Electronic Supplementary Material (ESI) for Soft Matter.

Movie S1. Fluid-Solid Transition in an Experimental Cooling-Heating cycle.

This movie illustrates the fluid-solid transition during an experimental cooling-heating cycle. The external field is first gradually increased from 0 to 8Oe, and then decreased from 8 to 0Oe. Each frame of the movie consists of (left) the raw experimental image and (right) of a false-color version in which particles are colored following the value of their individual square order parameter Φ_4. The color scheme for the order parameter is the same as in Figure 2. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the false-color images. The experimental time and field strength are indicated at the top of the movie.

Movie S2. Fluid-Solid Transition in a Simulated Cooling-Heating cycle.

This movie illustrates the fluid-solid transition, as calculated by dynamical Monte Carlo simulation, of a cooling-heating cycle. The external field is first gradually increased from 1.0 to 8.3Oe, and then decreased from 8.3 to 1.0Oe. Particles are colored according to the value of the individual square order parameter Φ_4. The particle sizes match those of Supplementary Movie S1, but for visual clarity, magnetic and nonmagnetic particles are represented with identical sizes. The color scheme for the order parameter analysis movie is the same as in Figure 2. The field strength is indicated at the top of the movie.

Movie S3. Magnetostriction Process.

This movie illustrates the magnetostriction process in an experiment with a magnetic field of 9.5Oe applied at different azimuthal angles ($\psi=5^o$ *and* $\psi=42^o$). The tilt angle is gradually increased from $\theta=0^o$ to $\theta=15^o$. To more clearly illustrate the magnetostriction effect, a black square connecting the centers of four nonmagnetic particles is drawn, and a red square connecting their initial positions is superimposed for reference. The experimental time and tilt angle θ are indicated at the top of the movie.

Movie S4. Simulated Martensitic Transformation at H=12Oe, $\psi=0^o$ (particles confined to a 2-D plane).

This movie shows a dynamical Monte Carlo simulation of the martensitic transformation as the tilt angle is varied, for H=12Oe and $\psi=0^o$ and particles strictly confined to a 2-D plane. The particles are colored using the same color scheme as Figure 5, where particles with at least one martensitic bond are colored red if they are magnetic and pink if they are nonmagnetic, while particles with only austenitic bonds are colored dark blue if they are magnetic and light blue if they are nonmagnetic. For visual clarity, magnetic and nonmagnetic particles are represented identical sizes in the movie. The tilt angle is indicated at the top of the movie.

Movie S5. Simulated Martensitic Transformation at H=5Oe, $\psi=0^o$ (particles confined to a 2-D plane).

This movie shows a dynamical Monte Carlo simulation of the martensitic transformation as the tilt angle is varied, for H=5Oe and $\psi=0^o$ and particles strictly confined to a 2-D plane. The movie uses the same color scheme as Figure 5 and Movie S4. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the movie. The tilt angle is indicated at the top of the movie.

Movie S6. Simulated Martensitic Transformation at H=12Oe, $\psi=45^o$ (particles confined to a 2-D plane).

This movie shows a dynamical Monte Carlo simulation of the martensitic transformation as the tilt angle is varied, for H=12Oe and $\psi=45^o$ and particles strictly confined to a 2-D plane. The movie uses the same color scheme as Figure 5 and Movie S4. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the movie. The tilt angle is indicated at the top of the movie.

Movie S7. Simulated Martensitic Transformation at H=5Oe, $\psi=45^o$ (particles confined to a 2-D plane).

This movie shows a dynamical Monte Carlo simulation of the martensitic transformation as the tilt angle is varied, for H=5Oe and $\psi=45^o$ and particles strictly confined to a 2-D plane. The movie uses the same color scheme as

Figure 5 and Movie S4. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the movie. The tilt angle is indicated at the top of the movie.

Movie S8. Experimental Martensitic Transformation at H=12Oe, ψ≈0°.

This movie illustrates the martensitic transformation as the tilt angle is varied for H=12Oe and $\psi \approx 0^{o}$. Each frame consists of (left) the raw experimental configuration, (middle) the corresponding bond analysis, and (right) a Fourier transform of the raw image intensity. The bond analysis images use the same color scheme as Figure 5 and Movie S4. To highlight the changes in the Fourier transform during the martensitic transformation, red lines corresponding to initial configuration are superimposed for reference. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the false-color images. The experimental time and tilt angle θ are indicated at the top of the movie.

Movie S9. Simulated Martensitic Transformation at H=12Oe, ψ=0° (particles allowed to buckle in the third dimension).

This movie shows a dynamical Monte Carlo simulation of the martensitic transformation as the tilt angle is varied, for H=12Oe and ψ=0° and particles allowed to buckle in the third dimension (h=1.11σ_n). The movie uses the same color scheme as Figure 5 and Movie S4. For visual clarity, magnetic and nonmagnetic particles are represented with the same size in the movie. The tilt angle is indicated at the top of the movie.

Movie S10. Experimental Martensitic Transformation at H=12Oe, ψ≈45°.

This movie illustrates the martensitic transformation as the tilt angle is varied for H=12Oe and $\psi \approx 45^{o}$. Each frame consists of (left) the raw experimental configuration, (middle) the corresponding bond analysis, and (right) a Fourier transform of the raw image intensity. The bond analysis images use the same color scheme as Figure 5 and Movie S4. To highlight the changes in the Fourier transform during the transformation, red lines corresponding to initial configuration are superimposed for reference. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the false-color images. The experimental time and tilt angle θ are indicated at the top of the movie.

Movie S11. Simulated Martensitic Transformation at H=12Oe, ψ=45° (particles allowed to buckle in the third dimension).

This movie shows a dynamical Monte Carlo simulation of the martensitic transformation as the tilt angle is varied, for H=12Oe and ψ=45° and particles allowed to buckle in the third dimension (h=1.11σ_n). The movie uses the same color scheme as Figure 5 and Movie S4. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the movie. The tilt angle is indicated at the top of the movie.

Movie S12. Experimental Martensitic Transformation at H=5Oe, ψ≈0°.

This movie illustrates the martensitic transformation as the tilt angle is varied for H=5Oe and $\psi \approx 0^{o}$. Each frame consists of (left) the raw experimental configuration, (middle) the corresponding bond analysis, and (right) a Fourier transform of the raw image intensity. The bond analysis images use the same color scheme as Figure 5 and Movie S4. To highlight the changes in the Fourier transform during the martensitic transformation, red lines corresponding to initial configuration are superimposed for reference. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the false-color images. The experimental time and tilt angle θ are indicated at the top of the movie.

Movie S13. Experimental Martensitic Transformation at H=5Oe, ψ≈45°.

This movie illustrates the martensitic transformation as the tilt angle is varied for H=5Oe and $\psi \approx 45^{o}$. Each frame consists of (left) the raw experimental configuration, (middle) the corresponding bond analysis, and (right) a Fourier transform of the raw image intensity. The bond analysis images use the same color scheme as Figure 5 and Movie S4. To highlight the changes in the Fourier transform during the martensitic transformation, red lines corresponding to initial configuration are superimposed for reference. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the false-color images. The experimental time and tilt angle θ are indicated at the top of the movie.

Movie S14. Simulated Martensitic Transformation at H=5Oe, $\psi=0^{o}$ (particles allowed to buckle in the third dimension).

This movie shows a dynamical Monte Carlo simulation of the martensitic transformation as the tilt angle is varied, for H=5Oe and $\psi=0^{o}$ and particles allowed to buckle in the third dimension ($h=1.11\sigma_{n}$). The movie uses the same color scheme as Figure 5 and Movie S4. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the movie. The tilt angle is indicated at the top of the movie.

Movie S15. Simulated Martensitic Transformation at H=5Oe, $\psi=45^{o}$ (particles allowed to buckle in the third dimension).

This movie shows a dynamical Monte Carlo simulation of the martensitic transformation as the tilt angle is varied, for H=5Oe and $\psi=45^{o}$ and particles allowed to buckle in the third dimension ($h=1.11\sigma_{n}$). The movie uses the same color scheme as Figure 5 and Movie S4. For visual clarity, magnetic and nonmagnetic particles are represented with identical sizes in the movie. The tilt angle is indicated at the top of the movie.