The microstructure of the martensite in shape memory alloys is characterized by the combination of multiple habit plane variants (HPVs) to minimize the elastic strain energy upon transformation, which is so-called self-accommodation (SA). In the present study, the SA morphology of the B19' martensite is systematically investigated by SEM, CTEM and STEM. The SEM used was Cal Zeiss ULTRA 55. The STEM used was JEM-ARM200F equipped with a spherical aberration corrector for electron optic system. The surface relief morphology of wide area in polycrystalline bulk specimen was observed by SEM. The crystallographic aspects of each HPV was determined by electron diffraction experiments with CTEM. The interface structure between HPVs was investigated by HAADF-STEM.

There are twelve pairs of the minimum SA unit consisting of two HPVs with V-shaped morphology connected to a {-1-11}B19' Type I variant accommodation twin. It is found that an ideal SA morphology consists of three V-shaped units, i.e., a total of six HPVs, clustered around one of the <111>B2 poles with hexagonal shape as shown in Fig. 1. Triangular and parallelogram SA morphologies are also observed. The triangular morphology consists of a V-shaped unit and third HPV. Although there are four candidates of the third variant in the triangular SA morphology, specific two HPVs are only confirmed. The parallelogram morphology consists of two V-shaped units, i.e., a total of four HPVs [1]. The variant selection rule and the number of possible HPV combinations in each of these self-accommodation morphologies are established. It is revealed that there are four kinds of characteristic HPVs interface to complete the SA morphologies mentioned above. The HAADF-STEM observations well agree with the prediction of crystallographic aspects of the interfaces from the phenomenological theory of martensite crystallography and the geometrically nonlinear theory [2, 3].

In-situ cooling and heating SEM observations and three dimensional SA morphologies are also discussed. The evidence of thin foil effect in in-situ TEM observations will be provided.

References

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Fig. 1: SEM image of reverse transformation surface relief showing ideal six HPVs cluster around [111] in Ti-51.0 at% Ni alloy.