

SCIENCE ADVANCES | RESEARCH ARTICLE

BIOPHYSICS

A stretchable and strain-unperturbed pressure sensor for motion interference-free tactile monitoring on skins

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A stretchable pressure sensor is a necessary tool for perceiving physical interactions that take place on soft/deformable skins present in human bodies, prosthetic limbs, or soft robots. However, all existing types of stretchable pressure sensors have an inherent limitation, which is the interference of stretching with pressure sensing accuracy. Here, we present a design for a highly stretchable and highly sensitive pressure sensor that can provide unaltered sensing performance under stretching, which is realized through the synergistic creations of an ionic capacitive sensing mechanism and a mechanically hierarchical microstructure. Via this optimized structure, our sensor exhibits 98% strain insensitivity up to 50% strain and a low pressure detection limit of 0.2 Pa. With the capability to provide all the desired characteristics for quantitative pressure sensing on a deformable surface, this sensor has been used to realize the accurate sensation of physical interactions on human or soft robotic skin.

INTRODUCTION

In any soft tissue, be it from a soft robotic or human skin, the pressure created through physical contacts on or inside the bodies not only acts as one of the major means to perceive tactile interactions but also carries physiological information regarding health conditions. Hence, soft pressure sensors that transduce mechanical stimuli into electrical signals are highly desirable to enable applications ranging from medical implants (1–4), wearable health monitoring (5–10), and prosthetic electronic (e)-skins (11, 12) to technologies including soft robotics (13–16), human-machine interactions (17–21),

of pressures under varied strain states. Although this problem could be mitigated at the system level by establishing a series of individually adjusted calibrations under different strains and having a real-time measurement of strain during the sensor's operation, this would only overcomplicate the sensing system by requiring precalibration and even recalibration in runtime while still sacrificing sensing fidelity.

So far, attempts for decoupling the strain's effect to the pressure sensing typically approach this by increasing the areal stiffness of individual pressure sensors on a stretchable substrate to isolate the

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