Extreme deformation and adhesion in polymer-metal laminates

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Introduction

The mode of adhesion between polymer and the metal in polymer-metal laminates is of crucial importance for the high-tech industrial applications. The polymer does not directly adhere to the metal but requires an intermediary metal oxide coating. This laminate undergoes processing at high pressures and deformation rates in very short duration of time, thus stretching the laminate. As a consequence of repeated processing, new polymer and metal surfaces form at the interface. The metal oxide layer which is extremely thin (5-10nm) probably does not remain continous due to the formation of the new interface area, as shown in the illustration below.

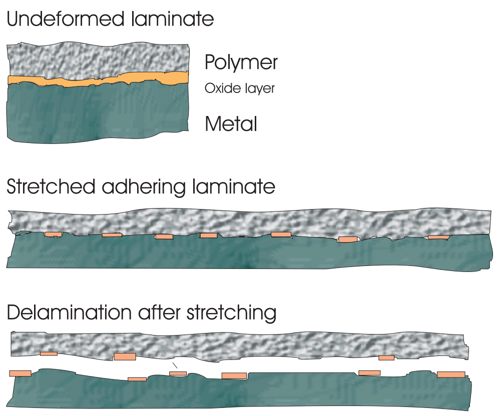


Fig. 1 *Schematic representation of laminate before and after stretching.*

FEM simulations as described in [1] indicate, high pressure and high strain rates enhance deformation resistance, but they do not take into account these physical changes occurring at the interface. The question remains, which properties of the laminate determine the adherance between the two materials, at the newly formed interface?

Aim

To understand the criteria that determine adhesion between polymer and metal during repeated extreme deformation conditions e.g. wall-ironing.

Experimental approach

- ☐ To study the properties of polymer and metal under high hydrostatic pressure and high strain rates, such as wall-ironing process [1].
- ☐ Study the morphology of the newly formed interface.
- ☐ Study which types of polymers, when coated on to metal and subjected to severe deformation, still adhere.

Materials studied

PET(Poly-ethylene-terepthalate) coated on ECCS (Electrochemically coated Steel). The metal surface at the interface was studied by etching away the PET coating.

Observations

After repeated processing (wall-ironing) of the laminate, the metal surface at the interface was studied. The PET coating was etched away using Phenol and observed under ESEM (Environmental Scanning Electron Microscope) and CLSM (Confocal Laser Scanning Microscope). Each wall-ironing process brings about a change in the surface at the interface as evident from ESEM images. Surface becomes rough and new surface is exposed as in fig. 2 and different modes of metal deformations are shown in fig. 3.

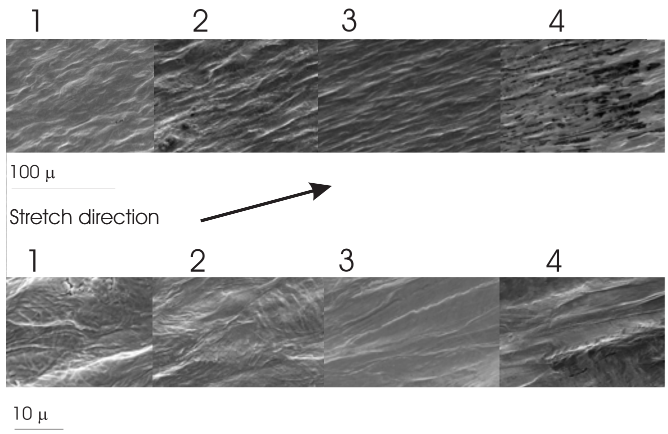
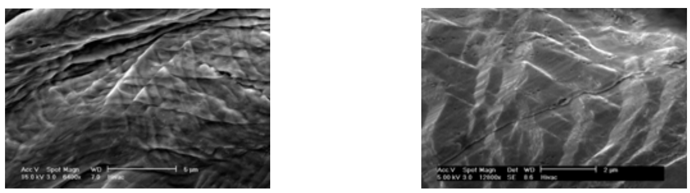


Fig. 2 *ESEM micrographs of metal surface after PET coating is etched away, showing the 4 sucessive stages of Wall-ironing process at lower and higher magnifications.*



slip twinning

Fig. 3 *Different deformation modes of metal.*

Conclusions

Results obtained so far show that understanding adhesion of the newly formed surface is very important. And also that the roughness and morphology of the interface need more investigation.

References:

[1] VAN DER AA, M.A.H. Wall Ironing of Polymer Coated Sheet Metal Phd thesis, 1999.