In-situ 4D-STEM of the Martensitic Phase Transformation in NiTi

Jennifer Donohue[a], and Andrew M. Minor[a,b,*]

[a.] Department of Materials Science and Engineering, UC Berkeley, Berkeley, CA 94720, USA.

[b.] National Center for Electron Microscopy, Molecular Foundry, LBNL, Berkeley, CA 94720, USA.

* aminor@berkeley.edu

Materials which undergo displacive phase transformation (DPT) with large recoverable strain are extremely useful for sensors and devices however, microscopic strain incompatibility causes the accumulation of defects at the transformation boundary [1-2] causing a high hysteresis. Understanding how the nanoscale strain landscape develops at and before the transformation front is critical to understanding the local origin of the hysteresis in DPT materials. Here, we use four-dimensional scanning transmission electron microscopy (4D-STEM) [3-4] to map the nanoscale strain landscape during *in situ* cooling of a NiTi through the phase transformation from austenite to martensite. Using this method, we track both phase distribution and strain as NiTi approaches then proceeds through the phase transformation. In Figure 1 we demonstrate the development of strain $<01\bar{1}>$ direction of the austenite lattice before the transformation as well as a map of the resulting coexisting martensite/austenite structure at the transformation temperature in NiTi. We also mark the increase in local diffuse scattering associated with the phase transformation (Figure 1, inset diffraction patterns). With this work, we correlate the development of diffuse scattering, with the local strain landscape as a function of temperature through the phase transformation in NiTi and correlate the resulting martensitic morphology with the precursor strain fields to reveal insight into the transformation dynamics in NiTi using *in situ* 4D-STEM.

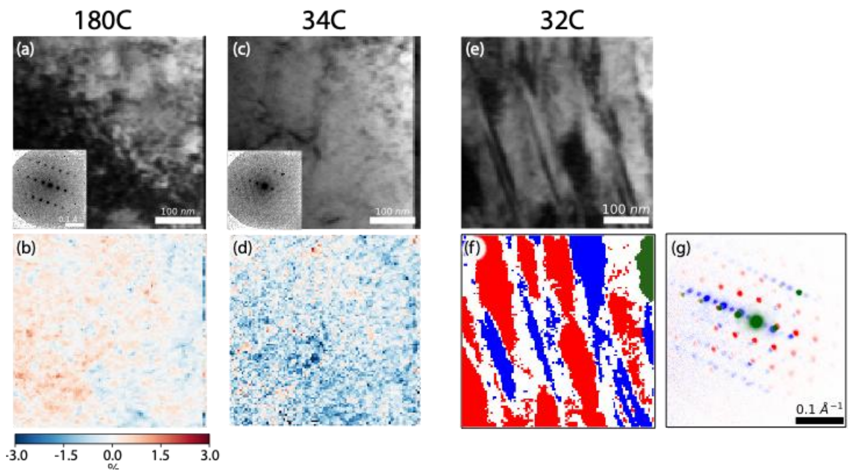

Fig.1 (a,b,e) bright field images of NiTi at the indicated temperature, (b,d) percent strain along the $<01\bar{1}>_{B2}$ direction (f) map of martensite (blue and red) and austenite (green) phases at 32C, and (c) overlaid diffraction patterns of each phase in (b)

Keywords: Displacive Phase Transformations, NiTi, In Situ, Electron Microscopy, 4D-STEM

Acknowledgment:

The authors acknowledge funding from the Department of Defense (DoD) through the National Defense Science and Engineering Graduate (NDSEG) Fellowship Program, and the National Science Foundation under STROBE Grant no. DMR 1548924. Work at the Molecular Foundry at Lawrence Berkeley National Laboratory was supported by the U.S. Department of Energy under Contract # DE-AC02-05CH11231.

References:

[1] Xu, Y. C. et al., Acta Materialia 171 (2019), p. 240-252. https://doi.org/10.1016/j.actamat.2019.04.027.

[2] Xu, YC. *et al,* npj Comput Mater 4(58) (2018), p. 1-7. https://doi.org/10.1038/s41524-018-0114-7

[3] Savitzky B. H. et al., Microscopy and Microanalysis 27(4) (2021), p. 712-743.

[4] Ophus, C., Microscopy and Microanalysis 25(3) (2019), p.563-582.