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Copper-Rubber Interface Delamination in Stretchable Electronics

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Introduction

Interface delamination is a precursor to the failure of stretchable electronics mechanistic patterns of metal interconnects and elastically mismatched rubber matrix materials.

The goal of this project is to characterize interface delamination of the copper rubber interface by means of *in-situ* Environmental SEM analysis of the delamination front during 90° Peel tests.

Results

From an analysis of systems of the same rubber but different Cu roughnesses, it was found that interfacial integrity is not only governed by chemical bonding, but also by;

- Local interface area (due to roughness)
- Mode mixity of the loading
- Mechanical interlocking

From a ESEM analysis of the delaminated surface of the same Cu (roughness) but 2 types of TPU (TU-Berlin) and 1 PDMS (IMEC Ghent) rubber system it was found that: The amount of rubber left at the surface A_r after delamination remarkably increased with decreasing Work of Seperation (Figure 1).

From *in-situ* observations of the realtime delamination tests it was found that: Interface delamination is a delicate balance between the forming, elongation and rupture of fibrils and interface delamination (Figure 2).

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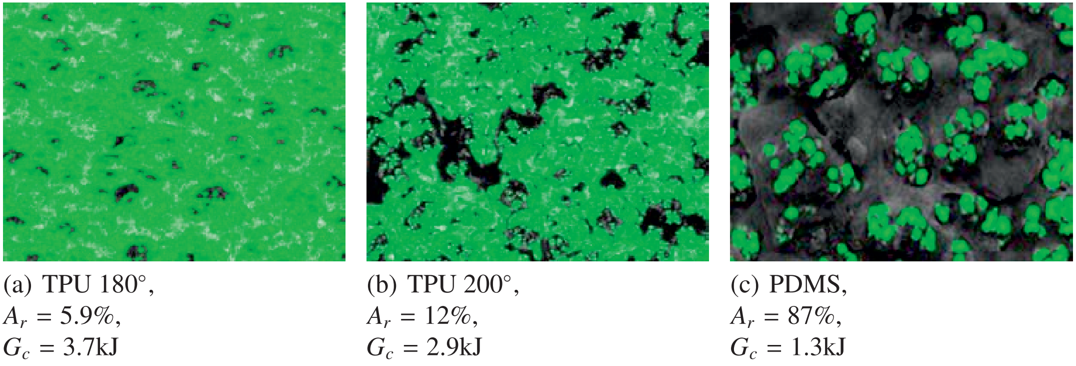
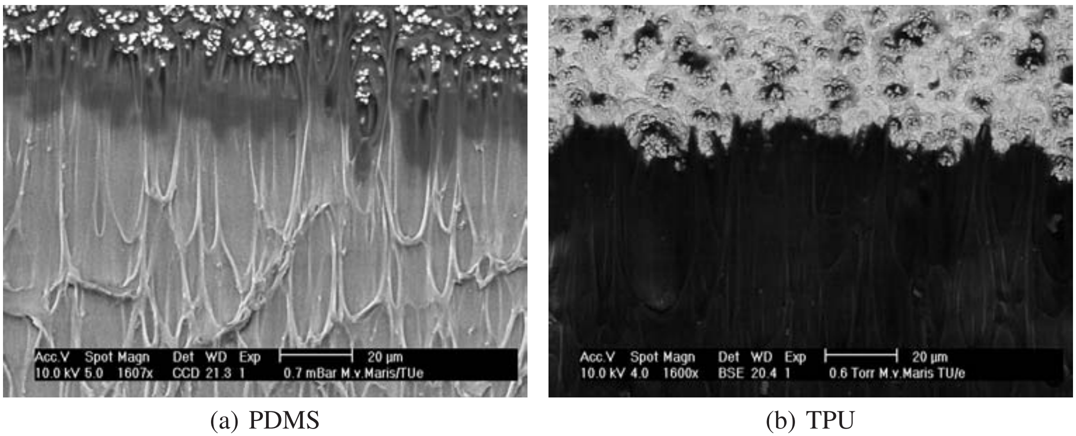


(a) TPU 180°, $A_r = 5.9\%$, $G_c = 3.7$kJ

(b) TPU 200°, $A_r = 12\%$, $G_c = 2.9$kJ

(c) PDMS, $A_r = 87\%$, $G_c = 1.3$kJ

Fig. 1: Analysis of ESEM images of the copper surface after peeling, rubber is shown in black and copper in green. With A_r the rubber fraction and G_c the Work of Seperation.



(a) PDMS

(b) TPU

Fig. 2: *In-situ* ESEM image of a progressing delamination front of the copper rubber interface.

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