Wearable strain sensors: design shapes, fabrication, encapsulation and performance evaluation methods

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Abstract Highly durable, stretchable, sensitive and biocompatible wearable strain sensors are crucial for healthcare, sports, and robotic applications. While strain sensor designs, fabrication and testing methods have been widely discussed by researchers, not many have discussed sensor improvements via implementing designs and protection layers that make the sensor more resilient. This paper will focus on sensor designs (straight line, U-shape, serpentine, and kirigami) and material selection that can provide better performance. Theoretical equations and calculations to indicate how the design shapes contribute to providing better performance are also included. An important aspect which is not often explored is having encapsulation layers which can significantly reduce the formation of cracks when the sensor is subjected to mechanical stress and bending. This review will

include post-fabrication steps that are necessary to incorporate protection layers for wearable sensors. Due to the curvilinear shapes of wearable sensors that often need to be in close contact with human skin, reliability and durability testing often differs greatly from that of traditional strain sensors. Recent techniques for performance evaluation specific to wearable sensors such as cyclic stretching, bending, stretch till failure, washability, signal latency, and tensile tests were also discussed in detail. This includes experimental setup and duration of testing and its significance was described. To ensure device safety for the user, biocompatibility assessments need to be made. In this review, cytotoxicity test methods such as trypan blue, cell proliferation and MTT assay were compared and evaluated. By consolidating recent developments, this paper aims to provide researchers and practitioners with a comprehensive understanding of the advancements, and future directions in this rapidly evolving field.

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