Group on Surface and Microstructure Mechanics at the Max-Planck-Institut für Eisenforschung

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The Department of Microstructure Physics and Metal Forming (Prof. Dr.-Ing. habil. Dierk Raabe) at the Max-Planck-Institut für Eisenforschung has recently opened a new research group on **Surface and Microstructure Mechanics**. The group is particularly concerned with investigating the fundamentals of elastic-plastic surface and interface mechanics of polymer coated, metal-coated, and uncoated sheet steels during forming.

Plastic straining of coated polycrystalline steels is typcially accompanied by the development of microstructural defects at the sample surface as well as in the interface between the steel sheet and the interface (which may be a polymer or a metal coating). These defects are due to a variety of dynamical mechanisms which are essentially induced by bulk plasticity of the steel substrate. They micromechanically interact with the coatings and transfer some of the metallic roughness created at the steel surface during forming through that layer to the surface.

It is pertinent in this context to differentiate between *intrinsic* and *extrinsic* defects at the surface and in the metal-coating interface. *Intrinsic* defects induced by bulk plasticity occur in the form of net residual surface displacement fields as a result of microstructure dynamics during plastic straining. Examples are glide steps, shear bands, or grain cluster deformation patterns. As *extrinsic* defects one can denote all surface changes that occur through the influence of the environment, i.e. by mechanical contact (tools, friction, non-homogeneity of forces and material flow) or by corrosion.

Intrinsic surface and steel-polymer as well as steel-metal interface defects occur at different spatial scales and can have different microstructural origin, similar to the corresponding hierarchy of bulk defects associated with plasticity. Fig. 1 shows some examples concentrating on those defects which originate from plastic deformation of the steel substrate. They include interface defects generated by elastic distortions, point defects, atomic slip steps, crystallographic slip steps created by sets of dislocations on parallel or identical glide planes in the metal (Fig. 1a), athermal transformations such as martensite formation, mechanical twinning (Fig. 1b), non-crystallographic glide traces caused by dislocation bands which contain slip activity on parallel and non-parallel glide systems, fracture and delamination, orange peel phenomena where iron crystals abutting on the metal-polymer interface undergo individual out-of-plane displacements (Fig. 1c), individual surface deformations by hard and soft phases, as well as ridging and roping phenomena, which are characterized by the collective deformation of larger sets of grains typically resulting in a banded topology (Fig. 1d).

Grain-scale micromechanical effects at the steel sheet surface or respectively in the steel-polymer or steel-Zinc interface are essentially determined by orange peel and ridging phenomena. They decide about surface roughness, friction conditions during forming, strain localization, optical appearance, and failure of constructional materials at an engineering scale.

Contacts with the new research group at the Max-Planck-Institut für Eisenforschung can be established in the Department of Microstructure Physics and Metal Forming at raabe@mpie.de.

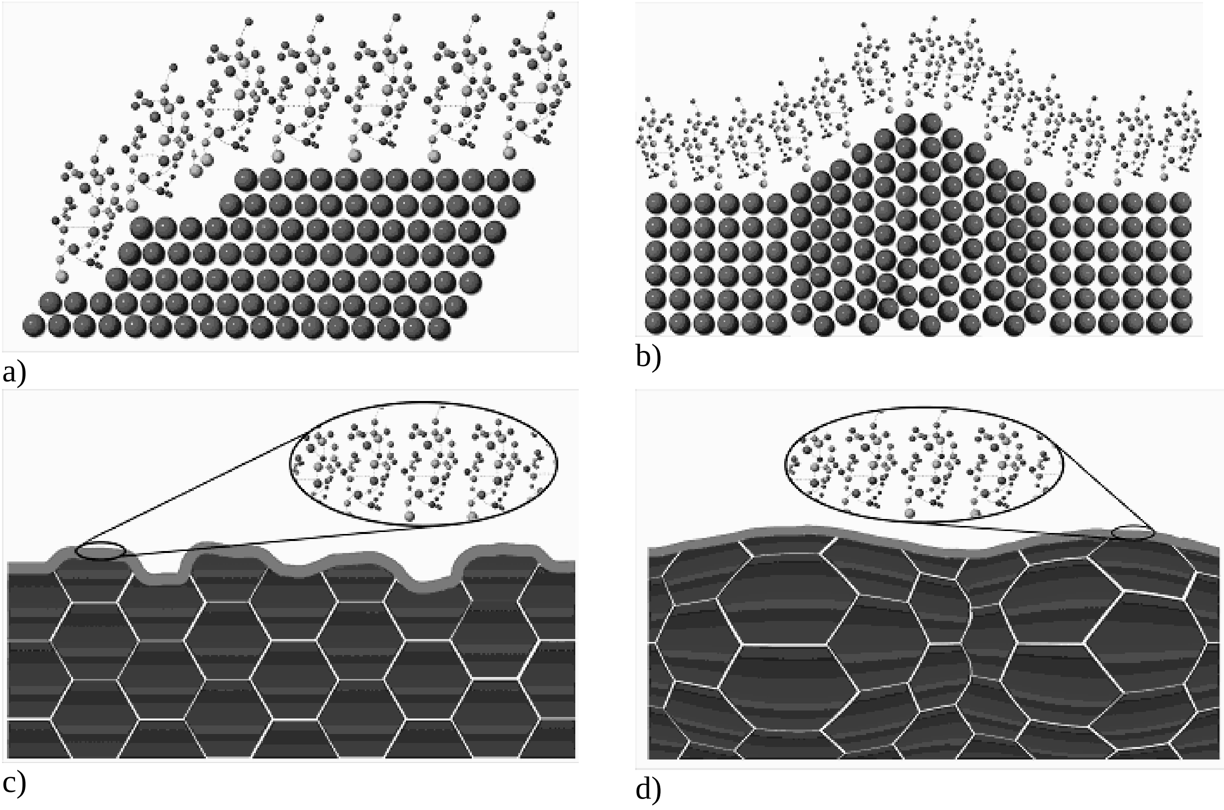

Figure 1
Some examples of steel-polymer interface defects induced by bulk plasticity of the steel substrate.
a) crystallographic slip steps;
b) athermal martensitic transformation and twinning phenomena;
c) orange peel phenomena where crystals at the interface undergo individual out-of-plane displacements;
d) ridging and roping, which are characterized by the collective deformation of larger sets of grains typically resulting in a banded surface topology. Ridging and roping occurs frequently in ferritic stainless steels.

References

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"Surface Micromechanics of Polymer Coated Aluminium Sheets during Plastic Deformation"