# Multimode Lasing from High-Refractive-Index 2D Periodic Photonic Devices


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The recent advancements in plasmonics have stimulated research into efficient and compact laser configurations based on the extraordinary field enhancement and large cross-sections provided by the plasmon resonances supported by metallic nanostructures [1]. However, plasmonic-based lasers suffer from the inherent absorption losses of the metal and, in addition, are difficult to integrate with conventional CMOS technology. High-refractive-index (HRI) dielectrics, virtually free from absorption losses, are gaining increasing attention as building blocks for compact lasers [2]. As compared to plasmonic platforms, HRI nanostructures can simultaneously support both electric and magnetic modes, providing a higher degree of tunability for the intensity, wavelength, and quality factor of the resulting resonances [3]. These properties have been harnessed to achieve light emission with controlled directionality and polarization, as well as to enhance spectroscopy, sensing, and nonlinear optical processes, among other applications.

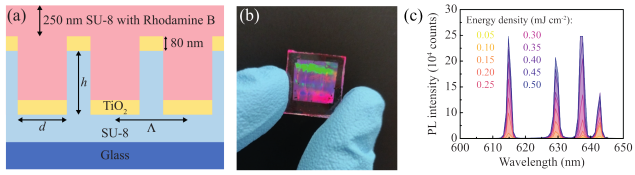


Figure 1: (a) Schematics of the system under study consisting of a SU-8 layer deposited on a microscope slide, which is patterned employing soft-lithography, covered by an evaporated $TiO_2$ layer of 80 nm thickness, and coated with a Rhodamine B-doped SU-8 layer, leaving a 250 nm thick superstrate. The lattice parameter of the optimal device is $\Lambda = 400$ nm. The unit cell contains a hole of diameter $d = 300$ nm and height $h = 350$ nm. (b) Photograph of one sample showing the typical iridescence. (c) Photoluminescence (PL) spectra of the $\Lambda = 400$ nm array under lasing conditions for increasing excitation energy densities

In this communication, we present a scalable soft nanoimprinting lithography method to create a series of HRI photonic architectures to achieve multimode low-threshold lasing [4]. A two-dimensional (2D) periodic square array of cylindrical holes is patterned into a 500 nm thick epoxy SU-8 layer, which is subsequently coated with an 80 nm layer of $TiO_2$ and covered with a Rhodamine B doped SU-8 layer, that fills the holes and leaves a superstrate on top of the holes layer of 250 nm (Figures 1a and b). We study arrays with different lattice parameters, finding that the optimal laser performance occurs when the optical resonances of the array align with the emission wavelength range of the dye. Furthermore, we observe that the anisotropy in the $TiO_2$ coating breaks the polarization degeneracy of the square arrays, leading to the emergence of new modes and enabling the simultaneous appearance of multiple lasing peaks (Figure 1c). Our work shows that, despite the simplicity of their fabrication process, the HRI structures reported here exhibit a high degree of complexity, leading to a rich optical response and enabling multiband lasing whose emission range is readily tunable through geometric adjustments. This offers an innovative approach to building robust HRI platforms for lasing with improved control over their emission properties.

## References


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