Fabrication Process of Ultra-Low-Loss High Quality Factor Silicon Nitride Photonics

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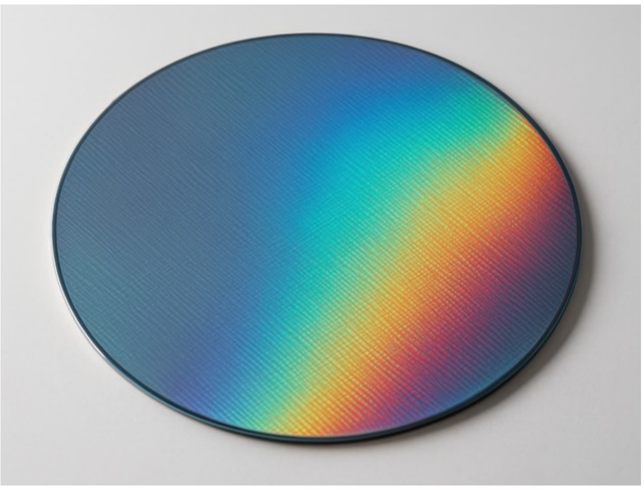

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Category
Hardware
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OVERVIEW

Robust, scalable fabrication of ultra-low-loss, high-Q silicon nitride photonic devices using amorphous silicon hard masks

- Enables crack-free, thick Si_3N_4 films for high-Q photonic devices, facilitating wafer-scale quantum and classical applications
- Precision metrology, quantum computing, quantum communication, sensing, spectroscopy, high-performance photonic integrated circuits

BACKGROUND

Silicon nitride (Si_3N_4) photonic integrated chips (PICs) have gained prominence due to their wide transparency window, high nonlinear coefficients, and low optical losses, making them key for both quantum and classical photonic devices. Historically, achieving ultra-high quality factor (Q) in Si_3N_4 devices has been limited by fabrication challenges, especially for thick films (>600 nm) that are prone to stress-induced cracking. Traditional methods to prevent cracks require complex processing or precise control, restricting scalability and manufacturability for wafer-scale integration. Crack-free technologies exist, but their complexity and sensitivity to processing conditions hinder widespread adoption, creating a demand for a robust, reliable, and scalable fabrication method. An improved approach is needed to routinely produce thick, low-loss Si_3N_4 devices that support cutting-edge applications in quantum optics, frequency combs, and advanced sensing, while maintaining compatibility with established silicon photonics manufacturing infrastructure.

INNOVATION

Researchers at the University of Michigan have developed a robust fabrication process employing an amorphous silicon (a-Si) hard mask to achieve ultra-low-loss, high-Q silicon nitride photonic devices with thicknesses up to 850 nm. The process involves stress-releasing trenches on large-area Si_3N_4-on-SiO_2 wafers, deposition of thick LPCVD Si_3N_4 films, and application of smooth a-Si hard masks. Unlike prior techniques, the approach avoids high-temperature annealing between deposition steps, preventing stress-induced cracks. The a-Si hard mask provides superior etching selectivity and surface smoothness, leveraging mature silicon fabrication recipes while significantly enhancing process reliability and yield. Devices fabricated with this method consistently demonstrate high-Q factors (up to 17.5 million), uniformity, and long-term mechanical stability, enabling scalable manufacturing. These technical advances address previous limitations and open broad applications in precision metrology, quantum information processing, integrated photonics, and advanced optical sensors.

ADDITIONAL INFORMATION

REFERENCES:

- "Manufacturing High-Q Silicon Nitride Photonic Chips via Silicon Hardmask Etching"

INTELLECTUAL PROPERTY:

Patent application pending.

KEYWORDS:

Silicon nitride , PIC, Photonics, Quantum, Sensing, Spectroscopy, Communication