

## ABSTRACT

## Metamaterial Photonic Devices Tunable with Thermochromic Materials and Liquid Crystals for Light Modulation and Smart Windows

Ibrahim Abdulhalim

Department of Electrooptics and Photonics Engineering, ECE-School, Ilse-Katz Center for Nanoscale Science and Technology, Ben Gurion University of the Negev, Beer Sheva 84105, Israel abdulhIm@bgu.ac.il

The use of liquid crystals (LCs) to tune the properties of photonic metamaterials is a topic of utmost importance since it provides a plethora of devices with superior performance. Liquid crystals possess strong electrooptic and thermooptic effects, can penetrate nano and micro holes, and therefore are ideal for making tunable metamaterial devices. The LC tunable metamaterial devices are flat, fast, have wide field of view and usually exhibit achromatic operation. Examples include wide field of view LC waveplates, tunable achromatic flat lenses, tunable achromatic waveplates, smart windows and more. Recently, we developed a number of tunable metamaterials using LCs including: (i) Tunable smart windows based on LCs doped with nanoporous microparticles combined with nanostructured VO2 metasurface to control both the visibility and the infrared radiation entering the building, (ii) Tunable achromatic waveplate made of a single thin LC retarder combined with deep nanograting, (iii) Tunable filter combining ultrathin LC layer with a resonating Fano resonance structure, and (iv) Tunable filter using thin LC layer combined with subwavelength grating. Several applications of these devices will be discussed.

## Recent publications:

[1] Saranya Bhupathi, Mohammad Abutoama, Yi Long, and Ibrahim Abdulhalim, Sculptured Thin Film Vanadium dioxide Thermochromic Coatings Grown by Oblique Angle Deposition: Investigation of Transmittance Response

and Modulation Enhancement by Experiment and Theoretical Modeling, J. Mater. Chem. C 9, 13304-16p (2021). https://doi.org/10.1039/d1tc02649f

[2] Saranya Bhupathi, Shancheng Wang, Mohammad Abutoama, Igal Balin, Lei Wang, Peter G. Kazansky, Yi Long, Ibrahim Abdulhalim, ACS Applied Materials&Interfaces, Femtosecond Laser-Induced Vanadium Oxide Metamaterial Nanostructures and the Study of Optical Response by Experiments and Numerical Simulations, ACS Applied Materials and Interfaces 12, 37 (2020). https://doi.org/10.1021/acsami.0c03844

[3] Majd Abu Aisheh, Mohammad Abutoama, Marwan Abuleil, Ibrahim Abdulhalim, Fast tunable metamaterial liquid crystal achromatic waveplate, Nanophotonics, 13 pages, (2023).

https://doi.org/10.1515/nanoph-2022-0656

P. Lakshmi Madhuri, Saranya Bhupathi, Shuddhodana, Zaher M A Judeh, Sheng-Hsiung Yang, Long Yi, Ibrahim Abdulhalim, Hybrid Vanadium Dioxide - Liquid Crystal Tunable Non-Reciprocal Scattering Metamaterial Smart Window for Visible and Infrared Radiation Control, Optical Materials Express, 11(8), 3023-37 (2021).