



Deep Elastic Strain Engineering of Microfabricated GaN

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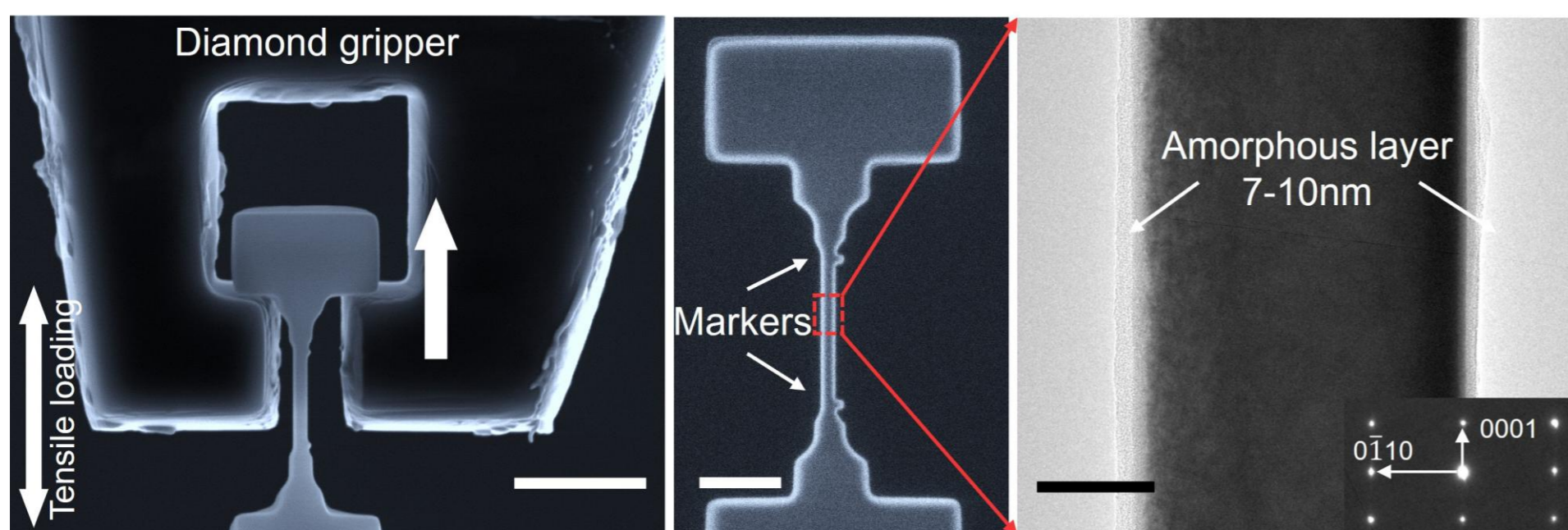
Introduction

Gallium nitride (GaN) as a direct bandgap semiconductor plays a central role in the development of efficient blue light-emitting diodes and laser diodes (Nobel Physics Prize 2014). Traditional chemical alloying (adding In/Al) shrinks the bandgap to tune light color, but this approach does not allow for dynamic and reversible modulation of the bandgap once the material is made.

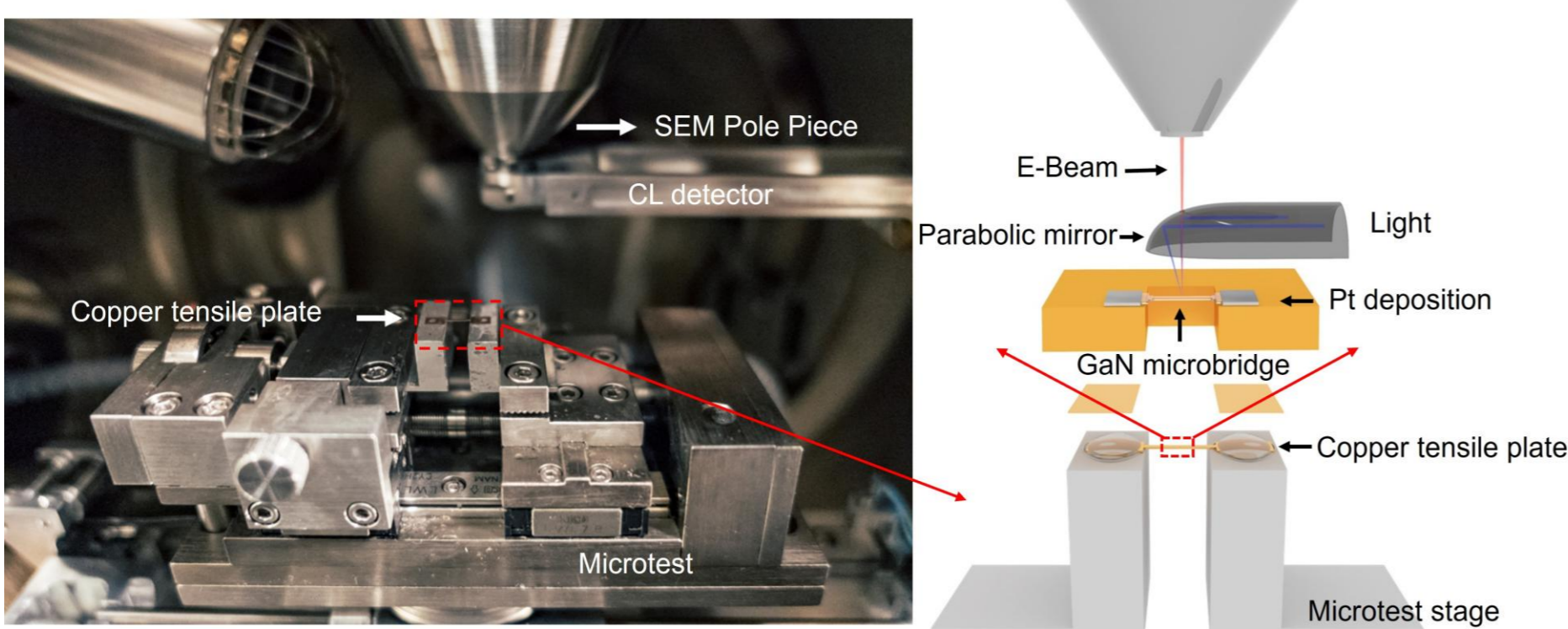
Here we show that ultralarge tensile elastic strain can be introduced in microfabricated single crystal GaN bridges, offering an unprecedented opportunity to reversibly, continuously modulate its band structure and optoelectronic properties through our nanomechanical-based deep elastic strain engineering (DESE).

Methodology

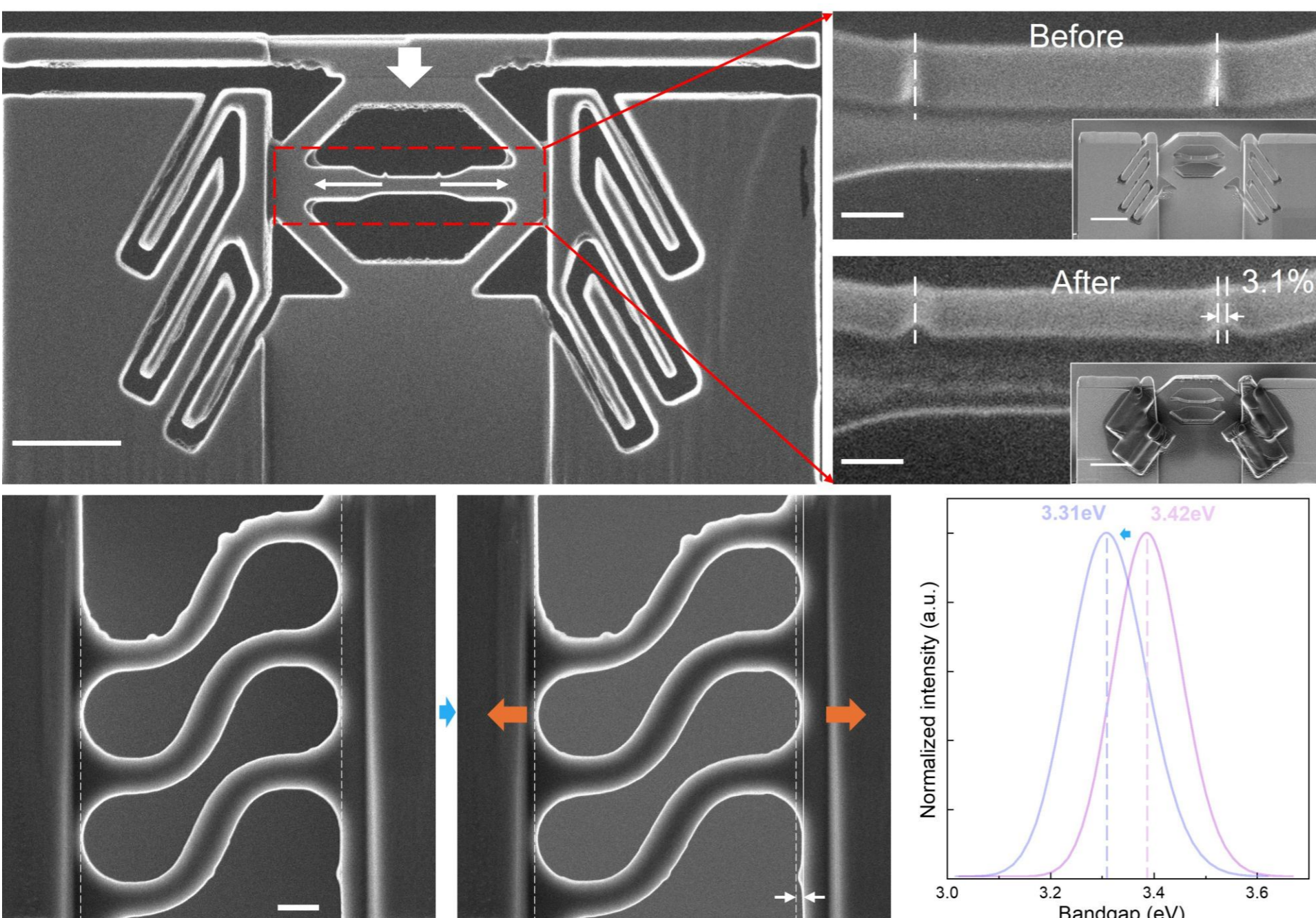
1. Microfabrication & *in Situ* Nanomechanical Testing



2. *In Situ* Optoelectronic Characterization



3. Design of Strain-Fixed GaN Device and Curved Structure

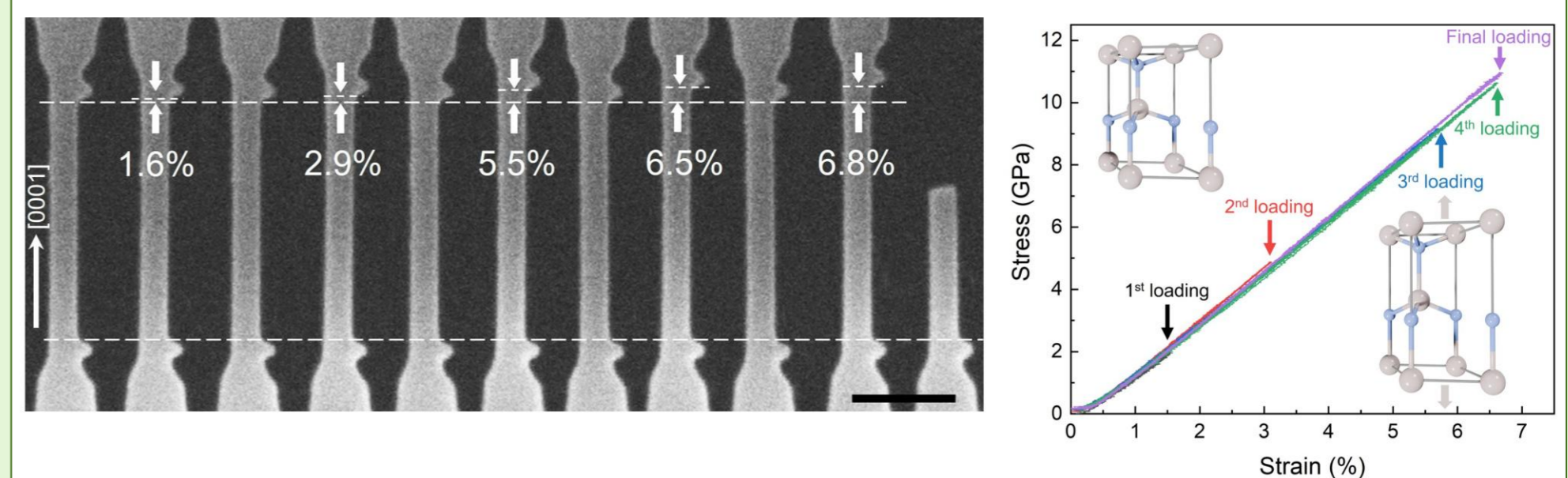


Objectives

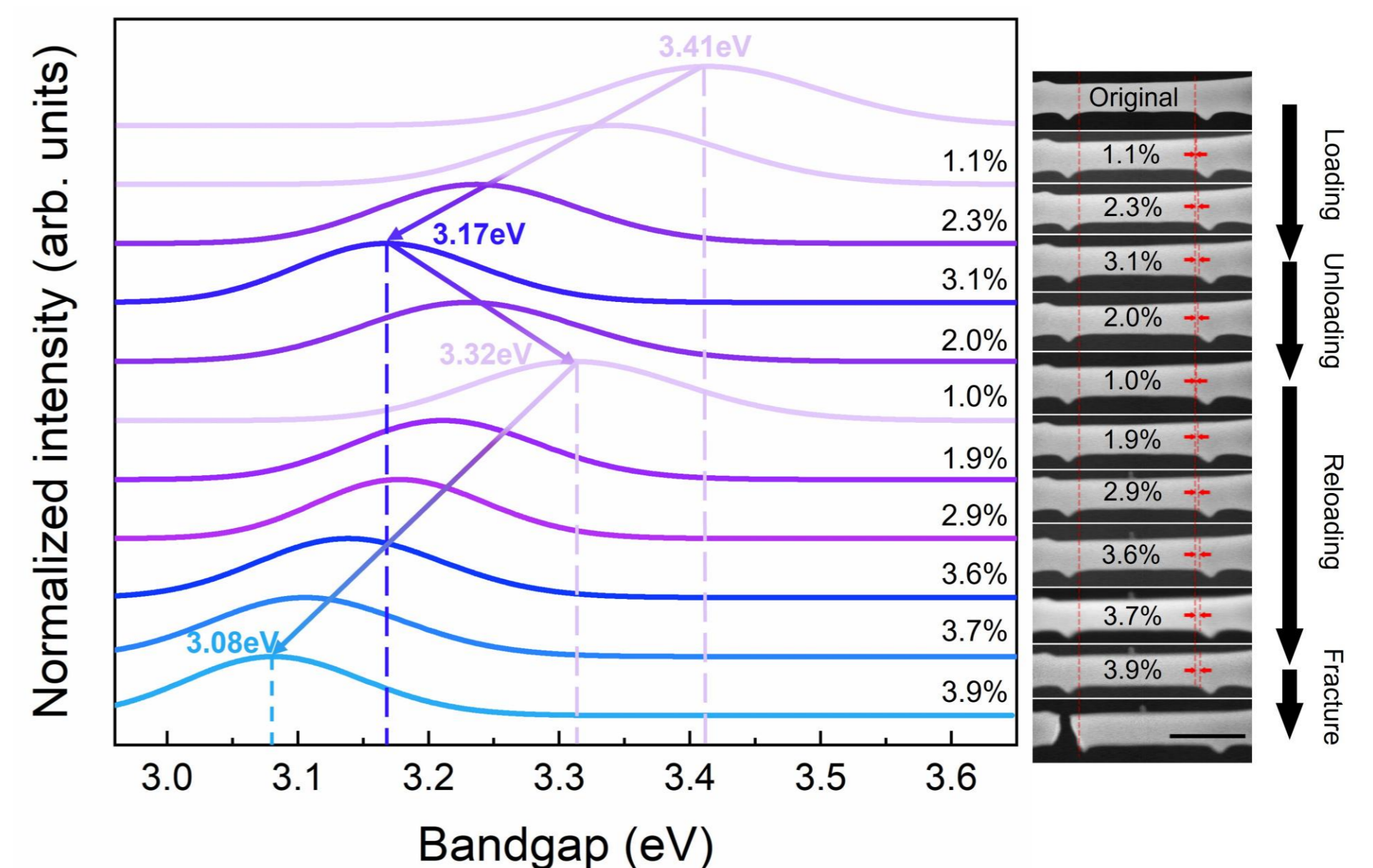
- 1. Microfabrication & Device Design:** fabricate freestanding microbridge tensile samples and strain-fixed push-to-pull devices.
- 2. *In Situ* Nanomechanical Testing:** perform quantitative *in situ* loading-unloading tensile tests to achieve and evaluate ultralarge, uniform elastic deformation of the GaN microbridges.
- 3. Modulate GaN band structure dynamically:** introduce continuous and reversible tuning of the energy bandgap and emission color through DESE as an alternative to traditional chemical alloying.
- 4. Validate mechanisms and demonstrate device applications:** combine *ab initio* DFT calculations with the strain-fixed GaN devices to facilitate novel applications in power electronics and tunable optoelectronics.

Research accomplishments

1. Achieving Ultralarge Tensile Elastic Strain in Microfabricated GaN



2. Deep Elastic Strain Engineering for Bandgap Modulation



Impact & Outlooks

- Industry Impact:** Enable novel applications in power electronics, RF components, and next-gen nano/micro-LED displays
- Design Revolution:** Establish DESE as a dynamic, reversible alternative to chemical alloying for continuous band gap modulation.
- Long-Term Vision:** Advance on-chip photonics by exploiting nanoscale elasticity, bypassing the limitations of fixed chemical compositions.
- “Mechanical” Blue LED**

S. Fan*, H. Wang*, C. T. Chou*, J. Chen, Y. Han, J. Zhou, X. Li, J. P. Chou†, J. Li† & Y. Lu†. **Physical Review X**, 2026, 16(1): 011014.

