ULTRASENS-E

All-dielectric and ULTRASENSitive microwave Electric fields sensor based on the electro-optic effect

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Budget: 283207,52 €

CominLabs days October 10-11

The team

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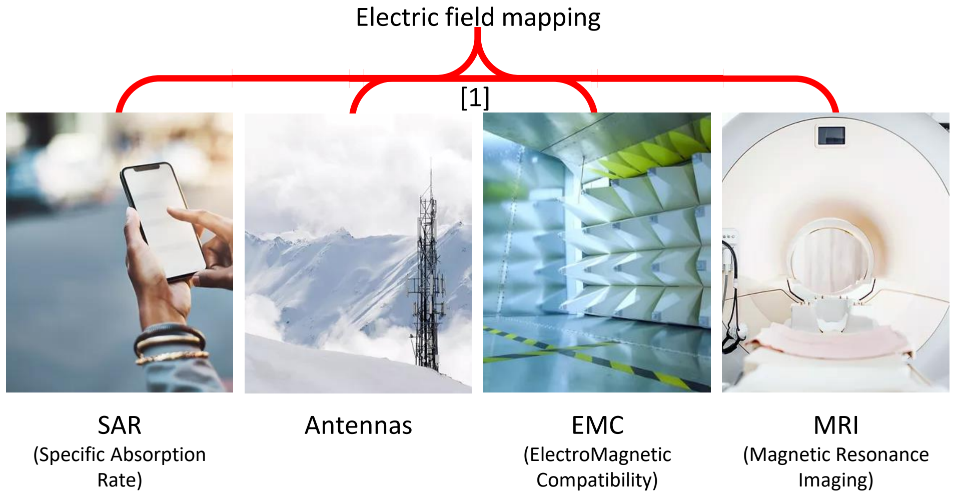
Abstract

We propose to increase the sensitivity of microwave electric field sensors by two orders of magnitude. To do this, we will combine a lens made by 3D printing focusing the wave on a photonic micro-resonator made with a very efficient electro-optical (EO) polymer. These improvements will be of great benefit to all areas of microwave radiation applications: for example, life sciences or electronics industry.

Exemples of application areas

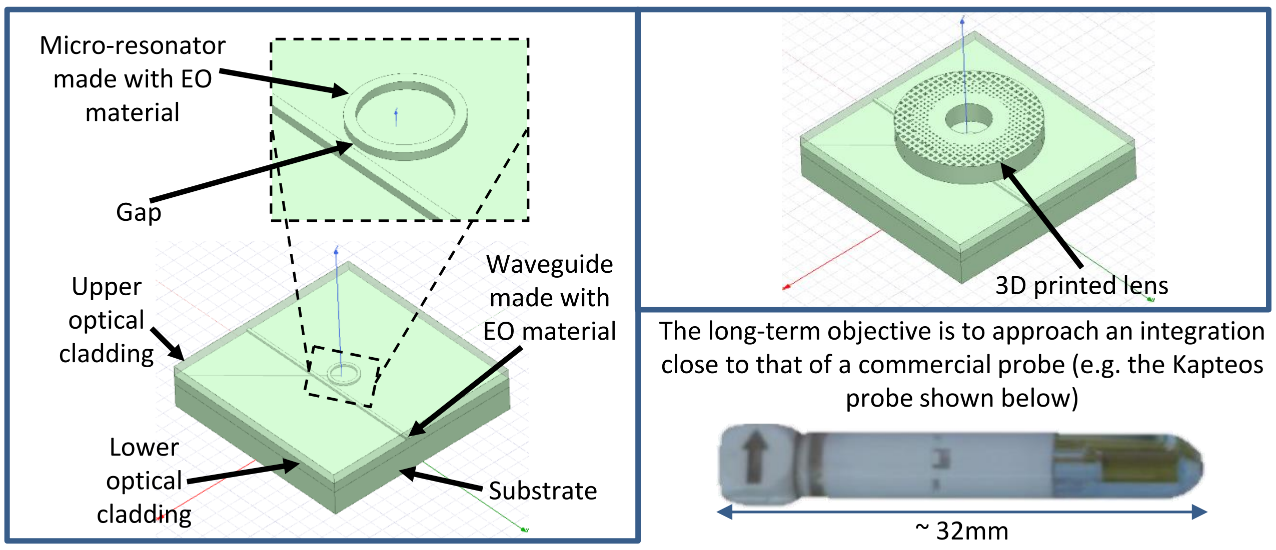


The existing and our approach

Electric field sensors presented in the literature are only based on Mach-Zehnder interferometers or Bragg gratings fabricated with various materials and the given sensitivities hardly go beyond 10^{-3} V·m^{-1}·Hz$^{-1/2}$[1, 2].

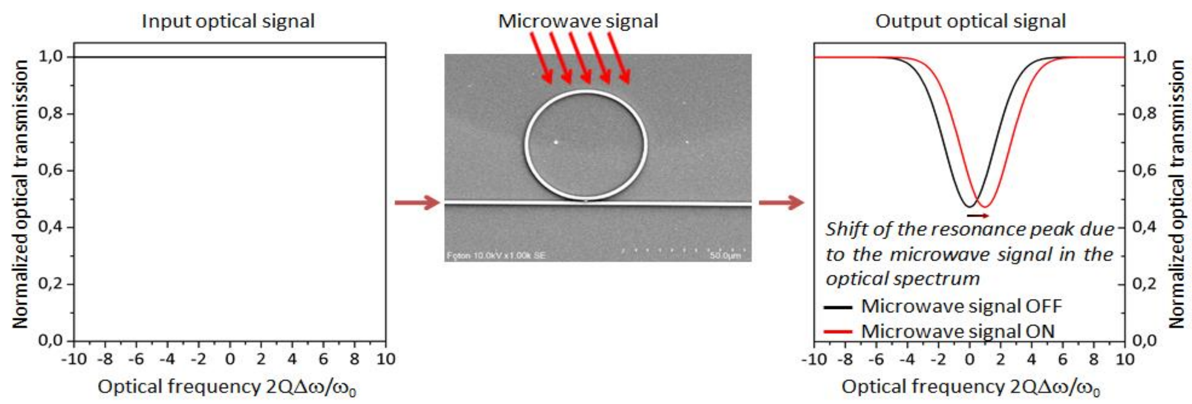
We propose a new approach to design and build the functional unit of an all-polymer integrated ultra-sensitive microwave electric field sensor based on an electro-optical modulator. By focusing the incident wave with a lens made by 3D printing on a photonic micro-resonator made with a very efficient electro-optical polymer, we propose to increase the performances of this kind of electric field sensor by improving the sensitivity by 2 orders of magnitude compared to the existing.

General diagram of the integrated functional unit (top figure) and its working principle (bottom figure)



The long-term objective is to approach an integration close to that of a commercial probe (e.g. the Kapteos probe shown below)

~ 32mm



Measured temporal variations of the E-field will be transformed into an intensity modulation of the laser (due to the EO effect).

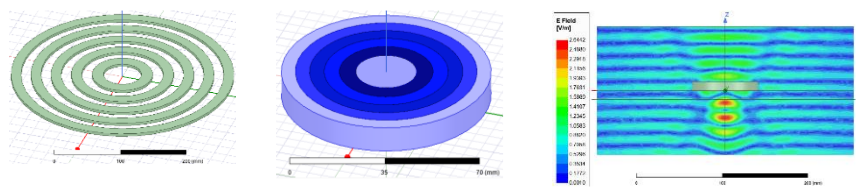
Measuring the amplitude and the phase of this modulation will give the amplitude and the phase of the E-field (by mixing the photo-current resulting from the detection of the optical signal with a local oscillator).

The targeted advances

- Use of new chromophores synthesized by ISCR,
- Integration and orientation of these chromophores in a host matrix (IPCMS),
- Obtaining sufficient electro-optical coefficients (IPCMS),
- Shaping of these new materials (Institute FOTON),
- Design and realization of the micro-resonator (Institute FOTON),
- Design and production of the lens by 3D printing (Lab-STICC),
- Assembly of the whole (Lab-STICC / Institute FOTON),
- Study of the nonlinear optical / microwave interface (Lab-STICC / Institute FOTON / Postdoc). The postdoctoral fellow will be physically at Lab-STICC but also will have a very strong interaction with the Institute FOTON.

What has already been done

- June 28, 2022 : Project kick-off meeting
- Purchase of various equipment and consumables essential to the good start of the project (calculation software, bench characterizations, ...).
- Christophe Vong has started his postdoctorate on September 1st.
- Objects have been shaped with the chosen materials in order to be characterized. The results of these characterizations will be used for the calculation and numerical optimization of the lens and the micro-resonator.
- We are in the process of choosing the right microwave lens. According to the first results, we are moving towards the choice of a Fresnel lens with a gradient index of refraction.



Binary Phase Fresnel Lens | Gradient Index Fresnel Lens | Example of E field obtained with a Gradient Index Fresnel Lens

[1] http://www.kapteos.com/en/all-faqs/faq-applications/.

[2] J. Peng et al., "Recent Progress on Electromagnetic Field Measurement Based on Optical Sensors," Sensors, vol. 19, no. 13, p. 2860, 2019, DOI:10.3390/s19132860.