# Ultra-transparent broadband terahertz polarizers by nanoimprint lithography

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The far-infrared (FIR) and particularly the terahertz (THz) region of the electromagnetic spectrum were often described as the final unexplored region of the electromagnetic wave spectrum [1]. This technology's primary applications include imaging in astronomy, spectroscopic techniques, detection of chemicals or explosives, security screening, wide-broadband wireless data communication, dry food inspection, etc. [2]. Thus recently, many functional devices are being developed, such as THz emitters, detectors, and passive components, e.g. lenses, filters, attenuators, and polarizers. In particular, polarizers are essential tools in spectroscopy. These devices manipulate the polarization degree of freedom of THz electromagnetic waves. Principally, linear polarizers are designed to separate light into two perpendicular polarization directions [3]. The linearly polarized component is transmitted, and the other component is either reflected or absorbed.
We report the largest broadband terahertz (THz) polarizer based on a flexible ultra-transparent cyclic olefin copolymer (COC) film. The COC polarizers were fabricated by nanoimprint soft lithography with the lowest reported pitch of 2 or 3 µm and depth of 2 or 3 µm and sub-wavelength Au double wire grid polarizer (DWGP) configuration. Fourier-Transform Infrared spectroscopy was used in a broad range of 0.9 - 20 THz to show transmittance of the bulk materials and fabricated polarizers based on Si and polymers. COC polarizers present superior performance than Si polarizers, with extinctions ratios of at least 4.4 dB higher, more than doubled transmission intensity, and a larger operating band. Numerical simulations support results from polarizer characterization. Both Si and COC polarizers fabricated in this work show a wider operation band than a commercial polarizer. Fabrication of the polymer polarizers can be easily up-scaled, indeed meeting functional requirements for many THz devices and applications, such as high transparency, lower-cost fabrication, and made of durable and flexible material.

## REFERENCES

[1] R. A. Lewis, J. Phys. D. Appl. Phys., 37 (2014)
[2] F. F. Sizov, Semicond. Physics, Quantum Electron. Optoelectron., 22 (2019) 67–79.
[3] Y. T. Cho, Appl. Spectrosc. Rev., 53 (2018) 224–245.

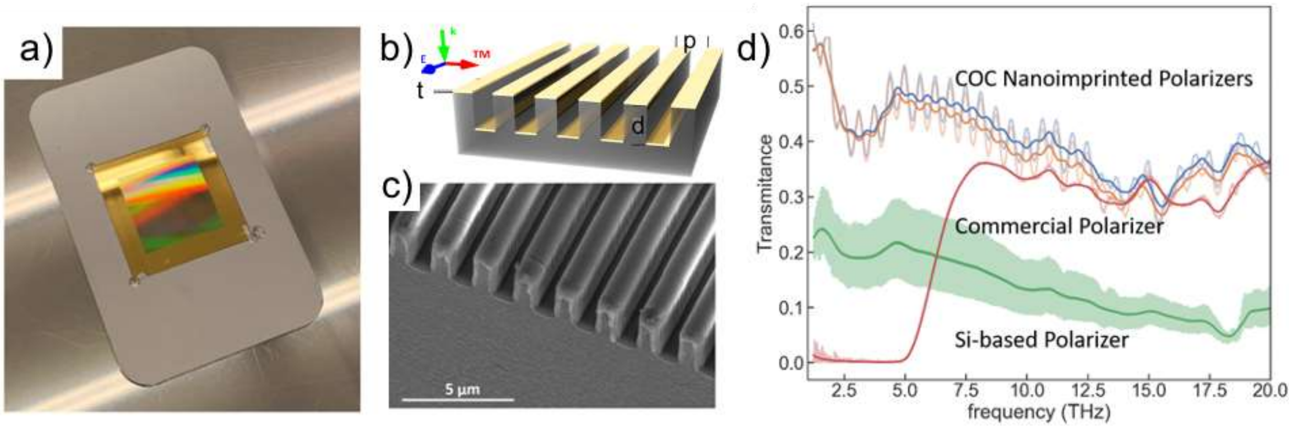


**Figure 1:** a) COC DWGP in the alignment support. b) Schematic sideview of double wire grid polarizer in COC/Si (grey) and gold (yellow). c) Cross section SEM image of COC DWGP. d) Transmitted intensity of single polarizers with t = 0.1 µm: A) COC *p* = 2 µm, *d* = 3 µm (blue), B) COC *p* = 3 µm, *d* = 3 µm (orange), C) Si *p* = 1 µm, *d* = 2 µm (green), and, D) commercial F350 polarizer from Bruker (red).