# Wavelength dependent light trapping in a chirped 3D photonic crystal made by two-photon lithography

**E. Otero[1]*, B. Soria[1], D. Gailevičius[2], V. Mizeikis[3], E. Puig Vilardell[2], K. Staliūnas[1,2], M. Malinauskas[2], J. Trull[1], C. Cojocaru[1]**

*[1]Department of Physics, Universitat Politècnica de Catalunya, Rambla Sant Nebridi 22, 08222 Terrassa (Barcelona), Spain*

*[2]Laser Research Center, Faculty of Physics, Vilnius University, Sauletekio Ave. 10, Vilnius, Lithuania*

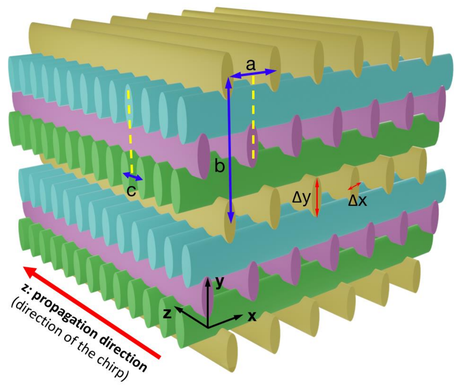
*[3]Research Institute of Electronics, Shizuoka University, 3-5-1 Johoku, Naka-ku, Hamamatsu, Japan*

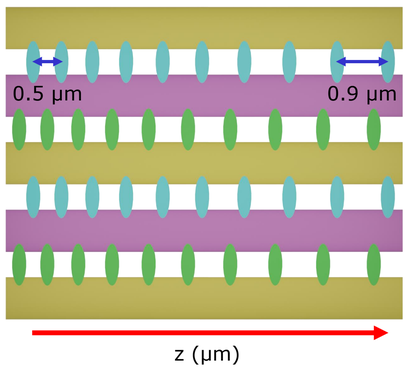
## ABSTRACT

The so called "rainbow trapping" effect (wavelength dependent light localization) is demonstrated in a chirped 3D woodpile photonic crystal in the visible and near infrared regimes. By varying the period in the propagation direction, the 3D structure is designed to progressively slow down the incident wave and to localize different wavelengths at different positions. A first experiment in the visible range shows good qualitative results, with green localizing near the beginning of the crystal and red propagating deeper. The measurements in the infrared regime show strong localization between 1400nm and 1700nm. This localization goes deeper into the crystal as the wavelength increases, agreeing nicely with our numerical simulations.

## 3D CHIRP WOODPILE STRUCTURE

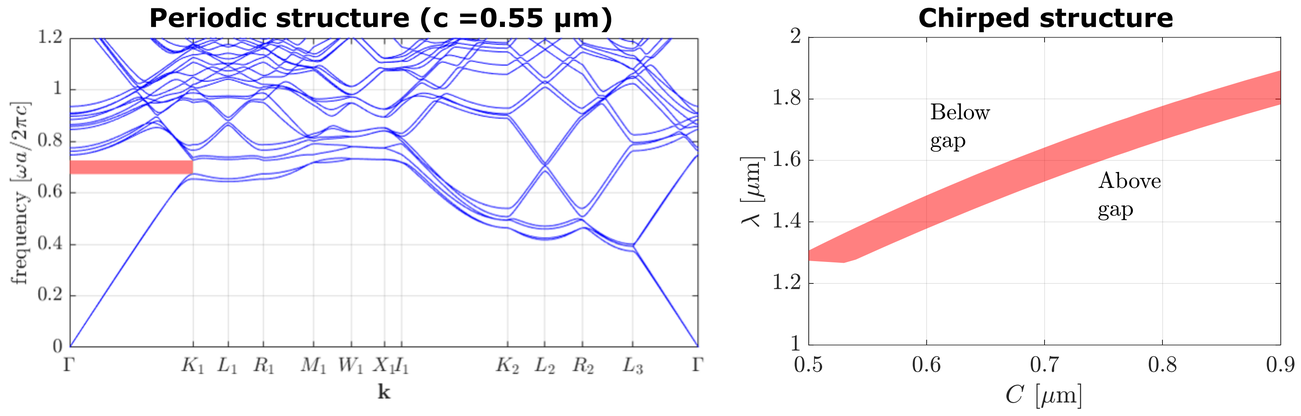
### SCHEMATIC REPRESENTATION



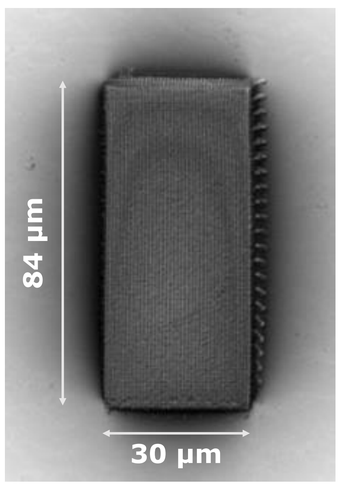

a ≅ 0.9 μm ; b ≅ 1.8 μm; c = 0.5 – 0.9 μm
Δx ≅ 0.3 μm ; Δy ≅ 0.78 μm

### THE BAND STRUCTURE



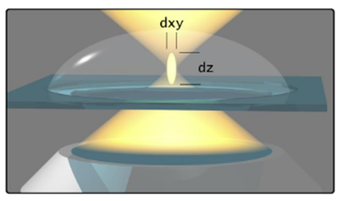

Chirping (slowly changing) the period will shift the location of the gap. By **shifting the location of the gap** along the propagation direction, **each λ is localized at a different position in the crystal**.

## FABRICATION

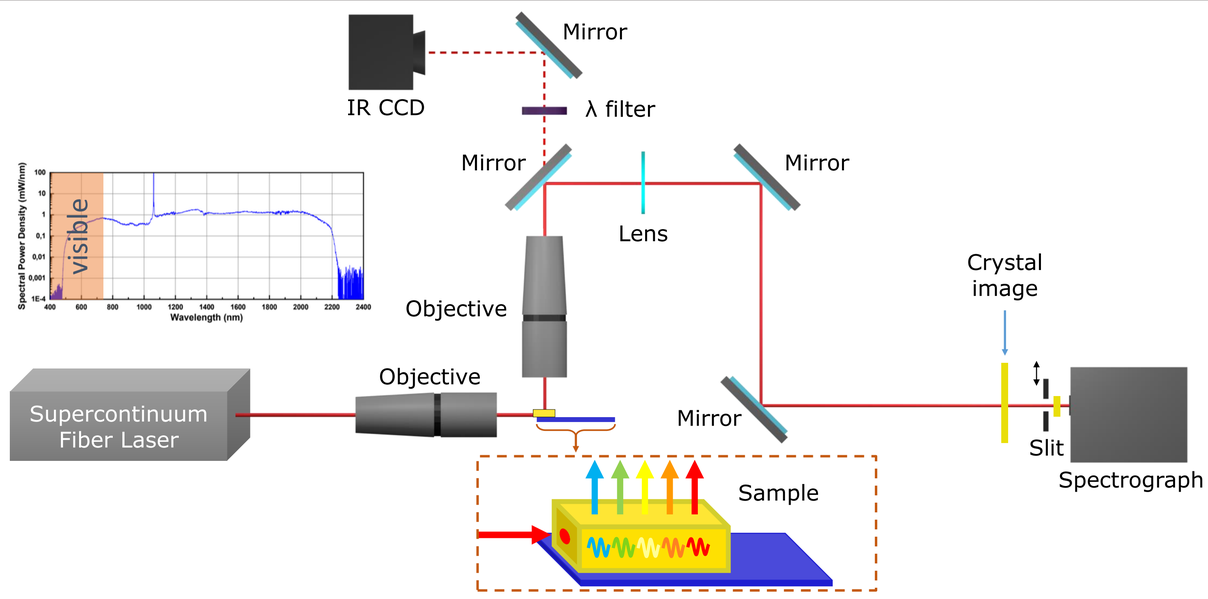



### Laser Direct Writing via Two-photon lithography

1. Polymerization of the resin (n = 1.52) in the high intensity through nonlinear absorption.
2. Sample translation in 3D space → photo-modificated 3D pattern (our structure).
3. Chemical development.

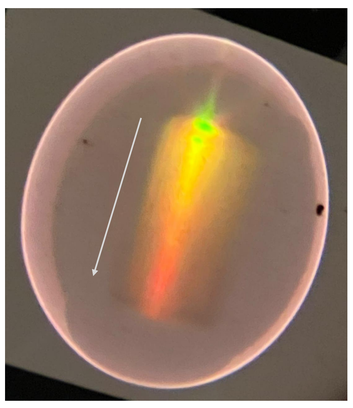


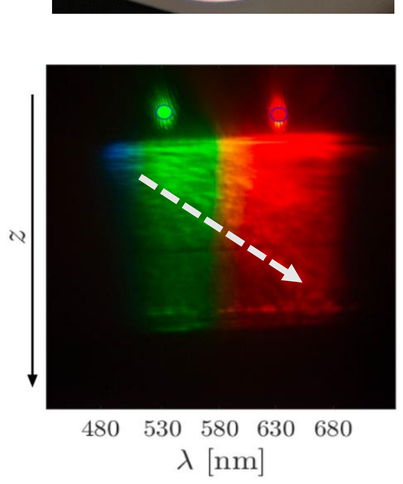

## EXPERIMENTAL SETUP



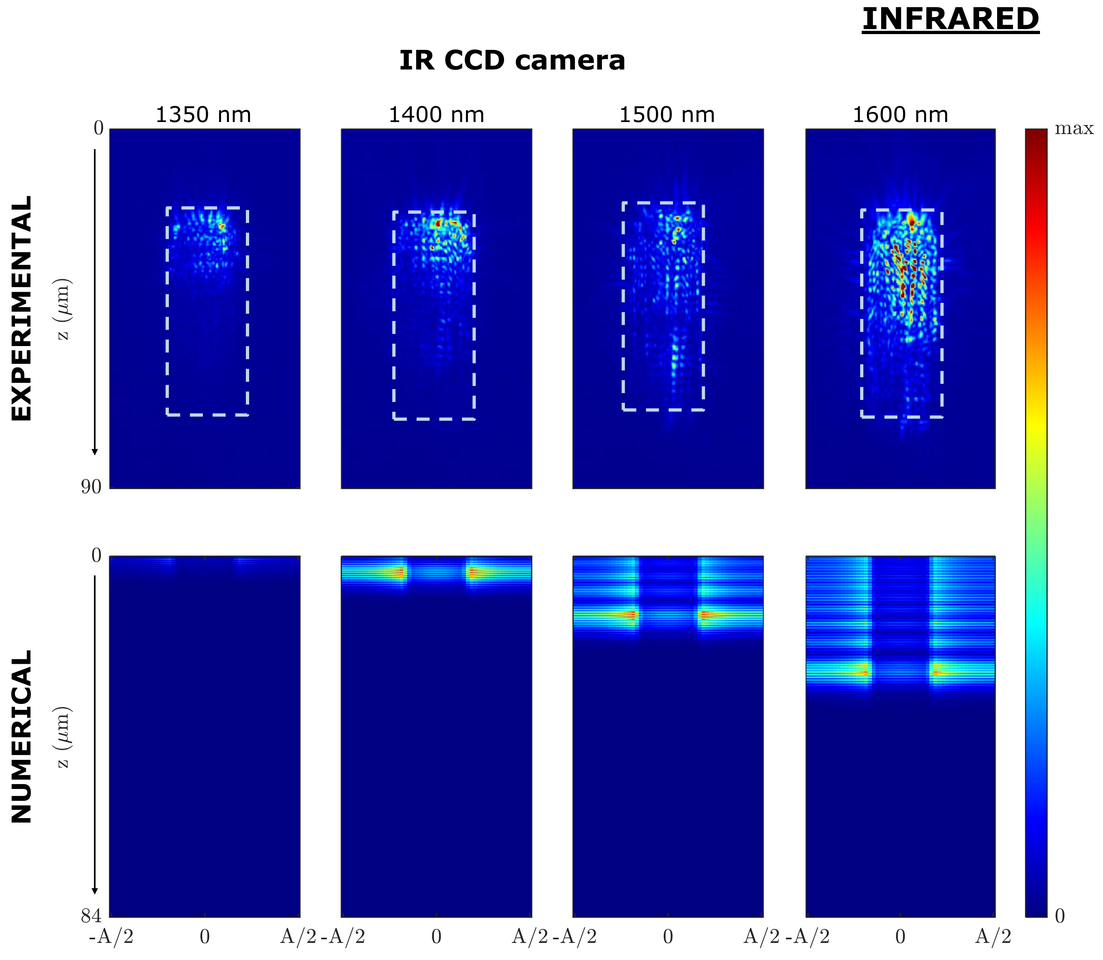

## RESULTS

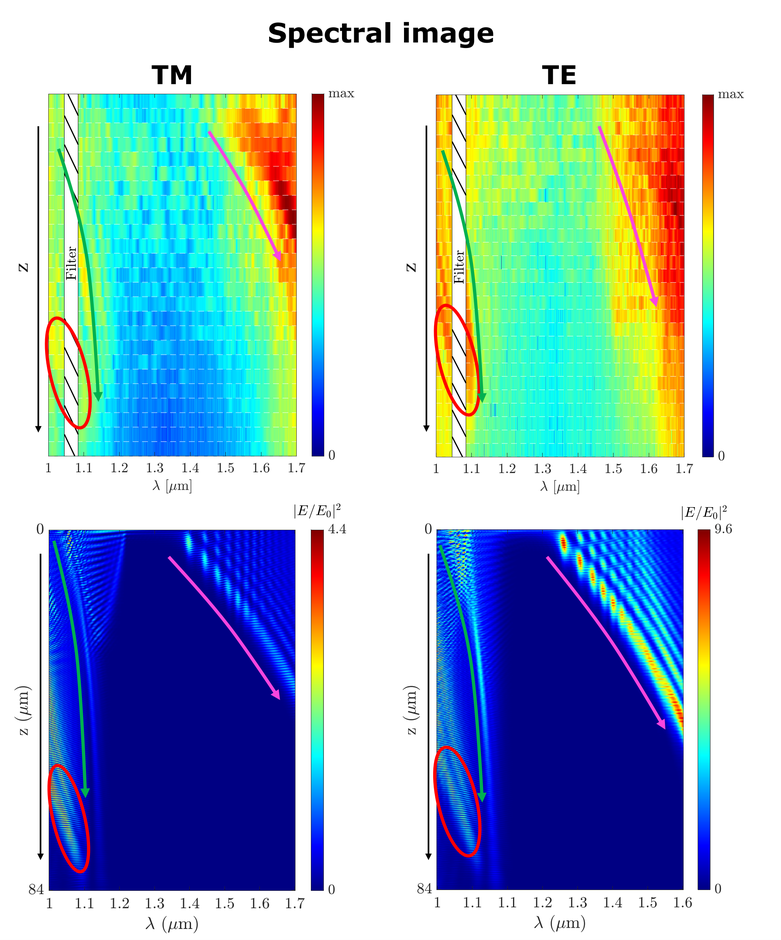
### VISIBLE






### INFRARED




## CONCLUSIONS

- Successful light localization measure as a function of position and wavelength in a chirped 3D PC in visible and IR range.
- Very good agreement between experiment and numerical simulation.
- Study of the effect of polarization on this kind of phenomena.
- Future work: application in sensing or new light sources.

## REFERENCES

[1] Z. Hayran, H.Kurt, and K.Staliunas: Rainbow trapping in a chirped three-dimensional photonic crystal, *Scientific Reports*, 7, 2017.

[2] E. Otero *et al.*: "Rainbow light trapping in a chirped 3D woodpile photonic crystal," *2024 24th International Conference on Transparent Optical Networks (ICTON)*, Bari, Italy, 2024

[3] S. Varapnickas and M. Malinauskas, Processes of Laser Direct Writing 3D Nanolithography, Springer, Cham, 2020.

## ACKNOWLEDGMENTS

EO, JT, and CC acknowledge Spanish Agencia Estatal de Investigación (project no. PID2023-148620NB-I00) and US Army Research Laboratory Cooperative Agreement N◦ W911NF-22-2-0236 issued by US ARMY ACC-APG-RTP.