

# The 3<sup>rd</sup> generation automobile sheet steels presenting with high strength and high ductility

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**ABSTRACT:** In this study, research and development on the 3<sup>rd</sup> generation automobile steel, with targets of  $R_m \times A$  no less than 30GPa% at  $R_m$  level of 1-1.5GPa, was carried out by Austenite reverted transformation and by quenching and partitioning. In both process, substantially enhanced ductility (30-40%) at ultrahigh tensile strength level (1-1.5GPa) was obtained. It is interesting to find that a strong dependence of the product of tensile strength to total elongation on the fraction of retained austenite phase of steels produced by both ART-annealing and Q&P processing techniques.

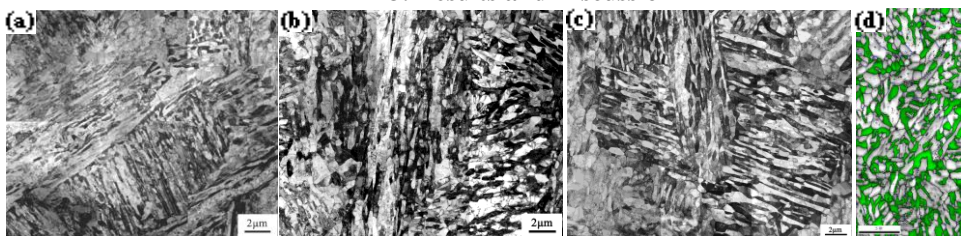
## 1. Introduction

High strength steel sheets have been increasingly applied in automobile industry [1]. As an index of formability and absorbed energy of materials, the product of tensile strength ( $R_m$ ) to total tensile elongation ( $A$ ),  $R_m \times A$ , has been applied to tailor the materials in auto industry [2]. In this study, research and development on the 3<sup>rd</sup> generation automobile steel was carried out to fabricate high strength and high ductility steel at low cost. Ultrafine grain sized duplex microstructure, mechanical properties and substantially enhanced work hardening behavior of medium manganese steels fabricated by ART-annealing and Q&P processing were demonstrated and analyzed in this study, which is financially supported by 973 program of Chinese government (No.2010CB630803).

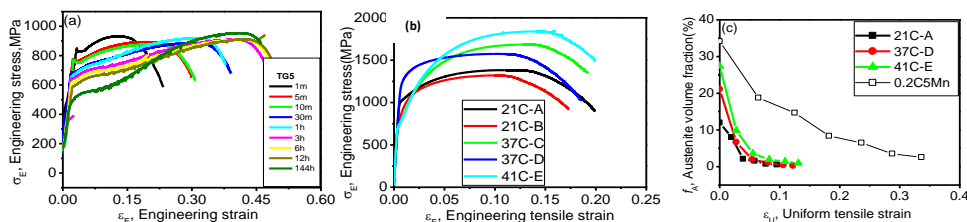
## 2. Experimental

Medium manganese steels (3-9%Mn and 0.01-0.4%C) were prepared. These steels were quenched into oil after austenitization at 750°C for half an hour and then intercritical annealing by austenite reverted transformation (ART-annealing) at 650°C with different time. The conventional Carbon steels of 21C, 37C and 41C were processed by Q&P process with relative short partitioning time at relative high temperature (500°C with ~1min). Microstructure and mechanical properties of the designed steels were examined by transmission electron microscopy (TEM), electron back scattered diffraction in scanning electron microscopy with field emission gun (EBSD-FEG/SEM), X-ray diffraction (XRD) and tensile test. Manganese contents in ferrite and austenite were measured by STEM and the carbon content in austenite was measured by XRD.

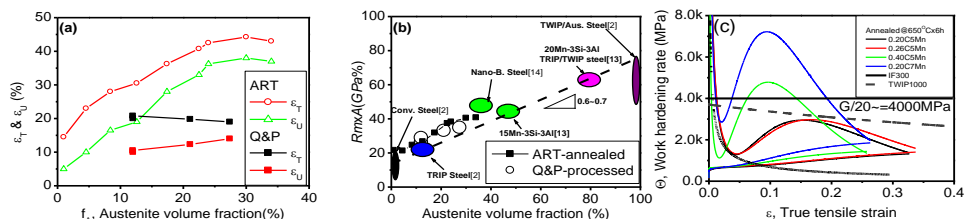
## 3. Results and Discussion



**Fig.1** Microstructure of Fe-0.2C-5Mn steel ART-annealed at 650°C with different time. (a) 1hr, (b)6hrs, (c) 48hrs examined by TEM and (d) 6hrs characterized by EBSD.



**Fig.2** Mechanical properties and austenite volume fractions. (a) ART-annealed steels, (b) Q&P processed steels and (c) Austenite fraction of ART and Q&P processed steels to indicate the TRIP behaviors[3].



**Fig.3** Mechanical properties as a function of austenite volume fractions and work hardening behaviors of processed steels (a) Ductility, (b)  $R_m \times A$  and (c) three stage work hardening[4].

## 4. Conclusions

The ultrafine grain sized austenite-ferrite/martensite duplex microstructures were obtained in ART-annealed medium manganese steels and Q&P processed conventional carbon steels. In both process, substantially enhanced ductility (30-40%) at ultrahigh tensile strength level (1-1.5GPa) was obtained, which results in a significant improvement of the product of tensile strength to total elongation about 30-40GPa%. These greatly improved ductility result from the aid of the phase transformation induced plasticity (TRIP effects) and the ultrahigh strength stems from the hard matrix, such as the ultrafine grained duplex structure in ART-annealed steels and the martensite matrix in Q&P processed carbon steels. Both ART-annealing and Q&P processing were demonstrated to be capable of producing ultrafine austenite-ferrite duplex structure in medium manganese steel, which presenting ultrahigh strength and high ductility, which meet the objective of the governmental program of 3<sup>rd</sup> phase 973.

## 5. References

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