First International Conference on Heterostructure Materials (HSM I) 12-15 July 2022, Hong Kong, China

Ultra-high Tensile Strength via Precipitates and Enhanced Martensite Transformation in a FeNiAlC Alloy

Yan Ma[1,3], Muxin Yang[1], Fuping Yuan[1,2], Xiaolei Wu[1,2]

[1]State Key Laboratory of Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Sciences
[2]College of Engineering Sciences, University of Chinese Academy of Sciences
[3]Department of Materials Science and Engineering, City University of Hong Kong, Hong Kong, China

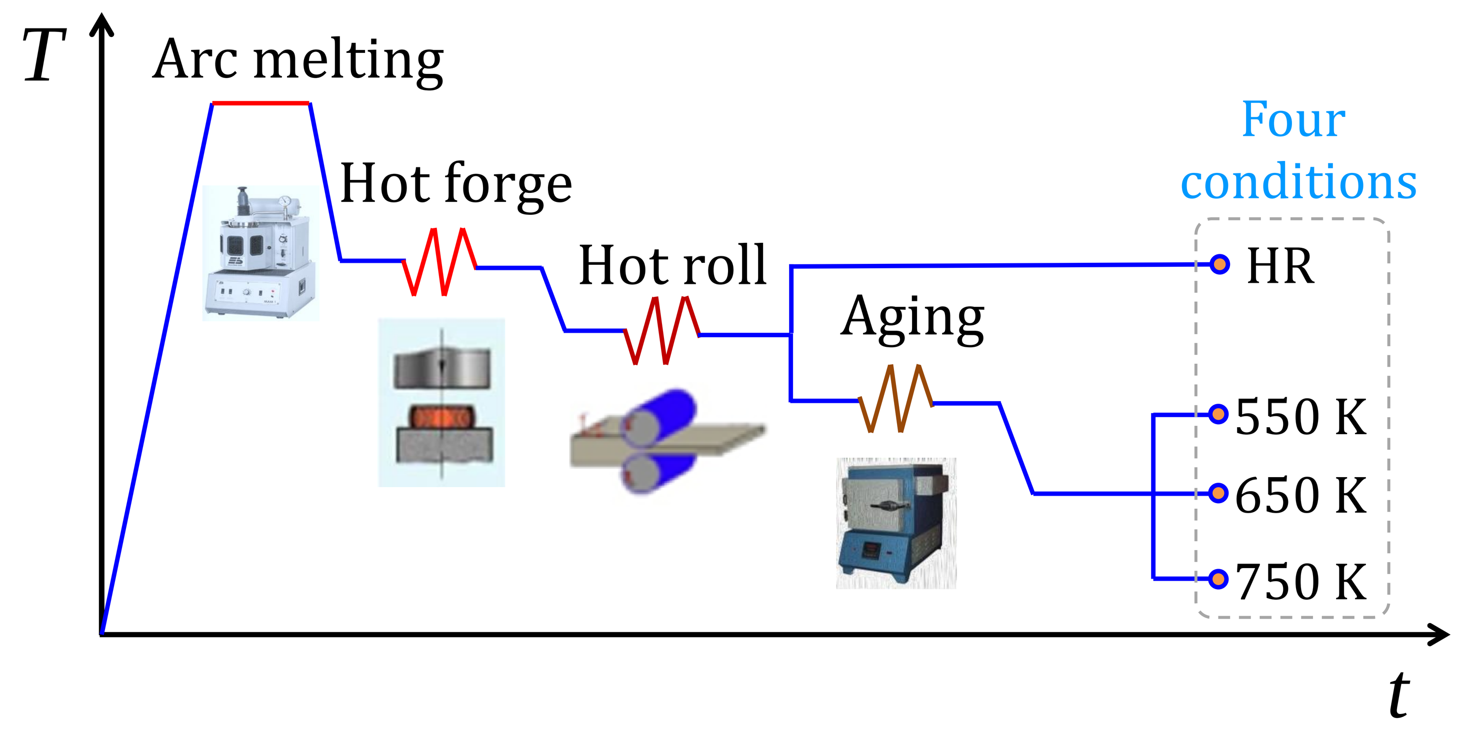
Introduction

Combining high strength with high ductility is a perennial challenge for the development of advanced structural materials. To achieve high strength, the materials are always cold-worked to refine the grains and increase the dislocation density. However, the strain hardening capacity will be severely reduced since the further accumulation of dislocations will be difficult.

To this end, we report a strategy for achieving an extraordinary high strain hardening rate by introducing a triple-phase microstructure, containing the B2 precipitates and martensite for strengthening, and the retained austenite for the TRIP effect.

Materials and Methods

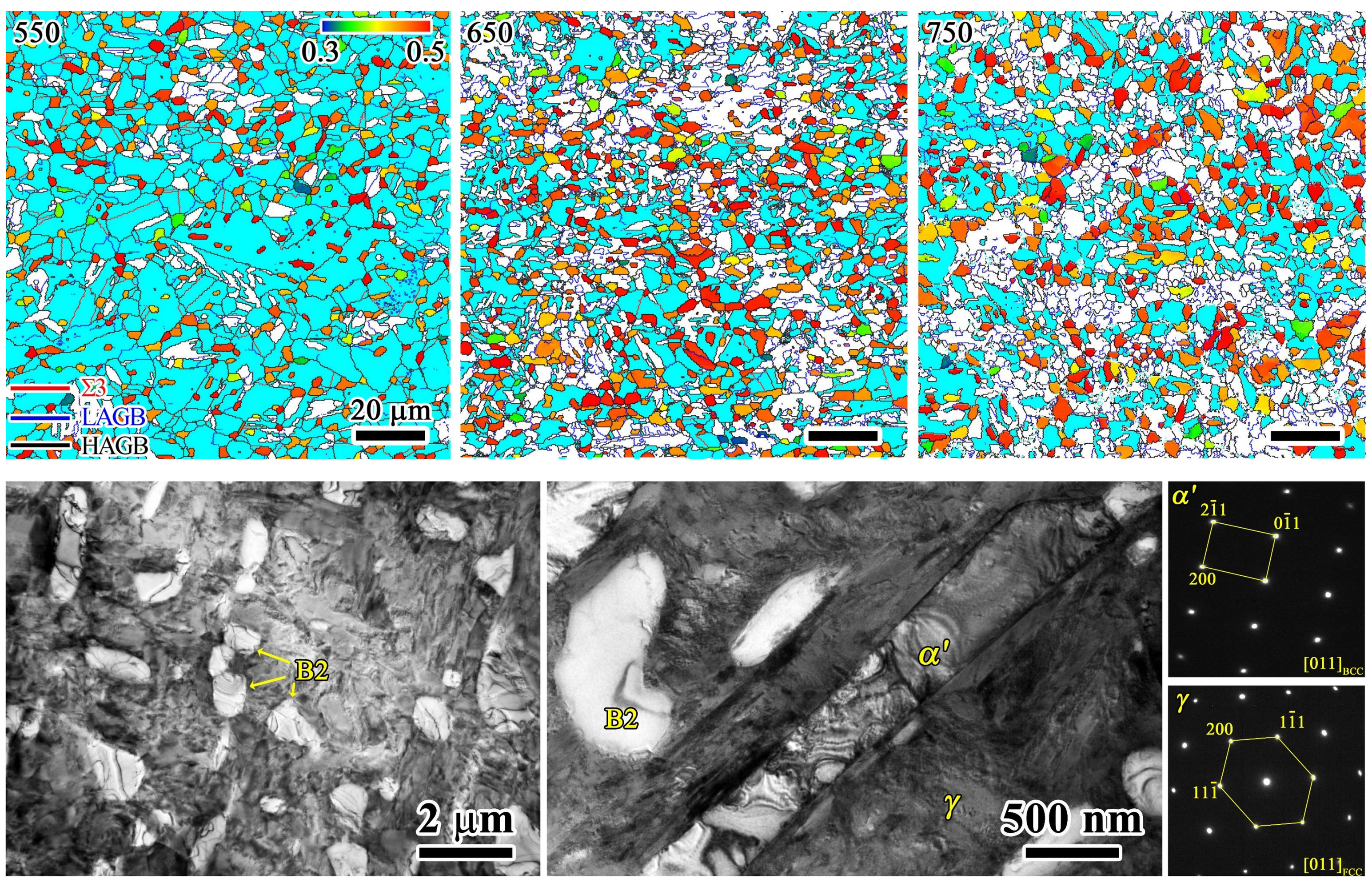
In order to produce the triple-phase structure, the FeNiAlC alloy was hot-rolled (HR) and aged at 550~750 K, as shown in the following sketch.

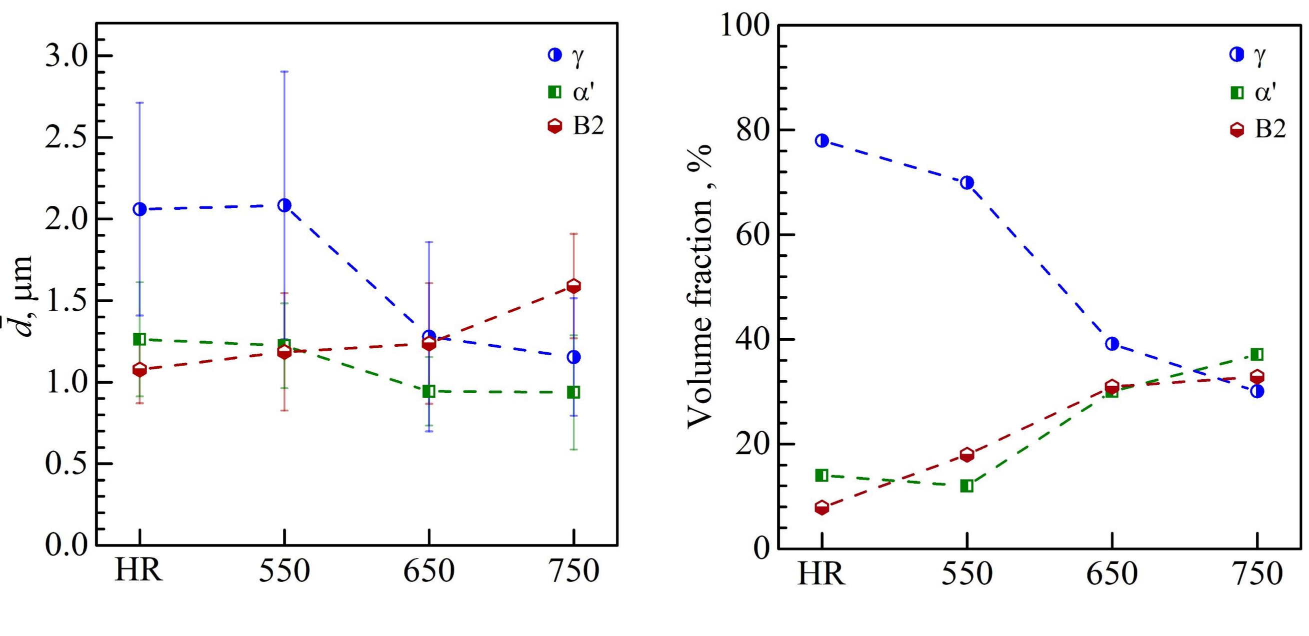


Result and Discussion

Triple phase structures

The typical EBSD maps show the three phases, containing the **B2 precipitates** colored based on the Schmid factor, the retained austenite γ colored in light blue, and the **martensite α'** colored in white.



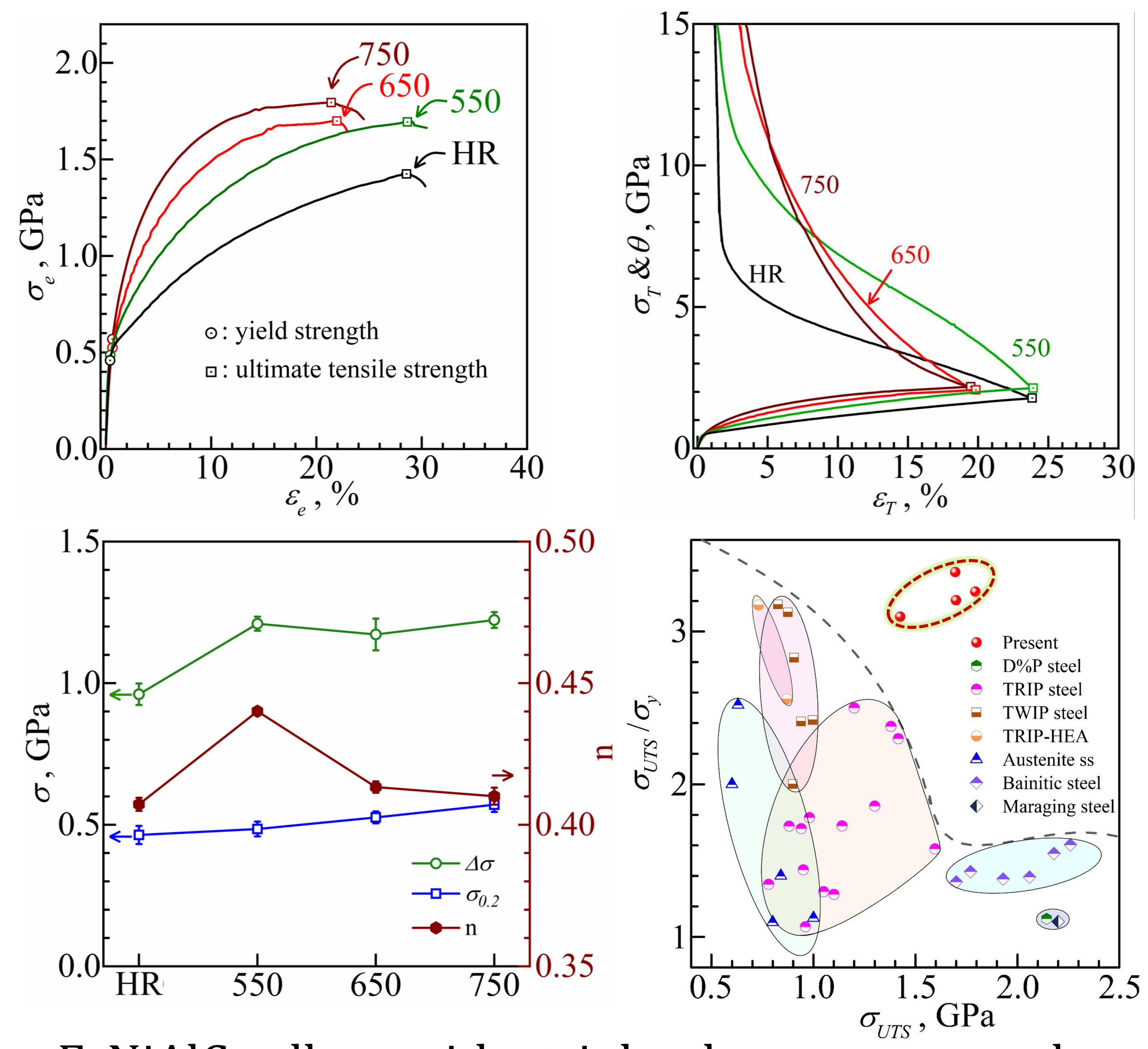


As the aging temperature increases, the volume fraction of γ decreases, whereas those of B2 and α' increase simultaneously. However, the grain size of B2 increases overtly, which is detrimental to ductility since it is hardly deformed.

Reference: Yan Ma, *et. al,* Mater. Sci. Eng. A, 2021

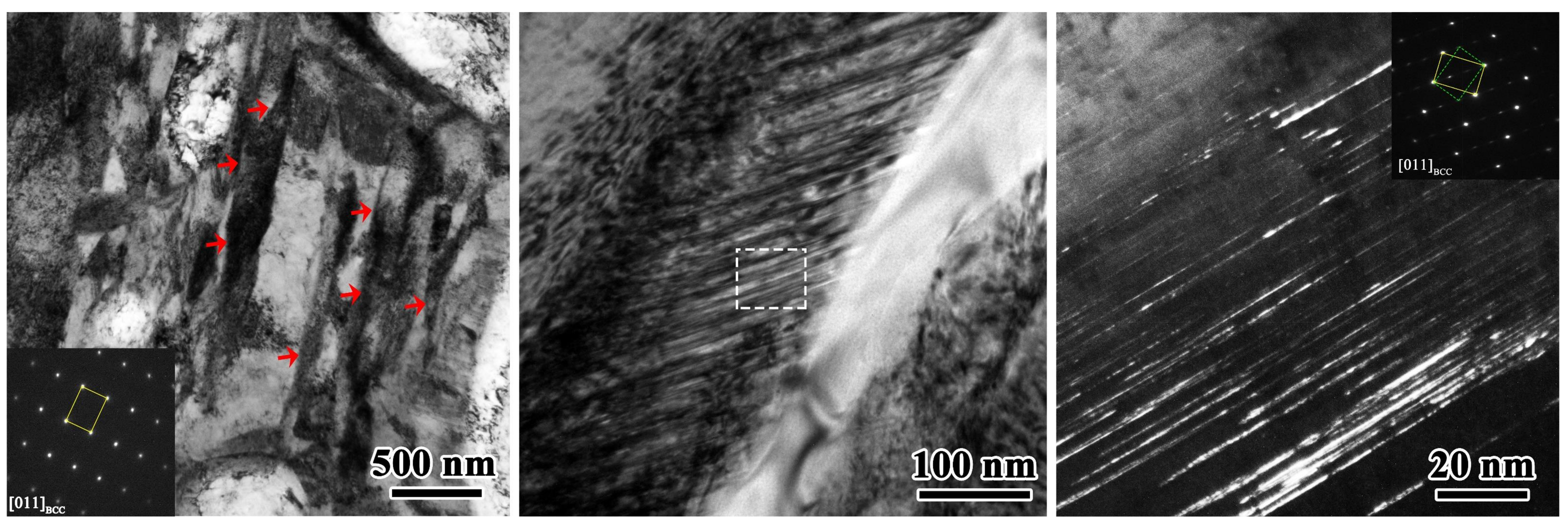
Result and Discussion

Mechanical properties



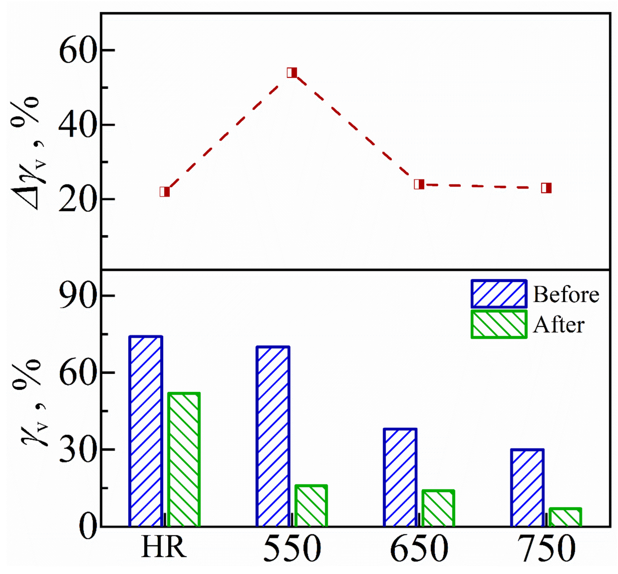
The FeNiAlC alloy with triple-phase structured exhibit extraordinary high strain hardening capacity (σ_{UTS}/σ_y), exceeding the other alloys and steels.

Strain hardening mechanism

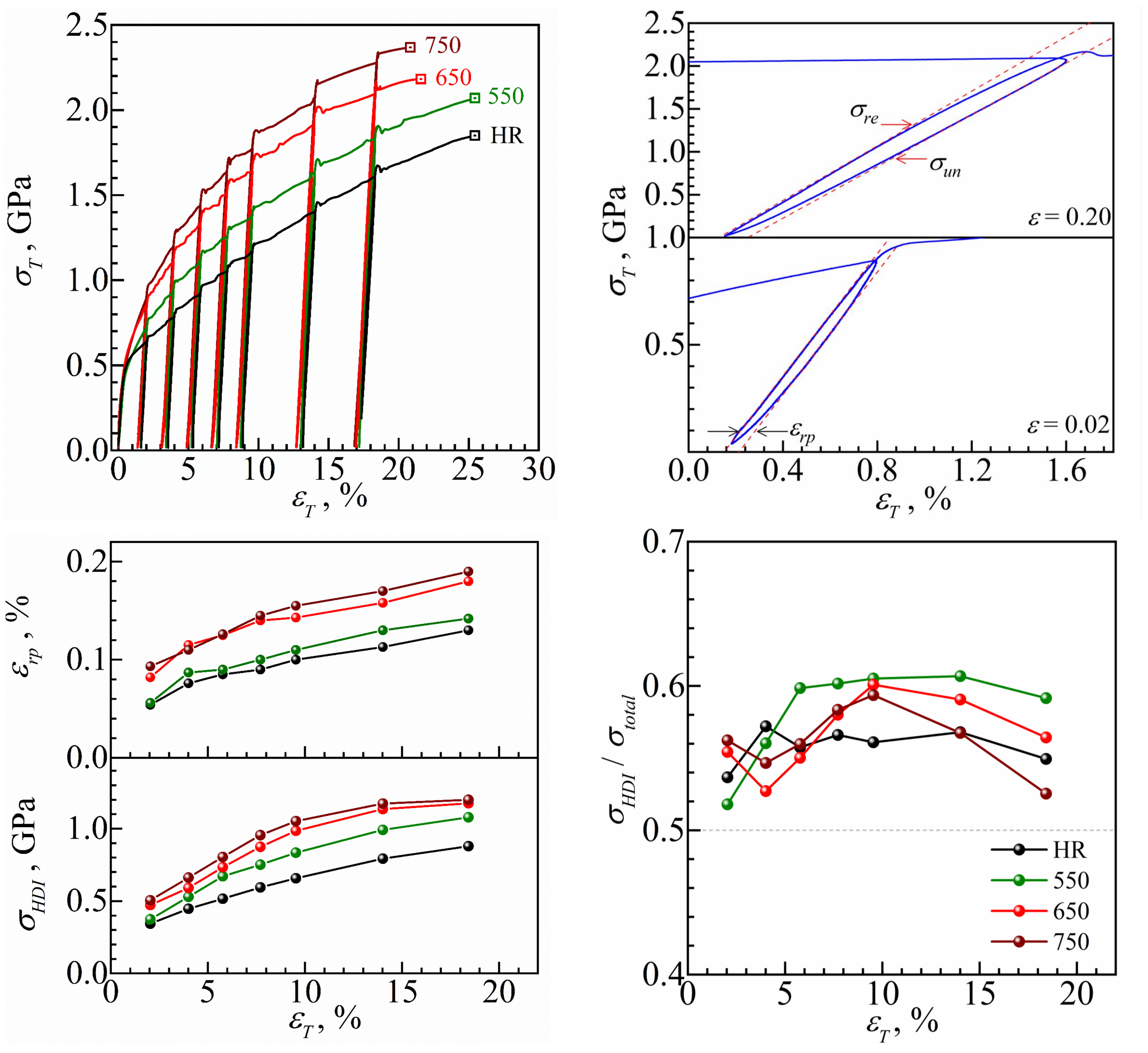


The martensite transformation of the retained austenite and high-density martensitic twins can be observed in the aged samples after deformation, rendering a significant strain hardening.

The largest volume fraction of martensite transformation can be seen in the 550-aged sample.



HDI strengthening and hardening



The HDI stress dominates the flow stress in the present material during the deformation, especially in the 550-aged material.

Conclusion

- The triple-phase structure leads to an excellent property with extraordinary high strain hardening capacity.
- The martensite transformation and martensitic twins contributed to the significant strain-hardening.
- The HDI stress and HDI hardening dominate the deformation.