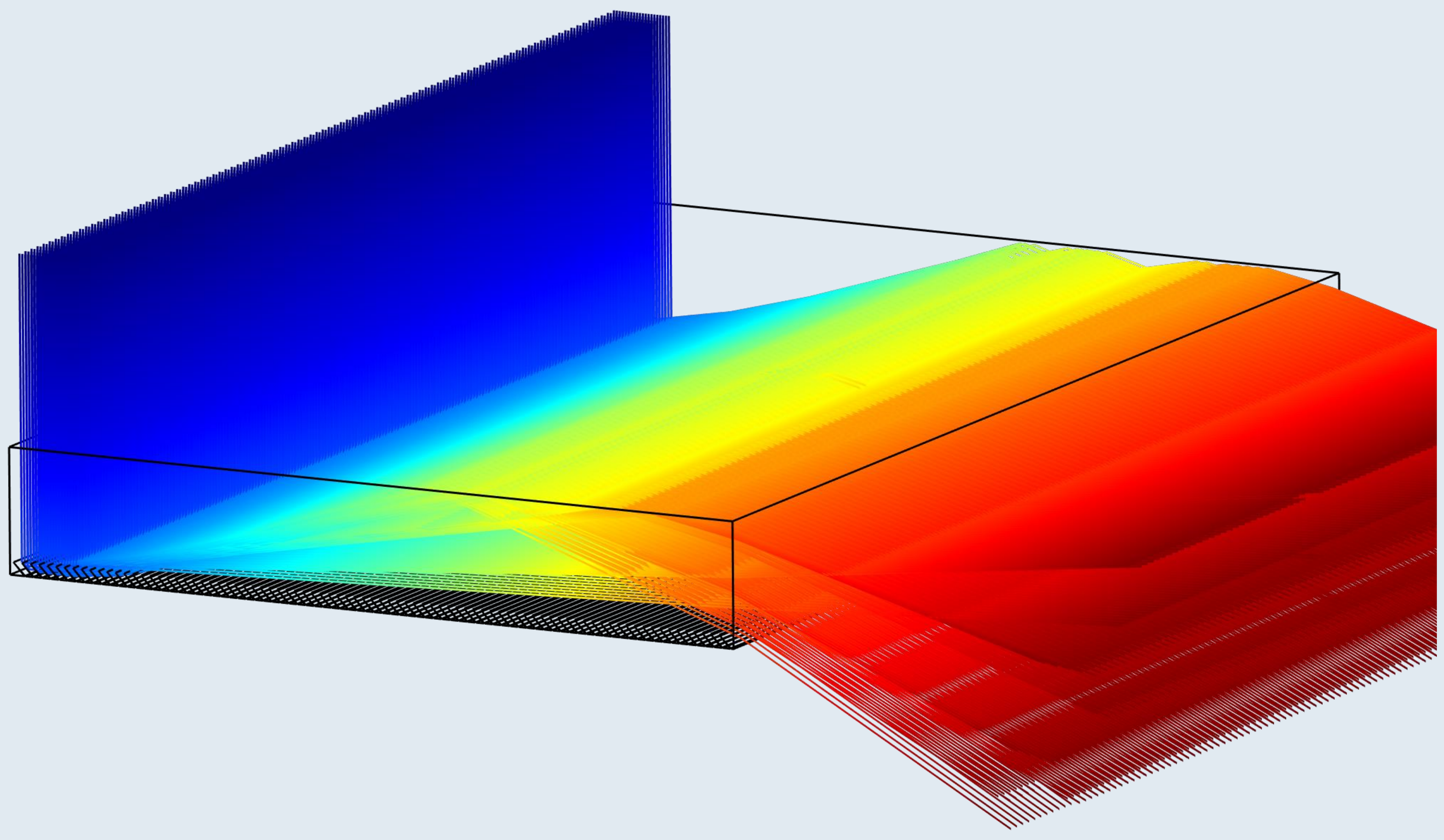

High Solar Acceptance Planar Waveguide-based Light Concentrator

Design, validation and optimization of the proprietary high solar acceptance waveguide-based Planar Light Concentrator (PLC) as a low-concentration solar optics solution.

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Introduction & Goals

Recently, PLC technology has been well acknowledged as a low-concentration solar optics solution, and many research efforts have been put forward to develop new designs, indicating its prospect for Concentrated PV/Thermal applications.[1,2] Waveguide-based PLC has evolved as a major contender among them.[3] However, for its applicability in built environments, such as for Building Integrated Photovoltaic solutions, solar acceptance through seasons is a prerequisite.

Herein, a novel waveguide based PLC has been designed and evaluated using the COMSOL Multiphysics software. The multi-parameters have been well defined, parametrized individually, and optimized with their causality. The geometrical concentration (GC) factor depending on the system size, the final output light concentration, and the solar acceptance has been evaluated. Prototype & its real time validation have been conducted based on the simulated optics design.

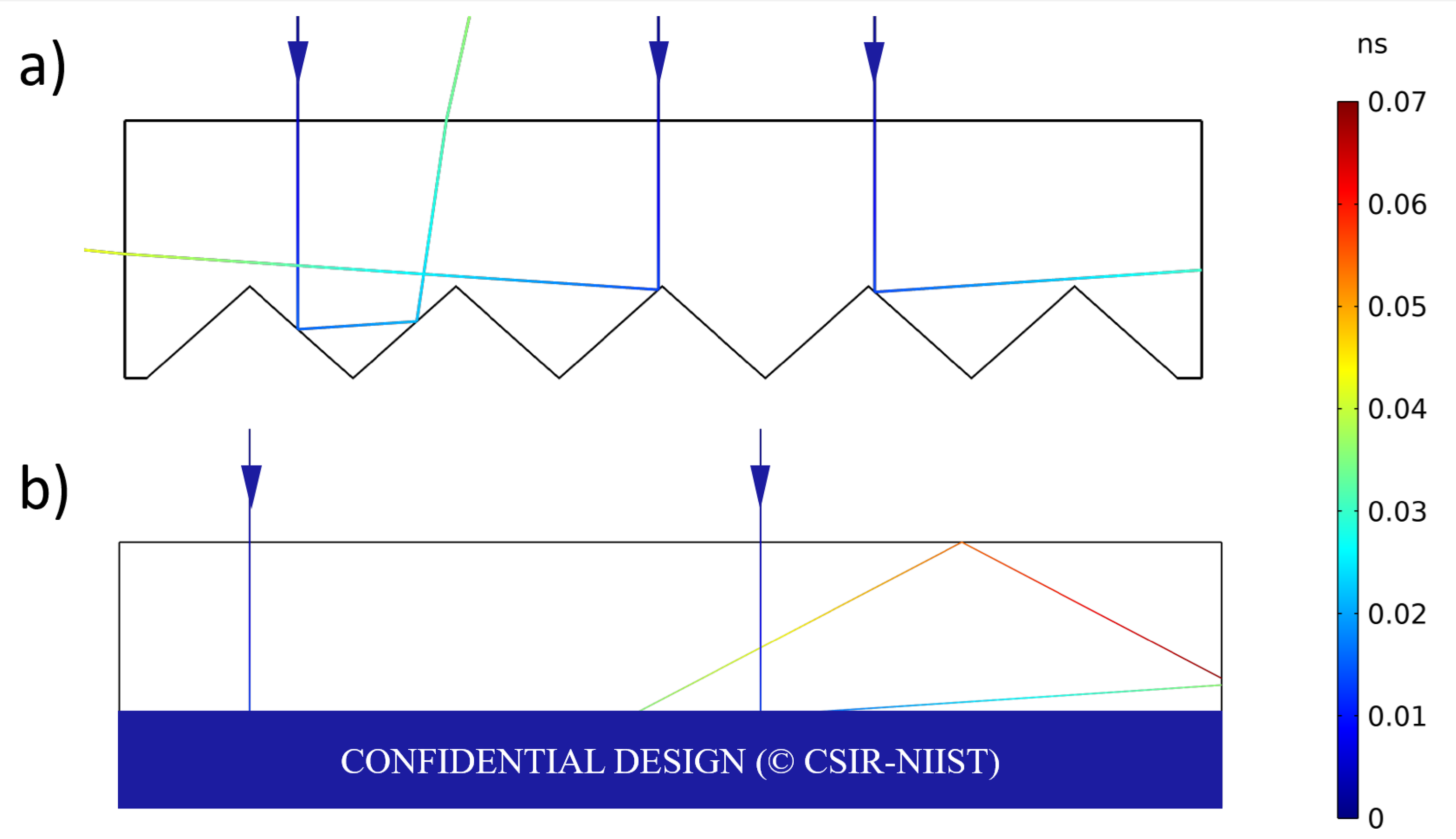

FIGURE 1. Ray tracing simulation of PLCs with a) conventional V-cut optics design, and b) proprietary PLC optics design of CSIR-NIIST

Methodology: Design from square-one

The proprietary optics design has been modelled by mitigating the restraints of conventional V-cut optics (Figure 1a) using 2D ray tracing in Ray Optics module. The single elemental proprietary design of CSIR-NIIST promised to have 100% light transmission through lateral direction (Figure 1b). The multi-parameters effecting the light transport have been defined and parametrized for optimum light concentration upon a fixed size and specific optics material. 3D ray tracing has been conducted for angular acceptance study within an axis, and is evaluated through COMSOL and graphically represented. Finally, the prototype based on the design has been developed and validated in real time conditions.

Results

Proprietary PLC has been designed, parametrized and optimized with acrylic material (1.49 refractive index) for GC 10X, 7.5X, 5X and 2.5X using 2D ray tracing. Optical efficiency (OE) of 42%, 50%, 58%, 60% has been obtained respectively for normal light incidence. Angular acceptance study has been conducted in an axis with 3D ray tracing, results are shown in Figure 2a. The OE loss has been marked maximum as 30%, 29%, 25%, 21% for GC 10X, 7.5X, 5X, 2.5X respectively within the solar seasonal angle shift window of ~±23°. The optimized design with 10X GC (10X10X1 cm^3) is fabricated (Figure 2b), and the solar acceptance has been visually validated in real-time conditions, as shown in Figure 2c.

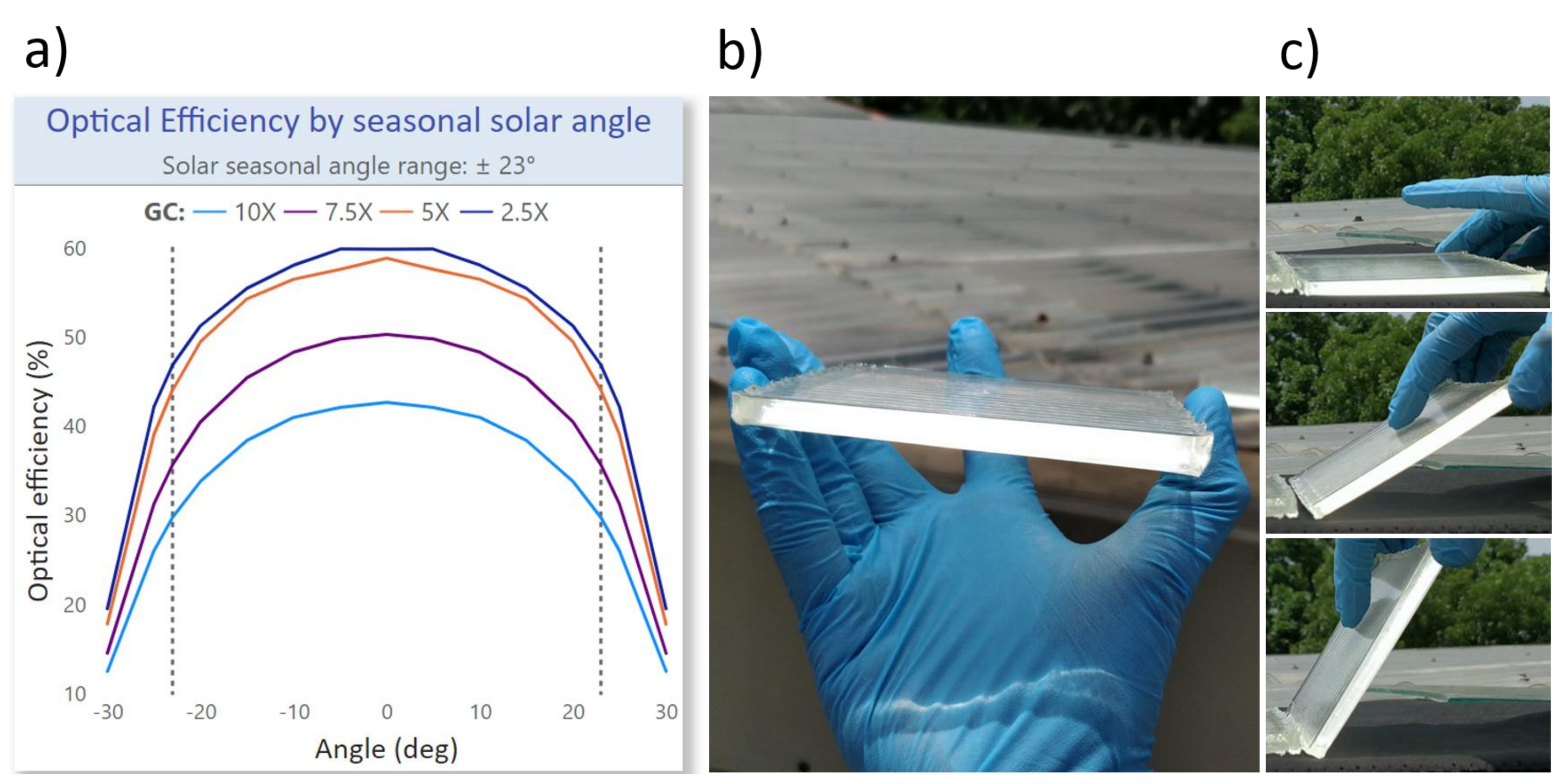

FIGURE 2. a) OE of PLCs with varying GC and incident angle, from 3D ray tracing, b) Fabricated PLC: 10X10X1 cm^3 size & GC 10X, & c) Solar acceptance validation under real-time condition

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