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Keynote: Experiments and viscoelastic analysis of peel test with patterned strips for applications to transfer printing

Huang, Yonggang, y-huang@northwestern.edu, Northwestern University

ABSTRACT

Transfer printing is an exceptionally sophisticated approach to assembly and micro/nanofabrication that relies on a soft, elastomeric “stamp” to transfer solid, micro/nanoscale materials or device components from one substrate to another, in a large-scale, parallel fashion. The most critical control parameter in transfer printing is the strength of adhesion between the stamp and materials/devices. Conventional peel tests provide effective and robust means for determining the interfacial adhesion strength, or equivalently, the energy release rate, and its dependence on peel speed. The results presented here provide analytic solutions for tests of this type, performed using viscoelastic strips with and without patterns of relief on their surfaces, and validated by systematic experiments. For a flat strip, a simple method enables determination of the energy release rate as a function of the peel speed. Patterned strips can be designed to achieve desired interfacial properties, with either stronger or weaker adhesion than that for a flat strip. The pattern spacing influences the energy release rate, to give values that initially decrease to levels smaller than those for a corresponding flat strip, as the pattern spacing increases. Once the spacing reaches a critical value, the relief self-collapses onto the substrate, thereby significantly increasing the contact area and the strength of adhesion. Analytic solutions capture not only these behaviors, as confirmed by experiment, but also extend to strips with nearly any pattern geometry of cylindrical pillars.