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ANISOTROPY OF UTRAFINE-LAMELLAR AND NANOLAMELLAR PEARLITIC STRUCTURES REVEALED BY *IN-SITU* MICRO COMPRESSION TESTING

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Applying severe plastic deformation to pearlitic steels leads to a transformation of the random ultrafine-lamellar (ufl) colony structure to a nanolamellar (nl) composite. The distinct reduction of the interlamellar spacing generates a high-strength steel with a strength of up to 3.7 GPa, which can readily be produced. Additionally, the ferrite and cementite lamellae align in a preferential direction giving rise to an anisotropic mechanical response.

The aim of this work is to determine the material anisotropy in terms of flow stress and deformation behavior in the nl state and to compare it with its ufl state. Thus, micron sized samples are fundamental in order to fit inside a single colony of a distinct lamellae alignment. In addition, these small dimensions ensure a homogeneous structure within the nl samples. The compression setup on the other side enables to characterize the deformation behavior up to large strains, since early failure as a consequence of necking is prevented. Hence, micro compression experiments are an established tool for characterizing deformation mechanisms of fine-scaled materials and they further allow to link the deformation characteristics observed in the scanning electron microscope (SEM) to the mechanical data.

In this work anisotropic mechanical properties could be successfully measured by micromechanical testing of pillars consisting of single ufl pearlite colonies and nl pearlitic structures for the first time. For both lamellae spacings three different types of micro pillars were focused ion beam milled, with the lamellae being aligned parallel, normal and inclined with respect to the loading direction. Comparing the stress-strain curves and the deformation characterstics of the ufl and nl micro pillars, it could be revealed that not only the interlamellar spacing but also the loading direction of the lamellae have a significant influence on the materials behavior. Especially, it was found that the yield point of the material is mainly controlled by the interlamellar spacing, whereas the lamellae orientation governs the hardening capability, the critical stress for the onset of localized deformation and thereby also the strength in a subsequently arising plateau regime. Furthermore, it could be shown that the global failure and deformation characteristics vary depending on the lamellae alignment. Finally it should be noted, that the anisotropy of the hardening behavior in the ufl and nl pearlite is different.

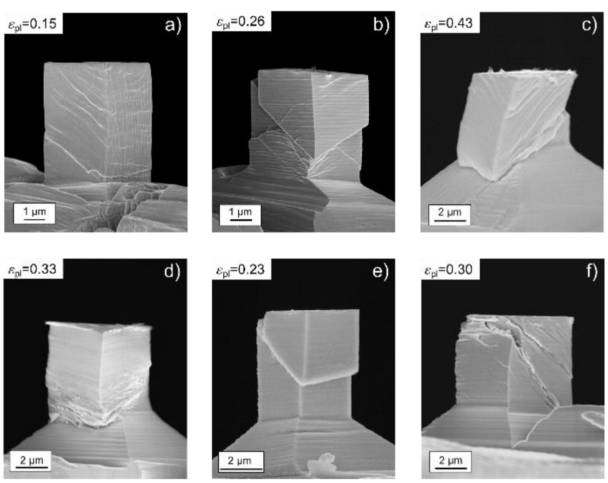

Figure 1 SEM images of a-c) ufl and d-f) nl pearlitic micro pillars. The surface morphology varies according to the ferrite and cementite lamellae alignment a,d) parallel, b,e) normal and c,f) inclined with respect to the loading direction.