Magnetic Shape Memory Effect in $MnNi_2Ga$

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Materials 286G
Final Presentation
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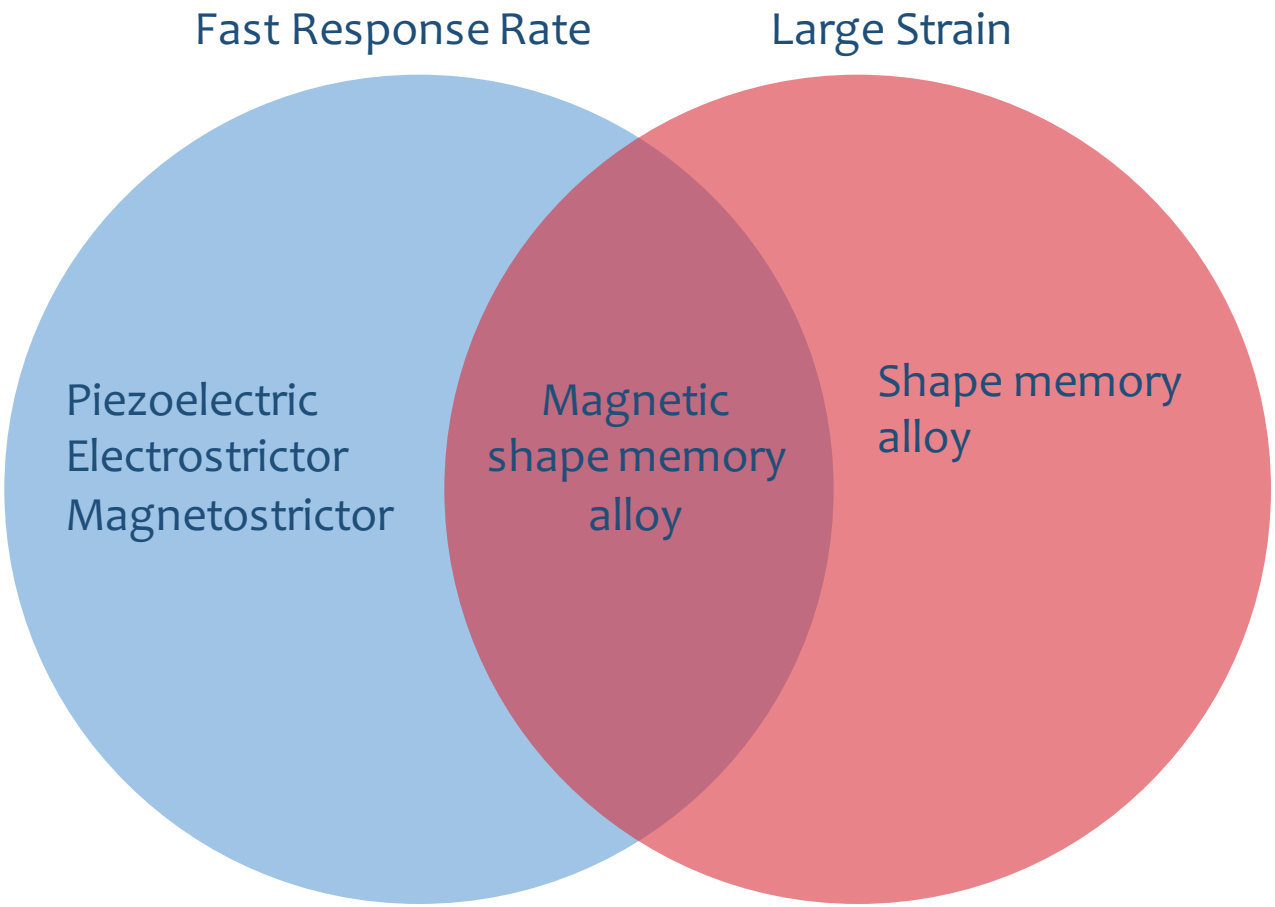
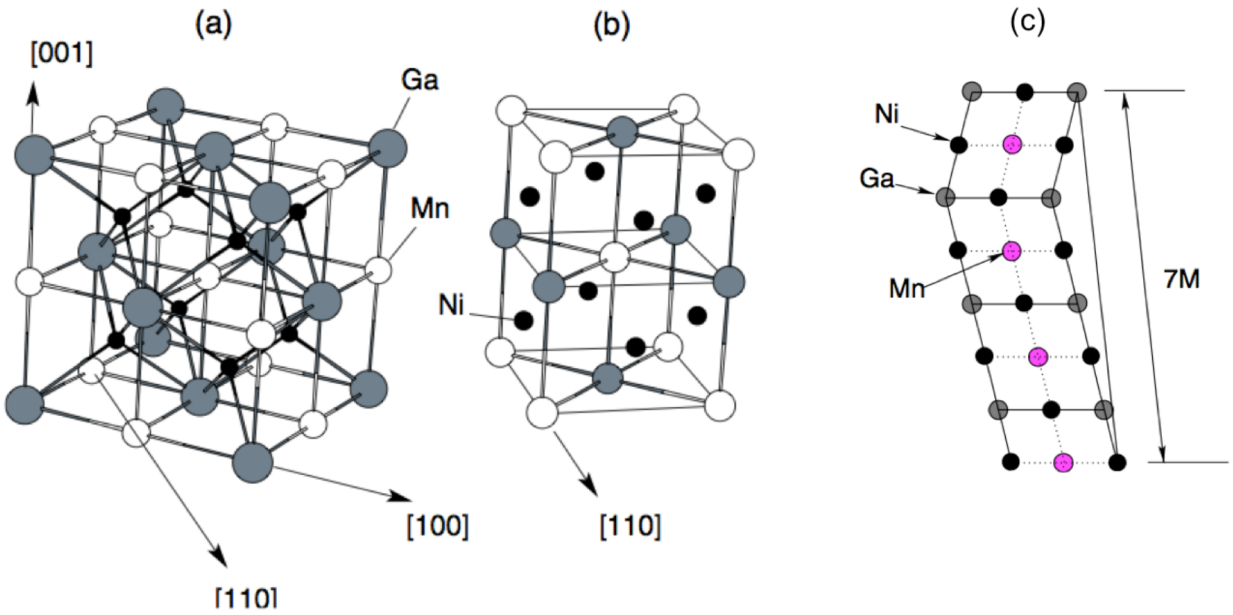
Applicable mechanical work from driving force (non-mechanical stimuli)



M. A. Marioni, R. C. O'Handley, S. M. Allen, S. R. Hall, D. I. Paul, M. L. Richard, J. Feuchtwanger, B. W. Peterson, J. M. Chambers, R. Techapiesancharoenkij, *J. Magn. Magn. Mater.* **290** (2004) p. 35.

Martensitic Transition



Cubic austenite to tetragonal martensite transition in $MnNi_2Ga$

Magnetic field induced phase transformation (MFIT)
Magnetic field induced reorientation of twin variants (MFIR)

- Solely in martensitic phase
- Martensite NM (c/a > 1), 5M, 7M (c/a < 1) structures

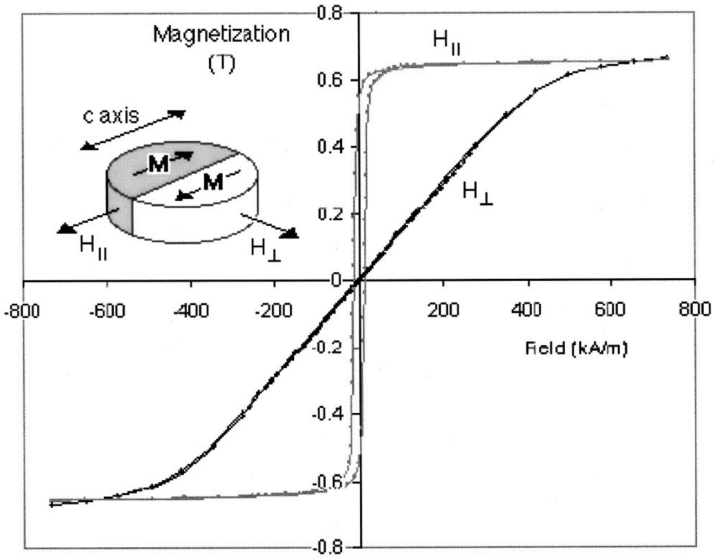
P. Entel, V. D. Buchelnikov, V. V. Khovailo, A. T. Zayak, W. A. Adeagbo, M. E. Gruner, H. C. Herper, and E. F. Wassermann, *Annu. Rev. Mater. Res.*. **19** (1999) (39–116).

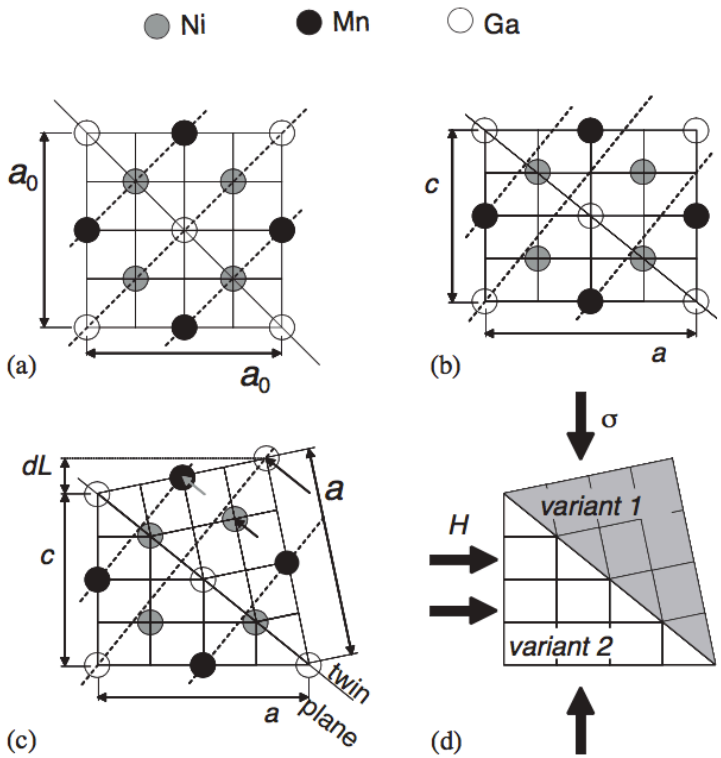
Martensitic Transition

Form 3 variants along <100> of parent phase
Variants related by twins
Easy axis of magnetization along short axis of u.c.

- Modulated structure c/a=.94
- Easy magnetization in **c** direction

Large magnetocrystalline anisotropy K_u





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S. J. Murray, M. Marioni, S. M. Allen, T. A. Lograsso, and R. C. O'Handley, *Appl. Phys. Lett.* **77** (2000) p. 886.

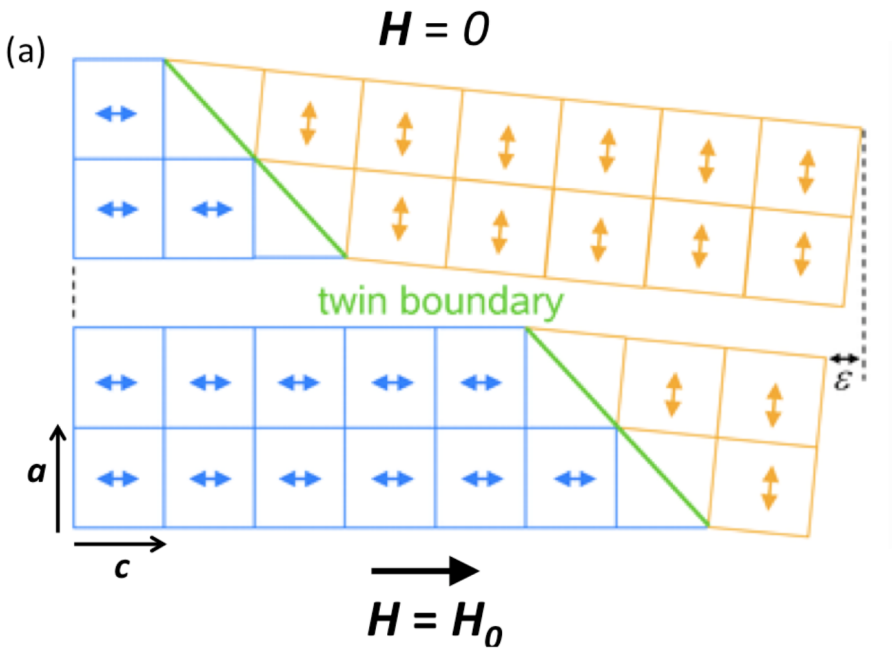
Reorientation of Twins

Applied magnetic field:
Variants restructure
Variant with easy axis aligned with field grows

- Lower energy than aligning spins in "hard" direction
- Results in compressive stress along long axis (a, b)

$\sigma_{Mag} > \sigma_{TW}$

$K_u = \varepsilon_o \sigma_{Mag}$

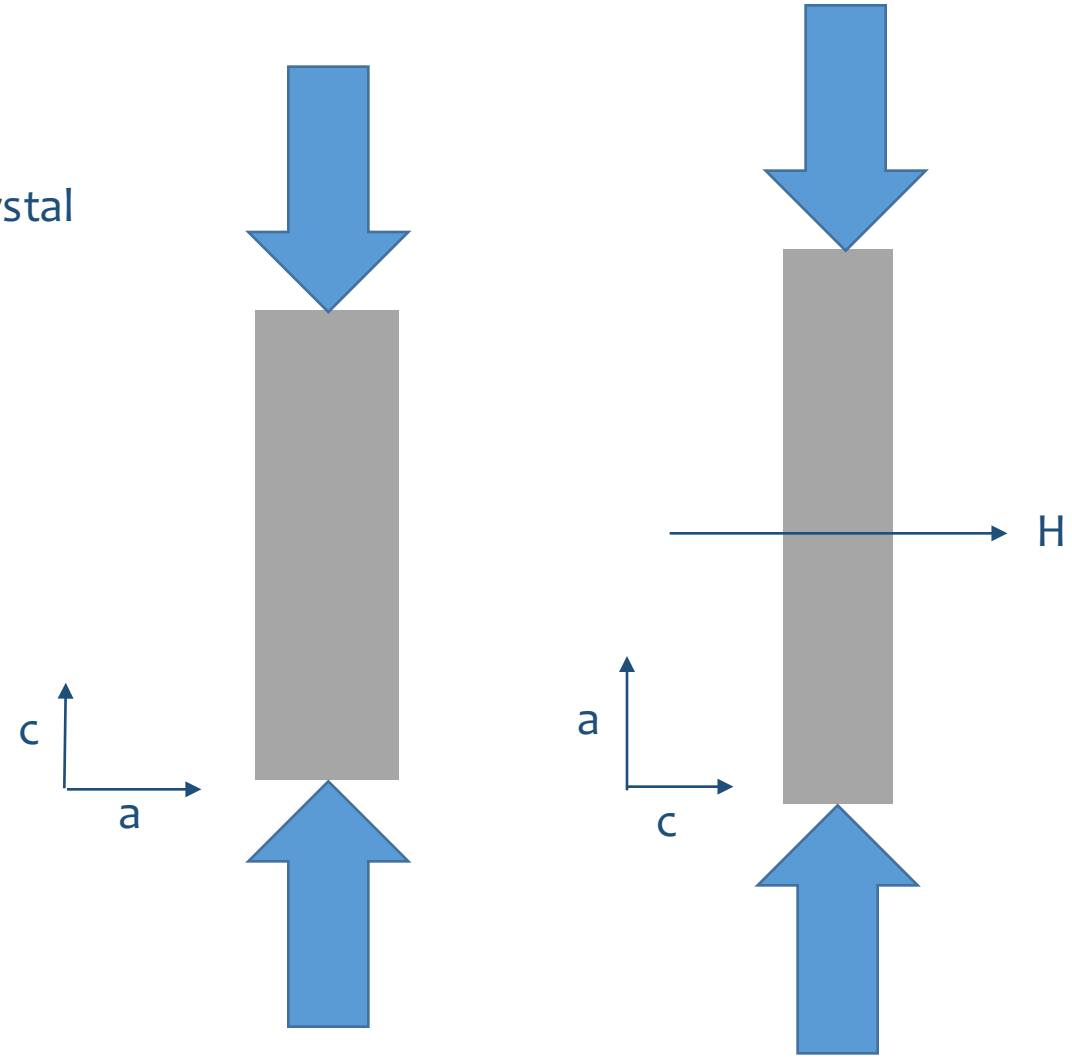


J.E. Douglas. Preliminary Exam Paper. November 6, 2012.
A. Sozinov, N. Lanska, A. Soroka, W. Zou, *Appl. Phys. Lett* 102, 021902 (2013).

Shape Memory Effect

Variants reorient in presence of magnetic field

- Full strain in single variant crystal



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Non-Modulated Structure

Requirement: $\sigma_{Mag} > \sigma_{TW}$

For NM structure

σ_{Mag}= 1 MPa

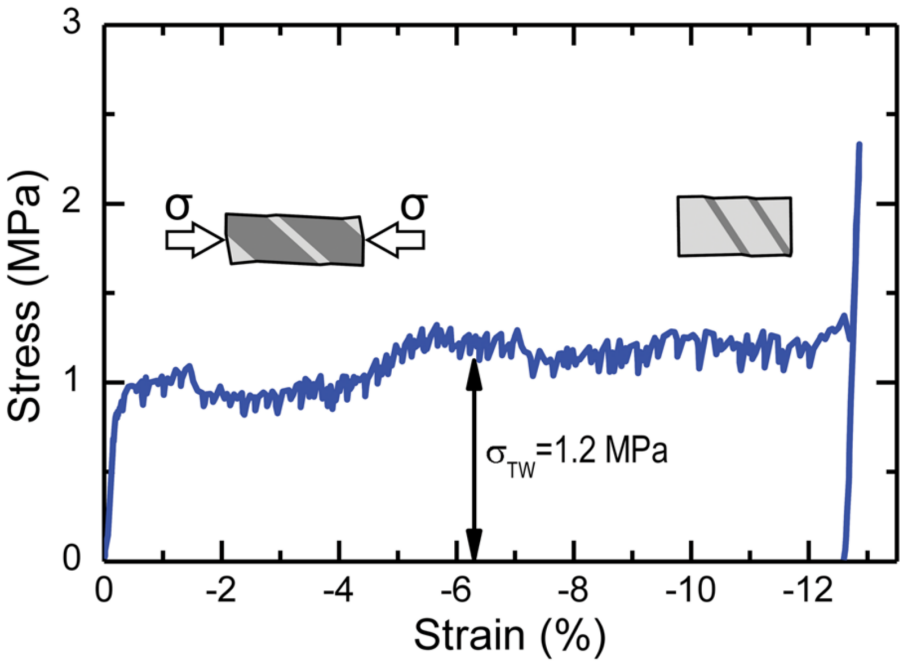
σ_{TW}=6.5 MPa

Magnetic field induced strain not observed

Lower c/a ratio!

c/a = 1.18-1.25 for NM structure

- High Curie temp (Co)
- High martensitic transformation temp (Cu)

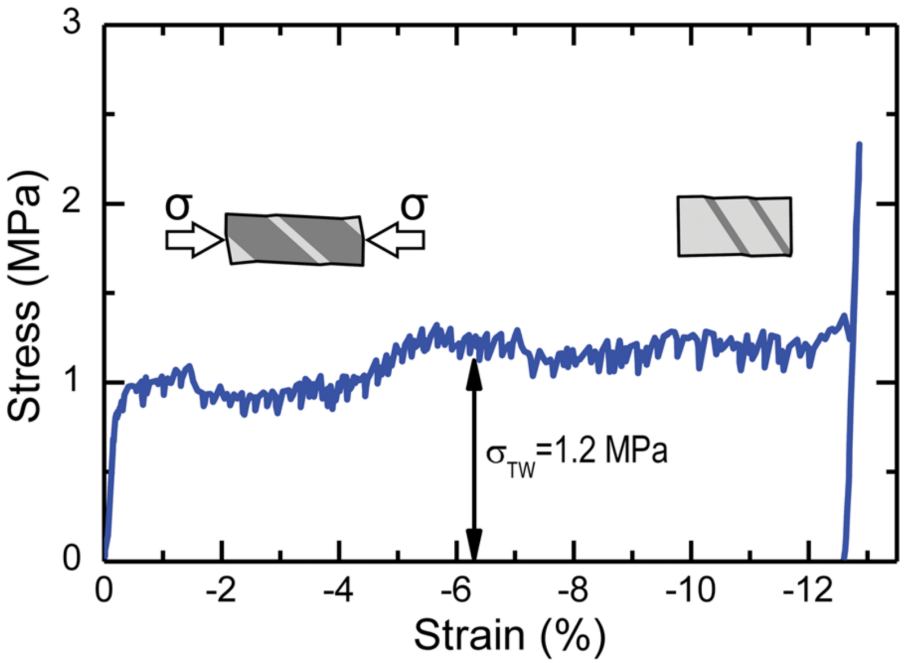


A. Sozinov, N. Lanska, A. Soroka, W. Zou, *Appl. Phys. Lett* 102, 021902 (2013).

Non-Modulated Structure

Lower c/a ratio = 1.147
Decrease σ_{TW} to $\simeq$ 1.2 Mpa

Allow for ε = 12% at 1.05T



A. Sozinov, N. Lanska, A. Soroka, W. Zou, *Appl. Phys. Lett* 102, 021902 (2013).

Thank You