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Tunable Microneedle Applicator for Delivery and Sampling

Stanford researchers have developed an innovative, mechanically tunable microneedle applicator that enables consistent and reliable insertion of microneedle arrays into skin for drug delivery, diagnostics, and sampling applications.

Microneedle array patches have emerged as a promising alternative to traditional injections, enabling minimally invasive delivery of vaccines and therapeutics as well as biomarker sampling through the skin. However, reliable application of microneedles remains a key challenge. Current systems often rely on manual thumb pressure or external applicators, making insertion highly dependent on user technique, applied force, and angle. This variability can lead to incomplete needle penetration, needle deformation, inconsistent dosing, and unreliable biomarker sampling. Existing applicators can also be bulky and expensive, limiting usability in decentralized or resource-limited settings.

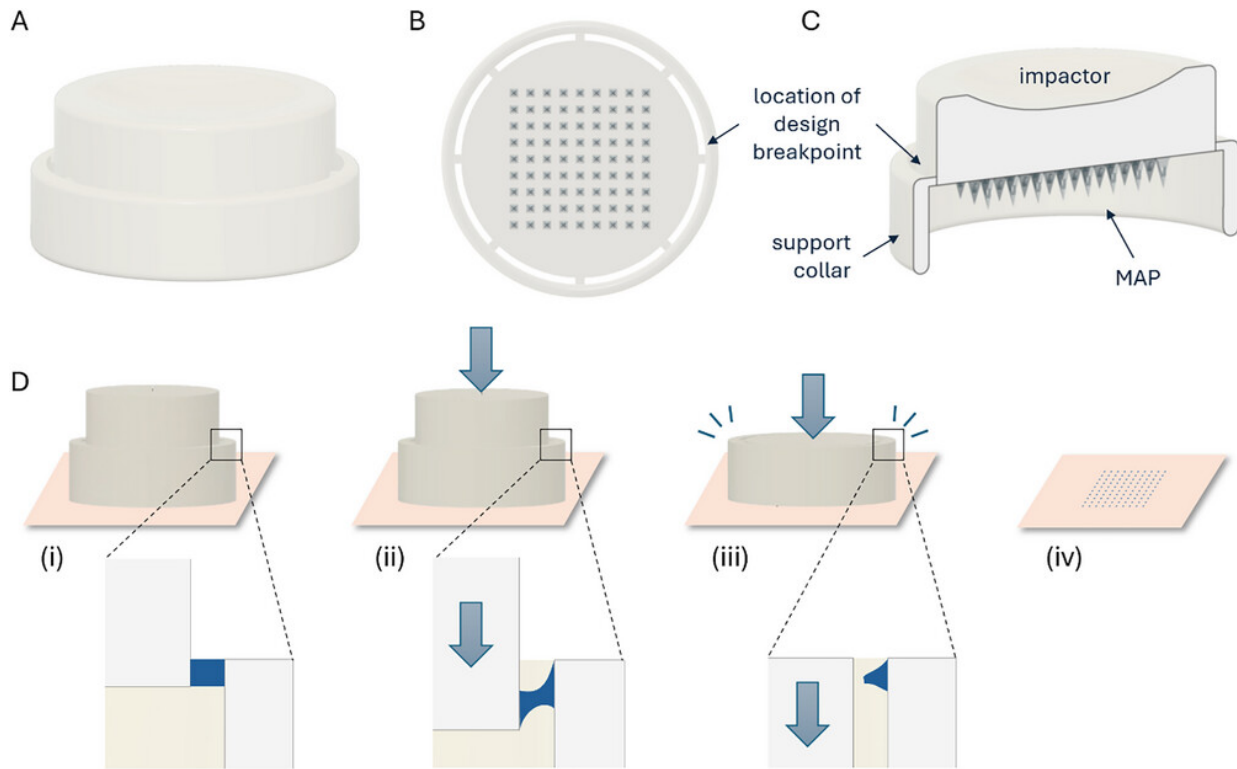
The Stanford technology addresses these challenges through a mechanically programmed insertion mechanism based on controlled breakage of engineered struts or membranes, ensuring that the patch is applied with a predefined and repeatable force independent of the user. When pressed against the skin, these structures break at precisely defined force thresholds, regulating insertion force and maintaining a consistent application angle.

The design is inherently single-use and compatible with scalable manufacturing, enabling reliable microneedle delivery across clinical, home-use, and research settings.

Stage of Development

Pre-clinical

Figure



Applications

- Self-administered vaccine and drug delivery patches
- Interstitial fluid sampling for biomarker diagnostics
- Transdermal delivery of biologics and anesthetics

Advantages

- Consistent, user-independent insertion force
- Controlled insertion angle and improved penetration
- Single-use design reduces contamination risk
- Scalable, low-cost manufacturing compatible with injection molding and 3D printing

Publications

- D.Ilyn, J. L.Hwang, I. A.Coates, et al. "[Tunable Applicator for Microneedle-Based Medical Devices.](#)" Advanced Materials Technologies (2026): e02525.

Innovators

- Dan Ilyn
- Joseph DeSimone
- Ian Coates
- John Tumbleston
- Maria Dulay
- Hsiang-Hua Hung
- Gunilla Jacobson

Licensing Contact

Sam Rubin

Licensing Associate, Life Science

[Email](#)