Supplementary Information

Synthesis of thin films with highly tailored microstructures

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Specimen preparation for TEM

Specimens for TEM analysis were fabricated out of Si/SiN, wafers having the TiAl/TiNi films on the top surface using microfabrication techniques. First, photoresist was spin coated on the back of the wafer. An EVG620 mask aligner was then used to align the coated wafer with a glass mask containing the TEM specimen patterns and exposed to UV light. The exposed photoresist was then developed to complete the pattern transfer. An STS deep reactive ion etcher was then used to back etch the wafer to reveal the freestanding thin film TEM specimens. The plan-view microstructures of the films were analyzed using a JEOL 2010F TEM while in-situ annealing experiments were carried out in a FEI Tecnai F20 TEM. A FEI NOVA200 dual beam focused ion beam and scanning electron microscope was used to fabricate cross-sectional TEM samples using conventional lift out techniques.
Supplementary Figure 1. TEM bright-field images of (a) 40 nm thick TiAl film with 0.5 nm thick Ti seed layer in the middle. (b) 40 nm thick TiAl film with 1.5 nm thick Ti seed layer in the middle. (c) 40 nm thick TiAl film with a 2 nm thick seed layer in the middle. The images correspond to the films in the as-deposited state (before crystallization).

Supplementary Figure 2. TEM bright-field image of (a) TiAl film, 100 nm thick with a single 1 nm Al seed layer in the middle after 4 hours of annealing at 650°C. The film was nanostructured at this temperature. (b) TiAl film, 100 nm thick with a single 1 nm Al seed layer in the middle after 4 hours of annealing at 750°C. The film retained its nanostructure even at this elevated temperature.
Supplementary Figure 3. (a) XRD measurements show the strong (111) texture of a TiAl film with a 1 nm Al seed layer after 4 hours of annealing at 650°C. (b) XRD measurements of a TiAl film deposited without any seed layer after 4 hours of annealing at 600°C. This film also exhibits a strong (111) texture.

Supplementary Figure 4. Cross-sectional TEM image of a TiAl film which was grown to have ultrafine grains (> 200 nm) in the bottom half and nanocrystalline grains (< 50 nm) in the top half. The bimodal microstructure was obtained by having a much larger seed layer spacing (λ) in the bottom half of the film compared to the top half.