# In-Situ Neutron Diffraction Study of Dual-Phase and Interstitial-Free Steels

**H. Ma [1], and M.A. Gharghouri [2]**

[1] University of Toronto, Department of Materials Science and Engineering, Toronto, ON, Canada M5S 1A7

[2] Canadian Neutron Beam Centre, National Research Council, Chalk River Laboratories, Chalk River, ON, Canada K0J 1J0

Dual Phase (DP) steels consist of a ferrite matrix containing a hard martensitic second phase in the form of islands. They have become one of most popular and versatile materials in the automotive industry based on their excellent combination of high strength and good ductility. The increased strength to weight ratio afforded by these steels can potentially yield increased fuel efficiency.

DP steels have high yield stresses, require large forces during forming, and tend to be anisotropic in nature. As a result, their anisotropic nature leads to significant variations in springback and significantly complicates the design of tooling and the stamping process. It is thus essential to develop methods to accurately predict springback. Although many factors can affect springback, the Bauschinger effect should be taken into account in modeling to ensure that the internal stresses developed during sheet forming are properly captured. DP steels demonstrate a strong Bauschinger effect due to the inhomogeneous deformation of two phases.

TEM observations at pre-strains of 3% and 10% show that dislocation pile-ups occur around martensitic islands. At the large deformation, dislocation walls and cells appear, as shown in Figure 1.

It has been shown that DP steels demonstrate internal stresses due to the inhomogeneous deformation of the two phases. To identify the micro-mechanisms responsible for the strong Bauschinger effect in DP steels, and to evaluate models, a systematic investigation of the deformation response of each constituent phase in the material is needed. The distribution of stresses between the phases is hence a key element in this investigation. In-situ tensile tests with neutron diffraction provide a good way to measure internal and residual stresses to see how they respond to loads.

In figure 2, lattice strains as a function of applied stress are compared for DP and IF steels. The internal and residual stresses are stronger in the DP steels than in IF steels under the same deformation conditions, which suggest a stronger Bauschinger effect for DP steels. The results of the experiment have been used to understand, explain and model the Bauschinger Effect leading to the eventual simulation of springback behavior of DP sheet steels.

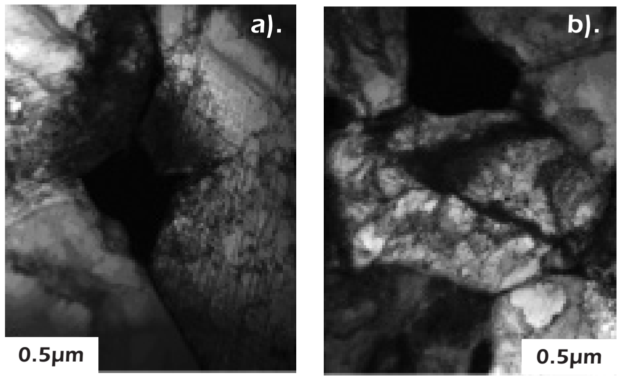


**Fig. 1** *TEM at pre-strains of (a) 3% and (b) 10%.*

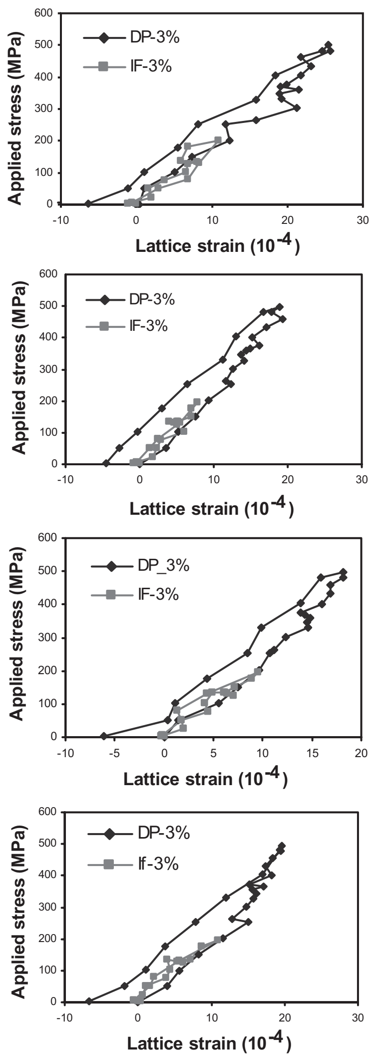


**Fig. 2** *The lattice strain measurement at the load for pre-strain of 3% and unloaded.*