Flexible stretchable electronic device with strain isolation utilizing microstructure

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Abstract

In the process of film deposition, due to thermal mismatch, residual stress and other factors, the stiff film will wrinkle when deposited directly on the elastomeric substrate, which presents difficulties in the heterogeneous integration of inorganic flexible stretchable electronic devices. Previously, some scholars proposed the use of microstructures to regulate the regulation of wrinkle morphology [1,2]. Based on this, this paper proposes a method of using microstructure to achieve strain isolation [3] between inorganic materials and elastomeric substrate to achieve the purpose of eliminating wrinkles. In this paper, the relationship between the elimination of wrinkle and the critical dimension of microstructure is established from the theoretical model, and the theoretical model is used to predict whether the copper film on the surface of different size microstructures on the polydimethylsiloxane (PDMS) substrate is wrinkled. The theoretical analysis results are in good agreement with the finite element model. Through finite element analysis, it can be found that the use of microstructure can not only achieve strain isolation, but also greatly reduce the energy release rate between the copper film and the PDMS surface, which plays an important role in avoiding the debonding of the copper film and PDMS. Finally, based on the above two characteristics, this paper proposes a flexible stretchable light-emitting diode (LED) array device that utilizes microstructure for strain isolation to verify the superiority of the design. Comparative experiments show that: devices with no microstructure protection, after applying 2.5% uniaxial strain (Figure 1a), the device is not working properly due to the breakage of the serpentine connecter the LEDs (Figure 1b); while the device with microstructural protection is applying 5% (Figure 1c). After the strain, it can still work normally. This paper provides a feasible solution to solve the problem of wrinkles in the deposition of hard films on soft substrates, and provides guidance for the design and preparation of flexible stretchable electronic devices.

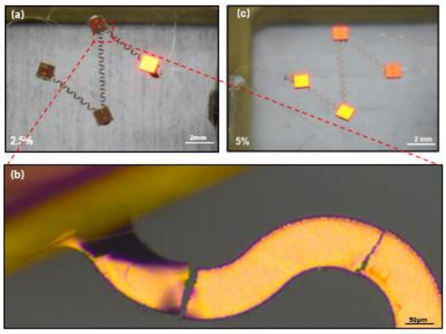

Figure 1: Flexible stretchable LED array device. (a) Without microstructure under 2.5% applied strain. (b) Optical image of cracks in the serpentine connecter. (c) With microstructure under 5% applied strain.

Keywords: elastomeric substrate, microstructures, strain isolation, stretchable electronics

References

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