Auxetic Mechanical Metamaterials to Enhance Sensitivity of Stretchable Strain Sensors

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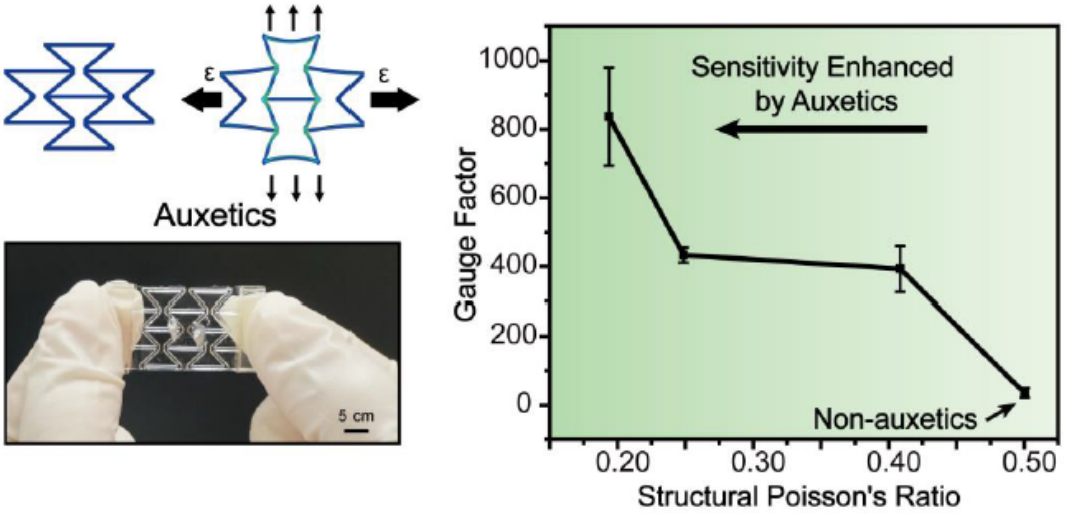
Abstract

Stretchable strain sensors play a pivotal role in wearable devices, soft robotics, and Internet-of-Things, yet these viable applications, which require subtle strain detection under various strain, are often limited by low sensitivity. This inadequate sensitivity stems from the Poisson effect in conventional strain sensors, where stretched elastomer substrates expand in the longitudinal direction but compress transversely. In stretchable strain sensors, expansion separates the active materials and contributes to the sensitivity, while Poisson compression squeezes active materials together, and thus intrinsically limits the sensitivity. Alternatively, auxetic mechanical metamaterials undergo 2D expansion in both directions, due to their negative structural Poisson's ratio. Herein, it is demonstrated that such auxetic metamaterials can be incorporated into stretchable strain sensors to significantly enhance the sensitivity. Compared to conventional sensors, the sensitivity is greatly elevated with a 24-fold improvement. This sensitivity enhancement is due to the synergistic effect of reduced structural Poisson's ratio and strain concentration. Furthermore, microcracks are elongated as an underlying mechanism, verified by both experiments and numerical simulations. This strategy of employing auxetic metamaterials can be further applied to other stretchable strain sensors with different constituent materials. Moreover, it paves the way for utilizing mechanical metamaterials into a broader library of stretchable electronics.



References

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