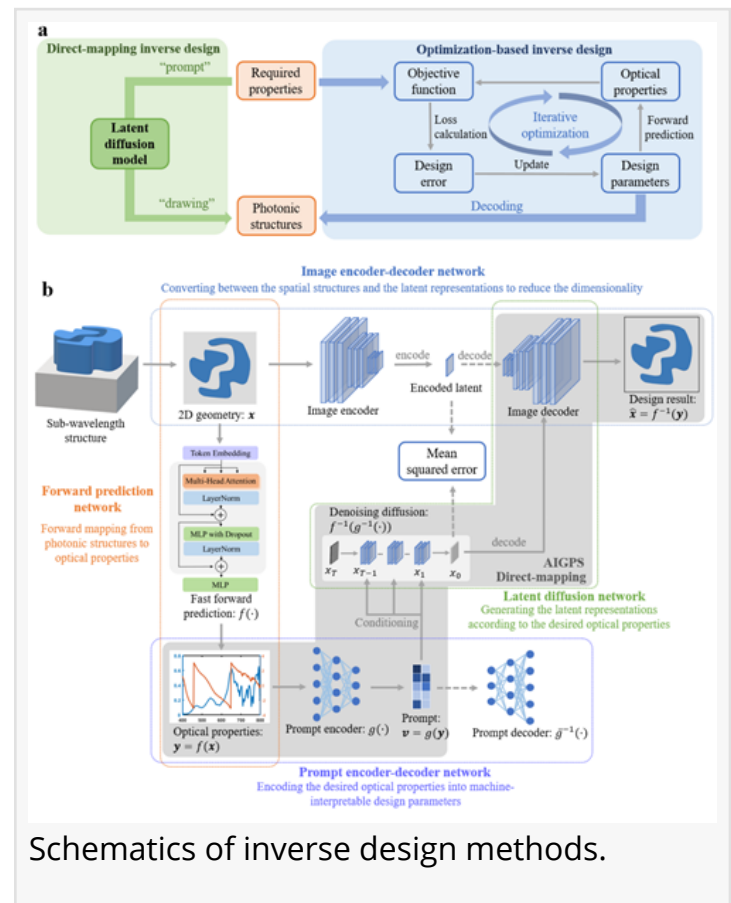


AI-Generated Photonics: Map Optical Properties to Subwavelength Structures Directly via a Diffusion Model

FAYETTEVILLE, GA, UNITED STATES, May 16, 2026 /EINPresswire.com/ -- Harnessing the power of generative AI, researchers at Tsinghua University have developed AIGP—a diffusion-based generative framework that enables instant translation of optical properties into fabrication-ready metasurfaces. By using transmission, phase, and polarization as “prompts,” AIGP directly maps optical properties to subwavelength, fabricable structures, generating high-fidelity metasurface designs in seconds. This breakthrough overcomes critical bottlenecks in photonic inverse design and paves the way for large-scale, AI-driven generative optical devices.

[Subwavelength structures](#) such as photonic crystals and metasurfaces offer transformative capabilities for light field regulation. However, their subwavelength scale precludes analytical modeling via geometric or wave optics. Traditional design methods rely on forward simulations, selecting optimal solutions from a predefined library of structures within a highly constrained design space. While recent inverse design approaches overcome this limitation by generating non-intuitive yet high-performing optical structures, they fundamentally reformulate the design problem as an optimization task that relies on iterative algorithms. Each iteration requires computationally intensive numerical simulations, such as finite-difference time-domain (FDTD) methods, resulting in substantial computational costs. Moreover, these methods commonly face inherent optimization challenges, including issues related to convergence, computational efficiency, and the identification of global optima.

In a new paper published in [Light: Advanced Manufacturing](#), a research team of scientists, led by Professor Kaiyu Cui from the Department of Electronic Engineering at Tsinghua University, China,



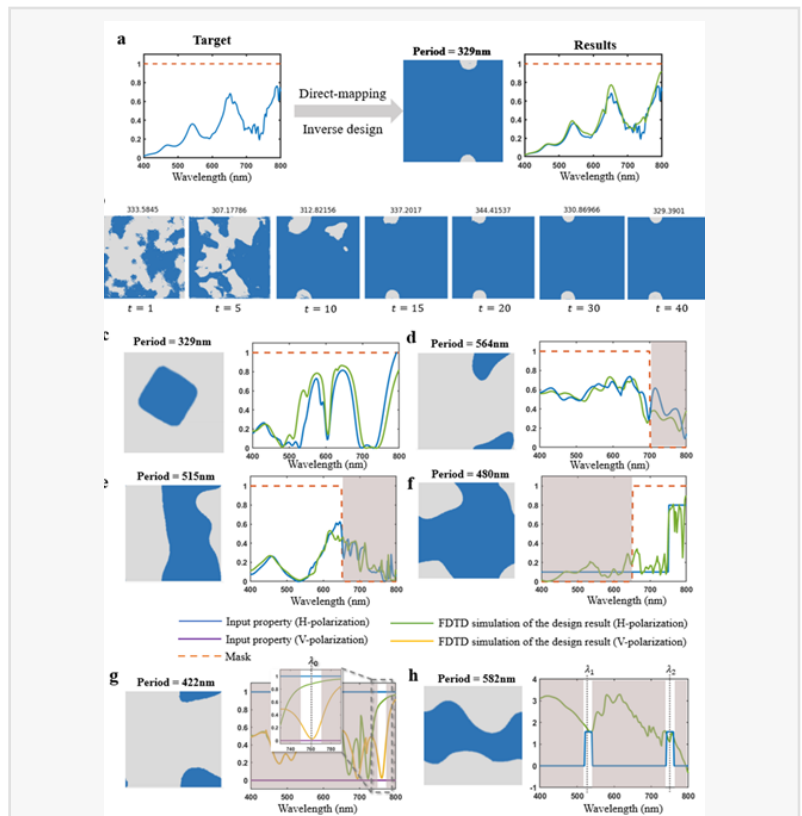
Schematics of inverse design methods.

and co-workers have developed a groundbreaking inverse design framework—artificial intelligence-generated photonic (AIGP)—that achieves direct mapping from optical properties to subwavelength photonic structures using a latent diffusion model. By leveraging the generative power of diffusion models, the system interprets optical specifications as "prompts," enabling the AI to "draw" the desired photonic structures with high precision and creativity—completely eliminating iterative optimization.

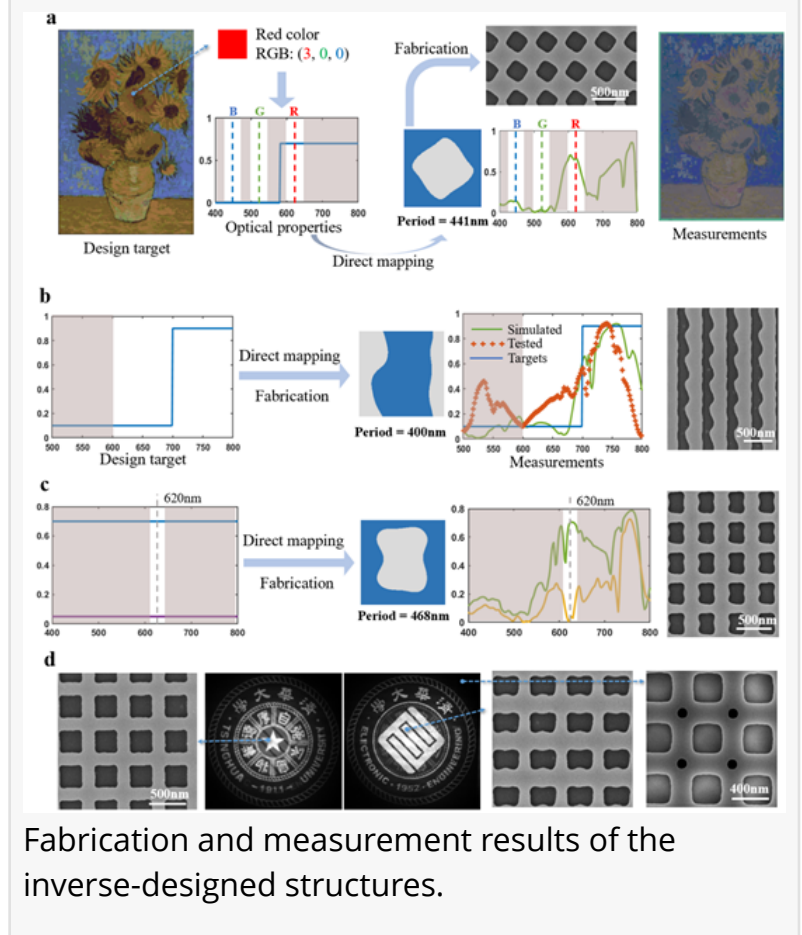
How It Works: From Prompts to Structures

To enable this direct mapping, the team developed a novel encoding scheme for optical properties and a dedicated prompt encoder network that resolves the long-standing non-uniqueness problem, providing a flexible interface for on-demand photonic design. A fast forward prediction network accelerates simulation and supports seamless end-to-end training. In parallel, a comprehensive training dataset incorporating freeform shapes was constructed to maximize design space while strictly respecting fabrication constraints, inherently filtering out non-manufacturable geometries from the source.

The scientists summarize three core advantages of the AIGP framework: "First, it achieves high-precision mapping, converting full-band transmission spectra, phase profiles, and polarization responses into corresponding metasurface structures within seconds—all ready for immediate fabrication. Second, it supports flexible design constraints,



Inverse design results of AIGP.



Fabrication and measurement results of the inverse-designed structures.

enabling polarization-insensitive device generation via C4 symmetry and allowing band-specific masking to adapt to diverse design goals. Third, it possesses fuzzy search capability: even with abstract requirements such as a single cutoff wavelength, AIGP can approximate ideal performance without relying on precise forward models.”

Experimental Validation: From Simulation to Chip

Experimental validation on a silicon-on-sapphire platform confirms its power. Sixty-four structural-color meta-atoms were directly generated and fabricated on a 230 nm silicon layer, successfully encoding a sunflower image onto a chip—demonstrating true "generate-and-fabricate" readiness. For an ideal long-pass filter response that is physically unattainable, AIGP delivered near-optimal solutions within seconds, with measured transmission spectra closely matching design targets. The method's strong generalization was further validated across bandpass filters, polarization beam splitters, and multi-wavelength phase modulators.

A New Paradigm for Photonic Innovation

In conclusion, unlike conventional methods reliant on iterative optimization, AIGP simultaneously addresses several critical challenges: non-uniqueness, robustness to unseen inputs, and the complete elimination of iterative procedures. These persistent obstacles—long considered inherent to the field—are now overcome, offering a transformative paradigm for AI-driven generative photonic design.

From simulation to fabrication, AIGP demonstrates end-to-end reliability: no iteration, one-shot mapping to physical devices. This technological breakthrough promises to accelerate the development of next-generation photonic devices and applications—including optical computing, metalenses, hyperspectral imaging chips, structural colors, and beam splitters—ushering in a new era of large-scale, AI-driven generative photonic innovation.

References

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