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Design optimization in stretchable electronics: from straight to curvilinear, from curvilinear to complex

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Abstract

Stretchable electronics, compared with conventional rigid, hard electronics in planar formats, can be stretched, compressed and deformed into arbitrary shapes to match complicated surface without electrical or mechanical failure in circuits. Thus, the stretchable electronics has many potential important applications. How to minimize the strain in functional devices to enhance the stretchability is a key issue in the design of stretchable electronics consisting of functional devices and substrates. In this paper, optimization approaches with Gene Algorithm are used for the design of functional devices and substrates in the stretchable electronics under large deformation. For functional devices (with or without substrate), the optimization results show that the optimized functional devices tend to have a "wavy" layout to isolate themselves from the applied strain. An elliptic beam model is adopted to characterize the influence of geometrical configuration on the max strain in "wavy" functional devices and we thus propose an optimal shape of functional devices. It is also found that the optimized substrate tends to have trenches, which is capable of transferring the tensile load into bending deformation in the near-device region and reduce the strain in the functional devices. Further parameter study suggests an optimal trench height to minimize the strain in functional device. The optimization strategy in this study provides useful insight and may lead to further improvements in the design of stretchable electronics.