ULTRASENS-E

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

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Christophe VONG, Vincent LAUR, Annaig MARTIN-GUENNOU, Azar MAALOUF

Joël CHARRIER, Jonathan LEMAITRE, Parastesh PIRASTEH, Yannick DUMEIGE

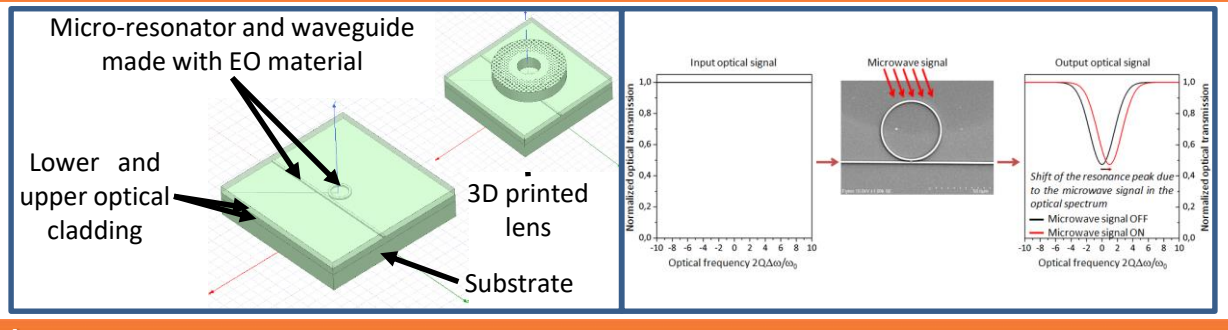
Service Providers

Loic MAGER, Alberto BARSELLA

Sylvain ACHELLE, Françoise ROBIN-LE GUEN

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.

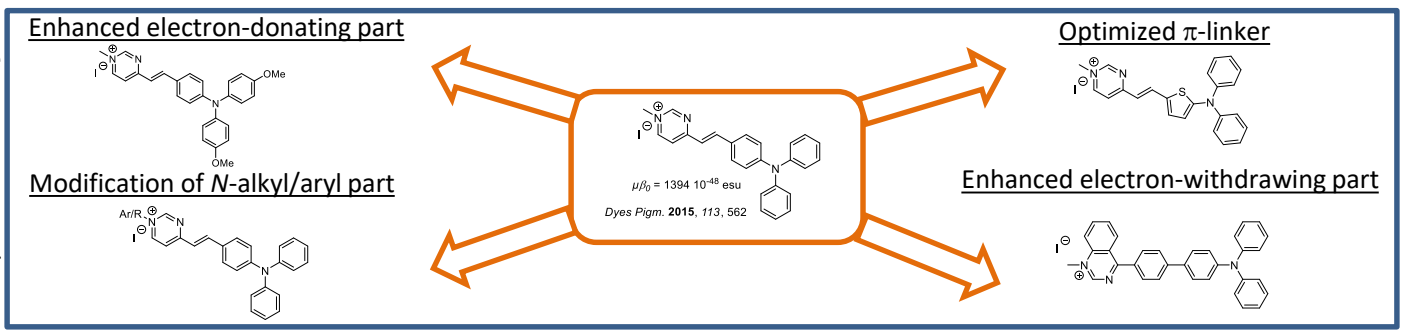


The long-term objective is to approach an integration close to that of a commercial probe (e.g. the Kapteos probe shown below)

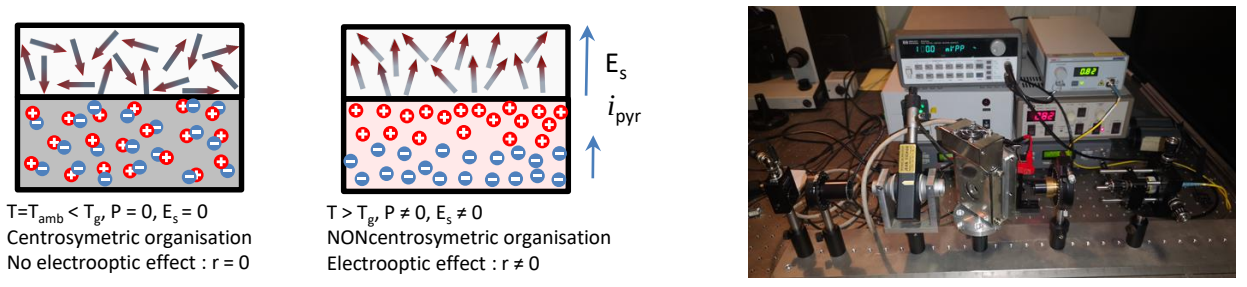
The past year's achievements

Following our initial results on *N*-methylated styrylpyrimidinium dye various structural modifications have been proposed to improve the NLO response:

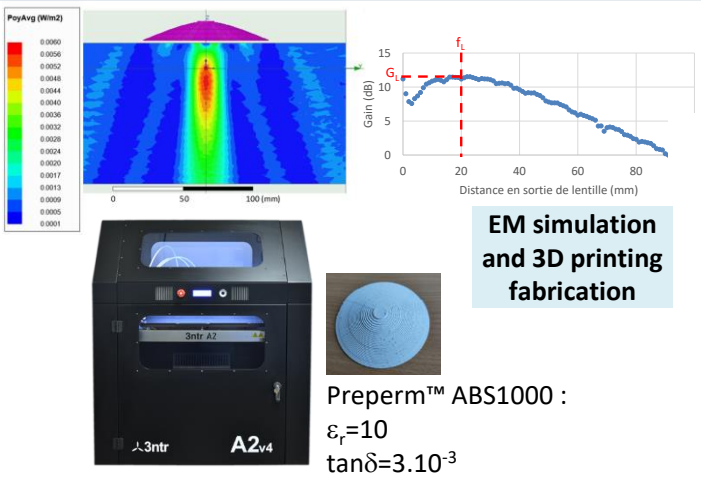
- Reinforcing the electron-donating strength of the NPh_2 group.
- Modifying the methyl in N1 of pyrimidine by other alkyl/aryl substuents.
- Optimizing the π-linker.
- Replacing the pyrimidine ring by quinazoline, a stronger electron withdrawing fragment.



- **Validation of the ellipsometer** for electro-optic properties measurement on thin doped polymer films.
- **Ongoing preparation of high Tg doped polymers**.
- **Tests on polarization** of the doped materials via pyroelectric generated strong cw electric field.

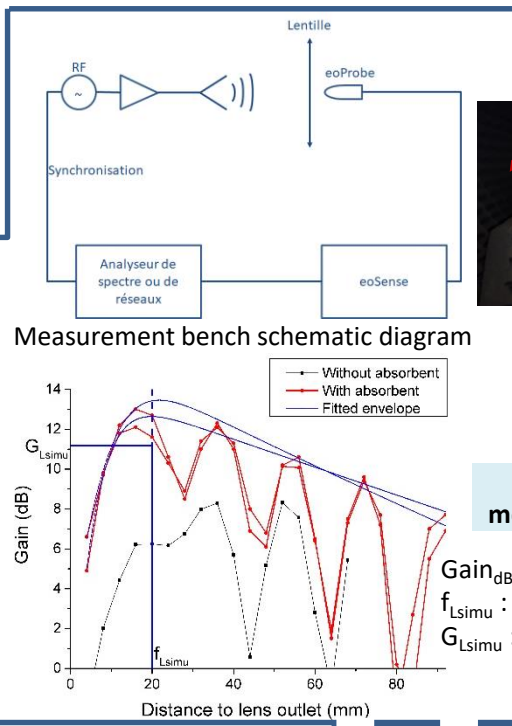


- **First study carried out entirely on a lens** (simulation, manufacturing and near-field measurement). Publication in JCMM 2023.
- **Study in progress on the optimization of a microwave lens** (miniaturization, increased gain and achromatism). Publication in a scientific journal scheduled for late 2023.



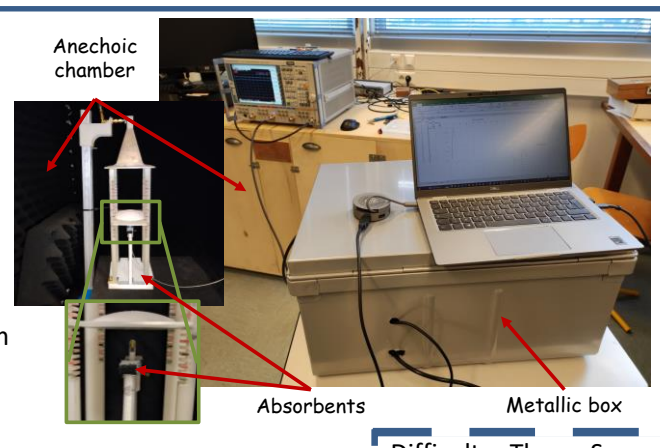
EM simulation and 3D printing fabrication

Preperm™ ABS1000 :
ε_r=10
tanδ=3.10^{-3}



Near-field measurement

$Gain_{dB} = G_{dB\ (with\ lens)} - G_{dB(without\ lens)}$
f_{Lsimu} : Focal length
G_{Lsimu} : Gain at focal length



Horn antenna : 15dB
Absorbents : -20 dB
VNA : ROHDE & SCHWARZ ZVA67
eoSense et eoProbe : Kapteos
f = 10 GHz
P = 20 dBm
Span : 1 Hz
Average : on 10 runs

Difficulty: The eoSense EO converter is also very sensitive to stray $E_{Microwave}$ fields.

Measurement bench automation: 10-week IUT internship funded by the SMART team of Lab-STICC

Improving the measurement environment: in progress

What's coming up

- Grafting the chromophore into a PMMA-type matrix.
- Doping a high Tg polymers.
- Tuning up of thin-film technology with these high Tg polymers.
- Performing various linear and non-linear optical characterizations on these materials.
- Setting up the new near-field microwave characterization bench.
- Publication on microwave lenses.