13–3 Neutrons in Development of High-Performance Materials

— Role of Deformation-Induced Transformation in TRIP Steels Revealed by Neutrons at J-PARC —

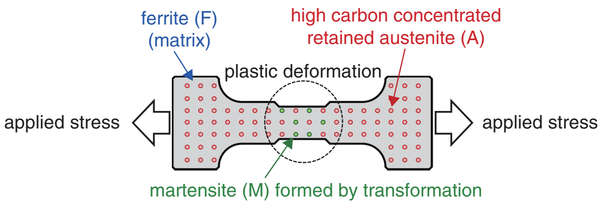

Fig.13-4 Illustration of TRIP effect
The M phase is formed during plastic deformation, and the material's strength and elongation are increased.

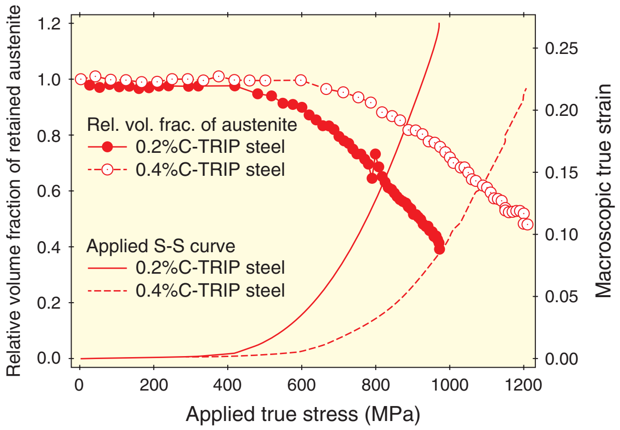

Fig.13-5 Changes in relative volume fraction of retained austenite and stress–strain curve of TRIP steels
Phase ratio does not change during deformation in common steels, whereas it varies in TRIP steels.

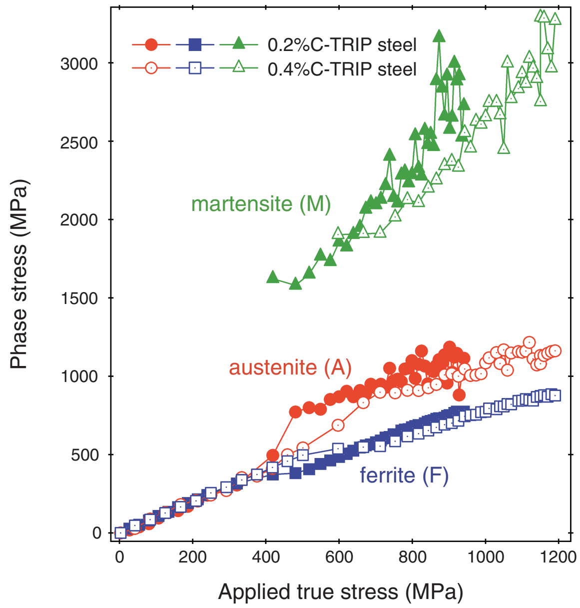

Fig.13-6 Stress partitioning among constituent phases of TRIP steel during deformation
The stresses were calculated from the phase lattice strains obtained from an *in-situ* neutron diffraction study during tensile deformation. We successfully separated the diffraction peaks to elucidate the stress partitioning between the M and F phases, which was not possible using the conventional instruments of ISIS and JRR-3 with low d-spacing resolution.

Transformation-induced plasticity (TRIP) is an important effect in steel that improves the strength and ductility and realizes excellent high-speed deformation behavior. Steels with 0.2%C-TRIP and 0.4%C-TRIP are known to have excellent shock absorption in collisions and are expected to be used in car bodies. The TRIP effect, as shown in Fig.13-4, occurs in steel having a metastable phase (the A phase) that can transform into a stronger phase (the M phase) during plastic deformation. However, there is almost no quantitative research on the behavior causing the TRIP effect that directly shows the contribution of the M phase to the strength. We attempt to understand this behavior using neutron diffraction.

We performed *in-situ* neutron diffraction experiments during tensile loading at room temperature using the Engineering Materials Diffractometer TAKUMI at the Materials and Life Science Experimental Facility of J-PARC. TAKUMI can perform an *in-situ* neutron diffraction experiment during deformation without interruption of the load or displacement because of its high intensity and instantaneous data collection system. The relative volume fractions of the A phase obtained from neutron diffraction, as shown in Fig.13-5, are gradually decreased with increasing applied stress after the onset of plastic deformation, showing that a deformation-induced martensitic transformation occurs. Fig.13-6 shows the phase stresses that are shared by the constituent phases in the TRIP steels during tensile deformation. The M phase stresses are found to be the highest and the ferrite phase stresses are the lowest among the constituent phases. Moreover, the bulk stresses that are estimated using these phase stresses and the volume fractions show good agreement with the applied stresses.

Reference
Harjo, S. et al., TRIP Steel Deformation Behavior by Neutron Diffraction, Materials Research Society Symposium Proceedings, vol.1528, 2013, 7p.