DESIGNING OPTICAL NAND GATE USING NON LINEAR PHOTONIC CRYSTAL RING RESONATOR

Project Review Presentation Under
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Photonic crystals (PhCs)

- Photonic crystals (PhCs) are periodic structures made of two materials with high and low refractive indices.
- They are categorized as 1D, 2D, or 3D based on their structure.
- **Photonic Band Gap (PBG):** The periodic nature of PhCs creates photonic band gaps, which prohibit the propagation of optical waves in specific frequency ranges.
- **Advantages of 2D PhCs:** Complete PBG and ease of design and fabrication make 2D PhCs more popular than 1D or 3D variants.
- PhCs are essential for designing optical devices like filters, demultiplexers, switches, and logic gates, critical for optical communication networks.
- They provide low loss, high bandwidth, and immunity to electromagnetic interference.

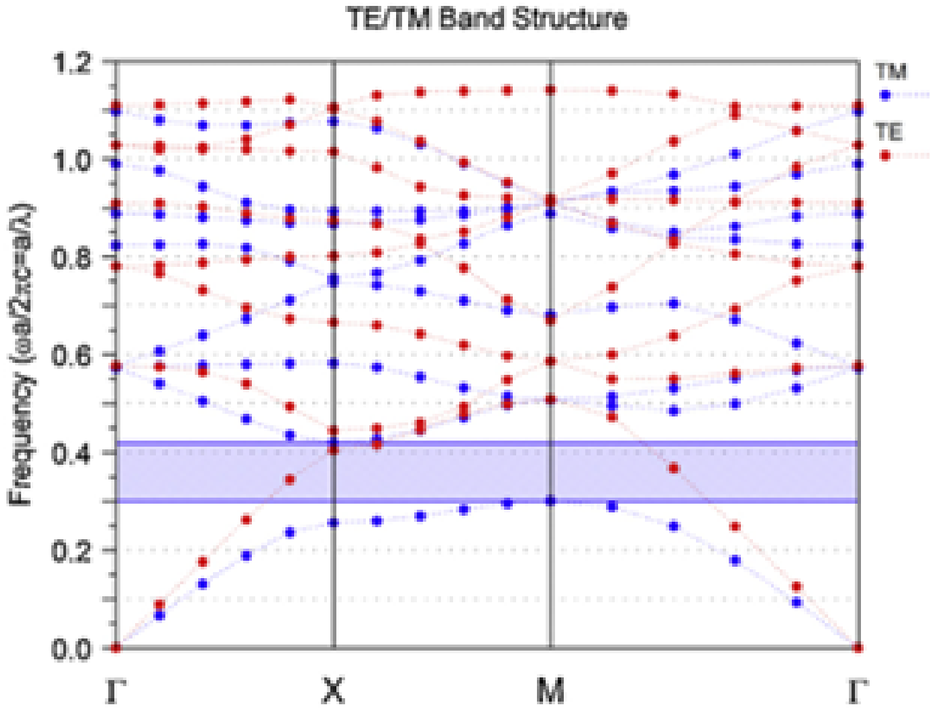
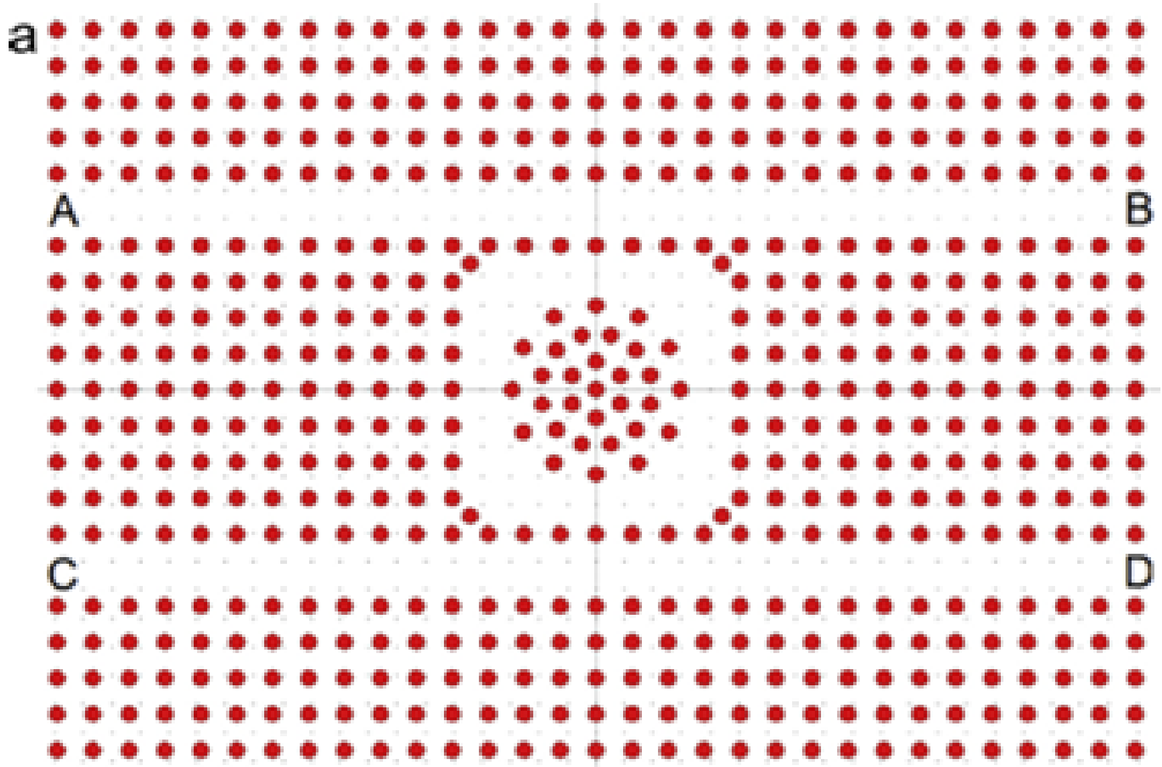


Fig. 1. The band structure of the fundamental structure.

PhC Ring Resonator(PhCRR)

- PhC ring resonators (PhCRRs) emerged as a compact and efficient alternative for optical filters, switches, and demultiplexers.
- PhCRRs consist of a resonant ring between bus and drop waveguides, allowing light at specific wavelengths to drop into the waveguide.
- Nonlinear effects, such as the Kerr effect, enable controllable optical behavior, allowing their use in designing optical logic gates.



schematic Diagram of PhCRR

RELEVANCE

- Optical NAND gates are foundational for advanced optical signal processing and communications networks.
- The all-optical approach avoids electronic components, enhancing speed, bandwidth, and reducing losses.
- Integration of photonic crystal technology offers compact, efficient solutions for optical computing.
- The advent of nonlinear photonic crystal ring resonators (PhCRRs) has enabled innovative designs for logical operations

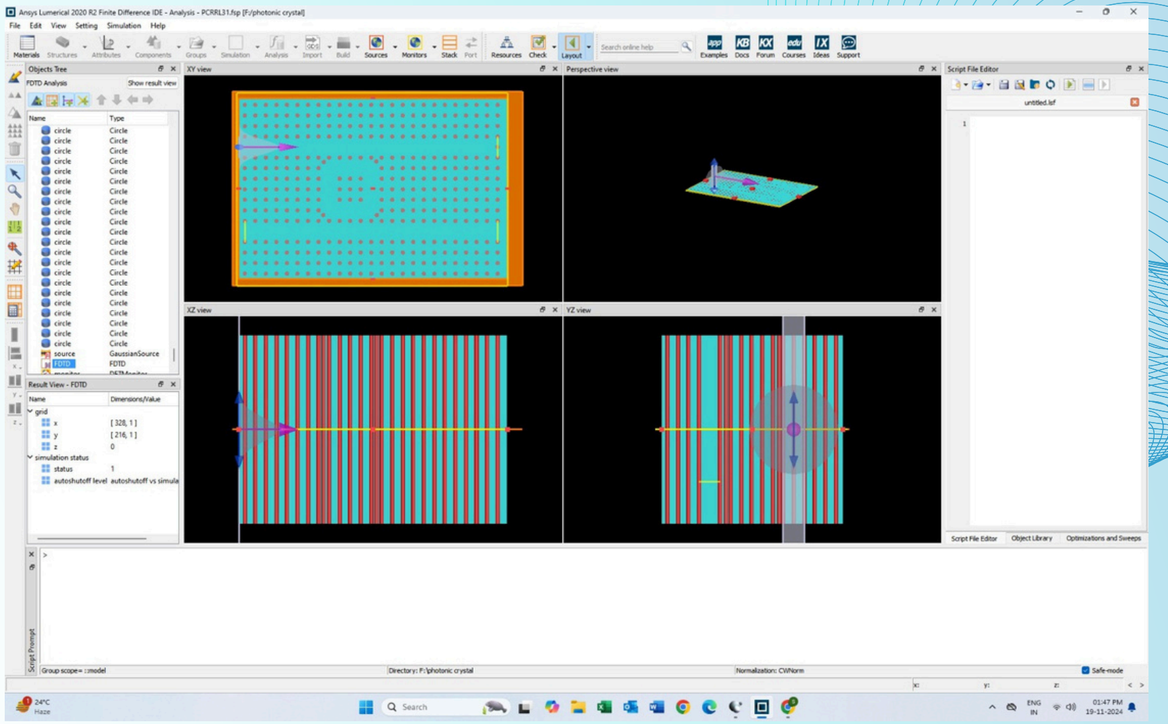
FEASIBILITY OF THE PROJECT

- Demonstrated operational designs like NOR and NAND gates using nonlinear PhCRRs.
- Achievable power intensity thresholds (e.g., 2 kW/μm² for switching).
- Well-documented methods, including Plane Wave Expansion (PWE) and Finite Difference Time Domain (FDTD), for analyzing proposed designs.
- PhCs are essential for designing optical devices like filters, demultiplexers, switches, and logic gates, critical for optical communication networks.

SYSTEM MODEL

The proposed PhCRR structure consists of:

- Two-dimensional photonic crystal arrays.
- Chalcogenide glass rods with high refractive indices (n = 3.1).
- Nonlinear Kerr effect exploited for switching behavior.



·Design:

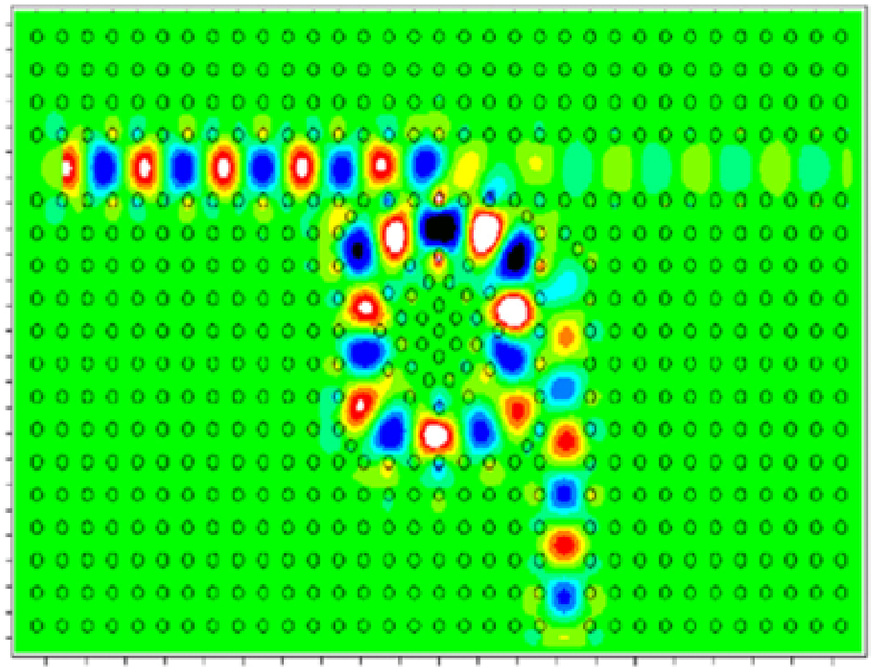
- - The structure consists of a nonlinear photonic crystal ring resonator coupled with input and output waveguides.

·Simulation:

- Lumerical FDTD is used to model and analyze the light propagation and resonance patterns.

HARDWARE / SOFTWARE REQUIREMENTS

- **Software:**
  - Lumerical FDTD for simulating optical interactions and analyzing resonance patterns.
- **Hardware (Theoretical):**
  - Nonlinear photonic crystal material for constructing the resonator.
  - Light sources to generate the input signals.
  - Detectors to measure and validate the output.

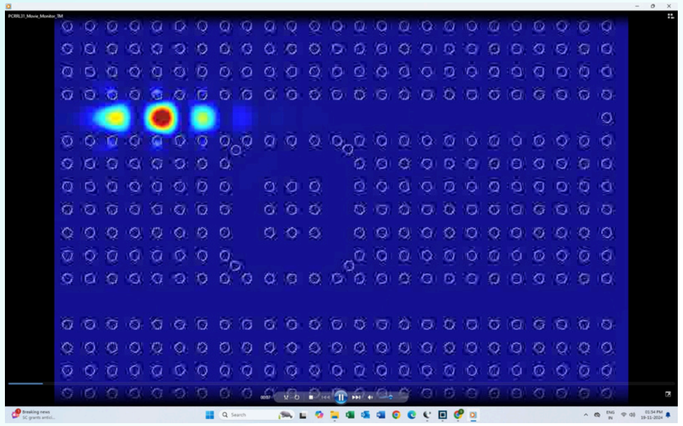


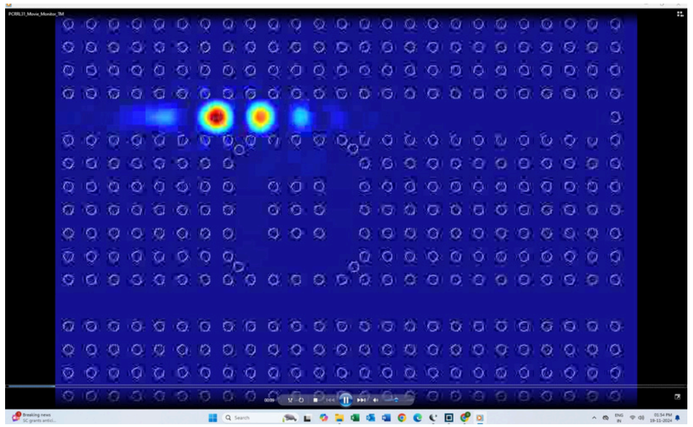
METHODOLOGY

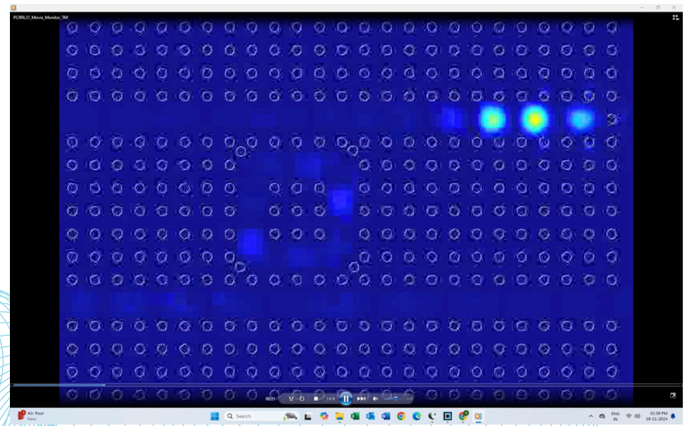
- Design: Develop the photonic crystal ring resonator layout in Lumerical FDTD
- Simulate band gap properties to ensure confinement and desired resonant wavelength.
- Optimization: Adjust design parameters for maximum efficiency and minimal signal loss.

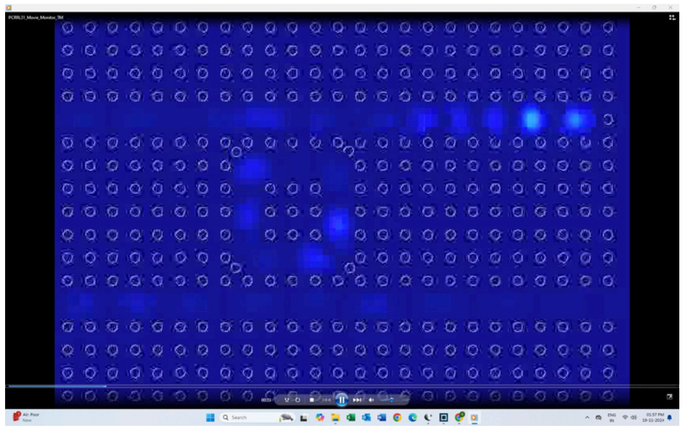
RESULTS

- Observed light propagation patterns in the designed Photonic Crystal Ring Resonator (PhCRR) using Ansys Lumerical FDTD.
- Verified changes in light propagation with varying power intensities, demonstrating nonlinear Kerr effect behavior.
- Observed efficient coupling of light from the input (bus) waveguide to the drop waveguide at specific conditions.









PROSPECTUS OF EXTENDING AS A MAJOR PROJECT

- Explore integration into larger photonic circuits for all-optical computing systems.
- Potential for extending designs to other logic gates (e.g., XOR, XNOR) using similar principles.
- Applications in high-speed data processing, secure communications, and quantum computing.
- nvestigate further miniaturization for compatibility with existing chip technology.

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THANK YOU