Domain interfaces and fatigue failure of NiTi polycrystalline strips

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ABSTRACT

Nickel-Titanium (NiTi) Shape Memory Alloy (SMA) with pseudoelasticity (superelasticity) and shape memory effect has many applications, most of which are under cyclic loadings. So, the fatigue performance is important (including functional fatigue and structural fatigue [1]); particularly, the structural fatigue (with significant microstructure damage leading to device/structure failure) has to be well understood before promoting large-scale engineering applications. Most of the existing fatigue study on NiTi SMA was focused on the fatigue criteria in terms of the nominal stress-strain responses (nominal stress/strain amplitude, mean stress/strain, energy dissipation, etc.), ignoring an important deformation feature — Lüders-like bands (macroscopic localized deformation domain) which could be formed in a stretched pseudoelastic NiTi polycrystalline strip due to the material’s mechanical softening property [2]. Recently, it was revealed that the macroscopic domain formation/evolution can influence the fatigue life of the NiTi strips significantly [3,4]. Interestingly (out of general expectation), the Lüders-band front (the domain wall/interface separating the high-strain Martensite domain and the low-strain Austenite domain) is not a fatigue weak zone: when the NiTi strip with the domains (A domains, M domains and the domain interfaces) under only “elastic” cyclic tensile loading (i.e., no interface propagation), the fatigue fracture failure occurs in a M domain rather than at a domain interface. That means, the domain interface (generally considered as a weak zone with stress concentration and/or compatibility problem) has a higher fatigue resistance than the M domains. To further understand this phenomenon, we conducted the fatigue tests on NiTi strips of different thicknesses. It is found that the strip’s thickness can influence the morphology of the domain interface (as the theoretical prediction in [5]) so as to affect the strip’s fatigue life. Moreover, the fatigue fracture failure can occur at the domain interfacial zone, depending on the strip’s thickness (i.e., depending on the morphology of the domain interface). It is implied that domain interface could be an important feature governing the fatigue life of NiTi strips.

REFERENCES