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TAILORING POLYMER-STEEL ADHESION DURING DEFORMATION-INDUCED STEEL ROUGHENING

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Polymer-coated steels are commonly used in industrial forming processes, e.g. for food and beverage packaging. Pre-coating the steels significantly reduces the environmental impact of the production process. However, during production the pre-coated steel is subjected to large deformations at increased temperatures and high strain rates. These large deformations result in surface roughening of the steel and hence the interface. After production, the interface must not exhibit any damage, even after a relatively long shelf-life period, as this damage triggers corrosion and compromises the quality of the content [1]. A recent experimental study showed that the interface is locally damaged during production due to the change in interface roughness [2]. In this contribution, the effect of roughening on the interface integrity is studied in a numerical-experimental framework.

A novel methodology for experimental determination of the three-dimensional surface deformation field has been developed [3]. The method uses Finite Element based global Digital Image Correlation (FE-DIC) to extract the full-field surface deformation from evolving surface height profiles. Thus, the proposed method provides new quantitative information for various surface deformation phenomena, and hence out-performs conventional methods using average height values.

The FE-DIC method was applied to in-situ evolving surface height profiles of a steel deformed in tension. The extracted surface displacement fields reveal the full-field kinematics accompanying the roughening mechanism. Local deviations from the (average) global displacements are the result of the formation, growth, and stretching of hills and valleys on the surface, see Fig. 1.

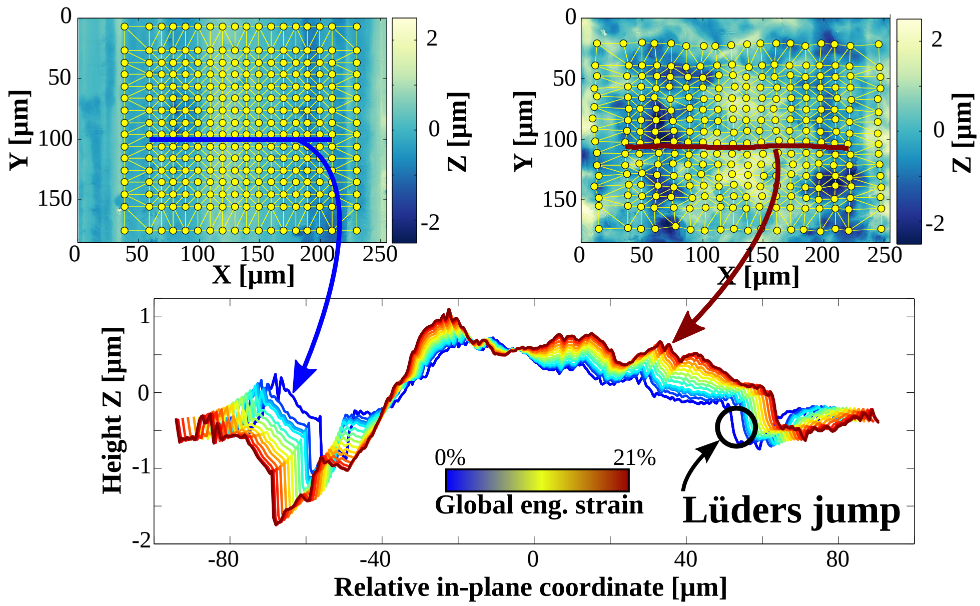

Figure 1: Example calculation of the FE-DIC method for a polymer-coated steel deformed in tension.

The surface displacements are prescribed in a two-dimensional numerical model consisting of a polymer layer with cohesive zone elements describing the polymer-steel interface. The simulations predict the initiation and propagation of the interface delamination as a result of the prescribed roughness evolution. Furthermore, polymer ageing strongly influences the predicted interface integrity and a polymer age is found which delays the damage initiation to a maximum tensile strain [4].

With the predictions, specific properties of the steel and the polymer can be tailored to reduce or even prevent damage and therefore improve the long-term reliability of products manufactured out of these materials.

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