ICCES, 2026, vol.36, no.1

Tech Science Press

DOI: 10.32604/icces.2026.015463

PROCEEDINGS

Reconfigurable Nano-Kirigami Surfaces: Multiscale Mechanics Modeling and Applications in Flexible Electronics

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ABSTRACT

Kirigami provides a mechanics-guided route to transform planar micro/nanostructures into three-dimensional (3D) architectures with programmable deformation and device functionality. This talk introduces reconfigurable nano-kirigami surfaces as a platform for soft materials and flexible electronics, with emphasis on how micro/nanoscale geometry, structural instability, fracture and interfacial mechanics can be used to program electromechanical transduction.

We first discuss nano-kirigami as a general mechanics platform. In our previous work, suspended and substrate-supported gold nanofilms were patterned by focused ion beam (FIB) cutting and ion-beam-induced stress engineering, enabling local buckling, rotation and twisting of nanostructures from two-dimensional precursors [1,2]. These 3D transformations can be predicted through topography-guided stress equilibrium and electromechanical coupling models. Although initially demonstrated through optical modulation and chirality at visible and near-infrared wavelengths, the same design principle-using programmed geometry and mechanics to amplify functional response-naturally extends to flexible electronic sensors.

In the context of flexible electronics, our prior work on pressure sensors provides the mechanics basis for this transition. For skin-electrode iontronic mechanosensing, soft contact and instability of high-aspect-ratio microstructures were used to amplify pressure-induced interfacial response, improving sensitivity and pressure resolution [4]. More recently, data-driven inverse design further established a framework for translating target pressure-response curves into microstructure geometries across material systems [5]. Together, these studies show that sensor performance is not determined solely by material selection, but by the coupled mechanics of soft contact, microstructural deformation, instability and interface-mediated signal transduction.

Building on this foundation, the talk will then introduce our more recent and ongoing work on resistance-type slit-based flexible strain sensors inspired by crack-shaped slit organs in spider exoskeletons [3]. In these devices, slit-like cracks in a conductive film on a compliant substrate convert tensile deformation into resistance change through crack opening, closure and propagation. FIB-enabled nano-kirigami offers a deterministic route to program slit geometry, spacing and orientation, while peridynamics-based crack propagation modeling predicts crack initiation, coalescence, cyclic hysteresis and propagation direction under repeated tensile loading. By connecting nano-kirigami fabrication, fracture modeling, instability mechanics and inverse design, this talk highlights how mechanics can be used as an active design tool for next-generation flexible electronic sensors.

KEYWORDS

Nano-kirigami; flexible electronics; pressure sensor; strain sensor; crack propagation; peridynamics; inverse design

Funding Statement: The author acknowledges the start-up fund support from the Presidential Young Scholar Scheme of the Hong Kong Polytechnic University.

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Conflicts of Interest: The author declares no conflicts of interest to report regarding the present study.

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