target label-free detection of biomarkers based on nanostructured surfaces and specific surface functionalization. We demonstrate a new photonic-crystal readout scheme based on multi-pinhole interferometry [2]. The simulation method is introduced and results are compared to experiments. This approach offers inherent differential referencing between a multitude of measurement fields on a surface. A theoretical study of an 11-plex and a 54-plex design is presented.

[1] M.-Ö. Özden, A. Teplyuk, Ö. Gümüs, D. Meyners, M. Höft, and M. Gerken, "Magnetoelectric cantilever sensors under inhomogeneous magnetic field excitation," AIP Adv., vol. 10, no. 2, p. 025132 (2020). https://doi.org/10.1063/1.5136239

[2] J. Bläsi, M. Gerken, "Multiplex optical biosensors based on multi-pinhole interferometry", Biomedical Optics Express Vol. 12, Issue 7, pp 4265-4275 (2021). https://doi.org/10.1364/BOE.426991

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