Supplementary Information

Mechanical anisotropy in austenitic NiMnGa alloy: Nanoindentation studies

Ashwin Jayaraman[1, 2], Kiran M. S.R.N. [1, 3,*], and Upadrasta Ramamurty[1]

[1]Department of Materials Engineering, Indian Institute of Science, Bangalore - 560 012, India

[2] Harvard John A. Paulson School of Engineering and Applied Sciences,

Cambridge, MA-02138

[3]SRM Research Institute & Department of Physics and Nanotechnology, SRM University,

Kattankulathur, Chennai 603203, Tamilnadu, India.

Fig. S1: Differential Scanning Calorimetry results obtained from the austenitic composition of NiMnGa studied in our work.

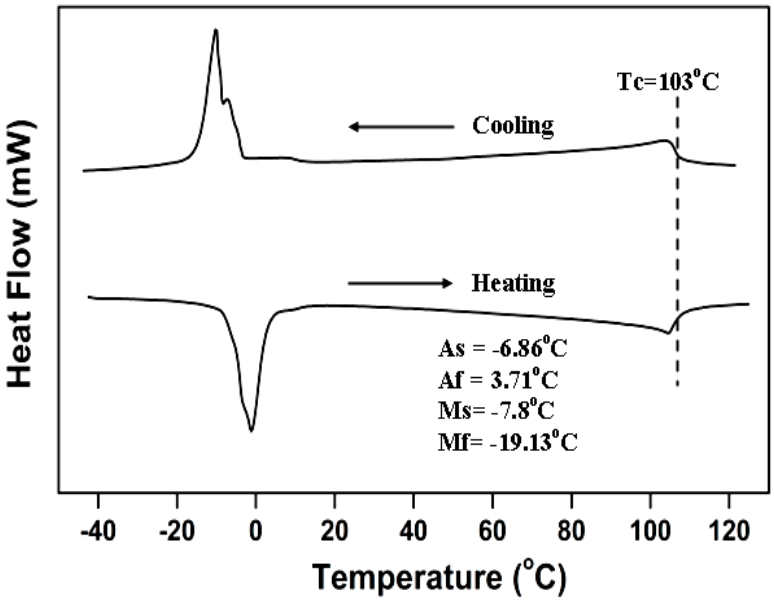

Fig. S2: X-Ray Diffractometry results obtained from the martensitic form of the austenitic NiMnGa studied in our work clearly showing the presence of indexed 7M martensite peaks.

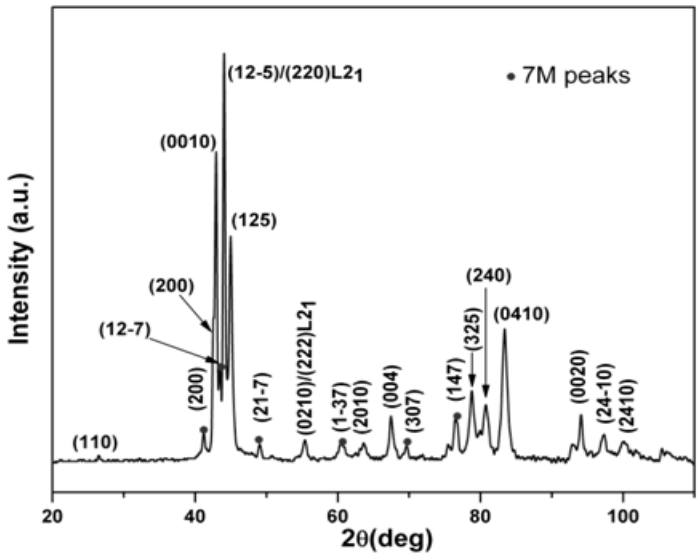

Table S1: Calculated Schmid Factor for all the slip systems possible in the NiMnGa Heusler structure with respect to the indentation stress direction.

Slip System	Indentation Stress Direction	Schmid Factor
(1-10)[111]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(1-10)[11-1]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(-110)[11-1]	[232]	0.062
	[010]	0.343

	[-120]	0.181
	[-1-21]	0.319
(-110)[111]	[232]	0.164
	[010]	0.457
	[-120]	0.302
	[-1-21]	0.160
(110)[-111]	[232]	0.367
	[010]	0.457
	[-120]	0.262
	[-1-21]	0.044
(110)[1-11]	[232]	0.141
	[010]	-
	[-120]	-
	[-1-21]	-
(110)[-11-1]	[232]	-
	[010]	0.343
	[-120]	0.222
	[-1-21]	0.436
(110)[1-1-1]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(-101)[111]	[232]	0.041

	[010]	0.065
	[-120]	0.126
	[-1-21]	-
(-101)[1-11]	[232]	0.0071
	[010]	-
	[-120]	-
	[-1-21]	0.274
(10-1)[111]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	0.247
(10-1)[1-11]	[232]	-
	[010]	0.049
	[-120]	0.277
	[-1-21]	-
(101)[-111]	[232]	0.312
	[010]	0.065
	[-120]	-
	[-1-21]	-
(101)[-1-11]	[232]	-
	[010]	-
	[-120]	0.045
	[-1-21]	0.029

(101)[11-1]	[232]	0.264
	[010]	0.049
	[-120]	-
	[-1-21]	-
(101)[1-1-1]	[232]	-
	[010]	-
	[-120]	0.197
	[-1-21]	0.0016
(0-11)[111]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(0-11)[-111]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(01-1)[111]	[232]	0.123
	[010]	0.39
	[-120]	0.176
	[-1-21]	0.41
(01-1)[-111]	[232]	0.055
	[010]	0.39
	[-120]	0.32
	[-1-21]	0.078

(011)[1-11]	[232]	0.148
	[010]	-
	[-120]	-
	[-1-21]	-
(011)[-1-11]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(011)[11-1]	[232]	0.33
	[010]	0.39
	[-120]	0.136
	[-1-21]	0.29
(011)[-11-1]	[232]	-
	[010]	0.39
	[-120]	0.49
	[-1-21]	0.161
(112)[-1-11]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(-1-12)[111]	[232]	-
	[010]	-
	[-120]	-

	[-1-21]	-
(11-2)[111]	[232]	0.047
	[010]	0.189
	[-120]	0.029
	[-1-21]	0.377
(-1-1-2)[-1-11]	[232]	0.341
	[010]	0.255
	[-120]	0.052
	[-1-21]	0.151
(-1-12)[-1-1-1]	[232]	0.047
	[010]	0.189
	[-120]	0.029
	[-1-21]	0.377
(112)[11-1]	[232]	0.341
	[010]	0.255
	[-120]	0.052
	[-1-21]	0.151
(11-2)[-1-1-1]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(-1-1-2)[11-1]	[232]	-
	[010]	-

	[-120]	-
	[-1-21]	-
(211)[1-1-1]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(2-1-1)[111]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	0.05
(-211)[111]	[232]	0.118
	[010]	0.302
	[-120]	0.247
	[-1-21]	-
(-2-1-1)[1-1-1]	[232]	0.392
	[010]	0.302
	[-120]	0.038
	[-1-21]	0.025
(2-1-1)[-1-1-1]	[232]	0.118
	[010]	0.302
	[-120]	0.247
	[-1-21]	-
(211)[-111]	[232]	0.392

	[010]	0.302
	[-120]	0.038
	[-1-21]	0.025
(-211)[-1-1-1]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	0.05
(-2-1-1)[-111]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(121)[-11-1]	[232]	-
	[010]	0.424
	[-120]	0.416
	[-1-21]	0.344
(-12-1)[111]	[232]	0.166
	[010]	0.49
	[-120]	0.276
	[-1-21]	0.327
(1-21)[111]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-

(-1-2-1)[-11-1]	[232]	0.167
	[010]	-
	[-120]	-
	[-1-21]	-
(-12-1)[-1-1-1]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(121)[1-11]	[232]	0.167
	[010]	-
	[-120]	-
	[-1-21]	-
(1-21)[-1-1-1]	[232]	0.167
	[010]	0.49
	[-120]	0.276
	[-1-21]	0.327
(-1-2-1)[1-11]	[232]	-
	[010]	0.424
	[-120]	0.416
	[-1-21]	0.344
(1-10)[110]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-

(-110)[110]	[232]	0.138
	[010]	0.49
	[-120]	0.296
	[-1-21]	0.293
(110)[-110]	[232]	0.138
	[010]	0.49
	[-120]	0.296
	[-1-21]	0.293
(110)[1-10]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(10-1)[101]	[232]	-
	[010]	-
	[-120]	0.093
	[-1-21]	-
(-101)[101]	[232]	0.029
	[010]	0.01
	[-120]	-
	[-1-21]	0.0167
(101)[-101]	[232]	0.029
	[010]	0.01
	[-120]	-

	[-1-21]	0.0167
(101)[10-1]	[232]	-
	[010]	-
	[-120]	0.093
	[-1-21]	-
(0-11)[011]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(01-1)[011]	[232]	0.11
	[010]	0.48
	[-120]	0.39
	[-1-21]	0.28
(011)[01-1]	[232]	0.11
	[010]	0.48
	[-120]	0.39
	[-1-21]	0.28
(011)[0-11]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	-
(110)[001]	[232]	0.44
	[010]	0.09

	[-120]	0.035
	[-1-21]	-
(110)[00-1]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	0.34
(-1-10)[001]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	0.34
(-1-10)[00-1]	[232]	0.44
	[010]	0.09
	[-120]	0.035
	[-1-21]	-
(-110)[001]	[232]	0.088
	[010]	0.09
	[-120]	0.105
	[-1-21]	-
(-110)[00-1]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	0.138
(1-10)[001]	[232]	-

	[010]	-
	[-120]	-
	[-1-21]	0.138
(1-10)[00-1]	[232]	0.088
	[010]	0.09
	[-120]	0.105
	[-1-21]	-
(101)[010]	[232]	0.49
	[010]	0.098
	[-120]	-
	[-1-21]	-
(101)[0-10]	[232]	-
	[010]	-
	[-120]	0.21
	[-1-21]	0.026
(-10-1)[010]	[232]	-
	[010]	-
	[-120]	0.21
	[-1-21]	0.026
(-10-1)[0-10]	[232]	0.49
	[010]	0.098
	[-120]	-
	[-1-21]	-

(-101)[010]	[232]	0.0293
	[010]	0.098
	[-120]	0.35
	[-1-21]	-
(-101)[0-10]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	0.45
(10-1)[010]	[232]	-
	[010]	-
	[-120]	-
	[-1-21]	0.45
(10-1)[0-10]	[232]	0.0293
	[010]	0.098
	[-120]	0.35
	[-1-21]	-
(011)[100]	[232]	0.411
	[010]	0
	[-120]	-
	[-1-21]	0.11
(011)[-100]	[232]	-
	[010]	0
	[-120]	0.31
	[-1-21]	-

(0-1-1)[100]	[232]	-
	[010]	0
	[-120]	0.31
	[-1-21]	-
(0-1-1)[-100]	[232]	0.411
	[010]	0
	[-120]	-
	[-1-21]	0.11
(01-1)[100]	[232]	0.059
	[010]	0
	[-120]	-
	[-1-21]	0.313
(01-1)[-100]	[232]	-
	[010]	0
	[-120]	0.24
	[-1-21]	-
(0-11)[100]	[232]	-
	[010]	0
	[-120]	0.24
	[-1-21]	-
(0-11)[-100]	[232]	0.059
	[010]	0
	[-120]	-

	[-1-21]	0.313

Table S2: Maximum Schmid factors for the 5 different family of slip systems possible in NiMnGa superstructure with respect to the indentation stress directions.

Indentation Stress Direction	Slip System family	Maximum possible Schmid Factor
[232]	{1-10}<111>	0.367
[010]		0.457
[-120]		0.49
[-1-21]		0.436
[232]	{11-2}<111>	0.392
[010]		0.49
[-120]		0.416
[-1-21]		0.377
[232]	{1-10}<110>	0.138
[010]		0.49
[-120]		0.39
[-1-21]		0.29
[232]	{-110}<001>	0.49
[010]		0.09
[-120]		0.35
[-1-21]		0.45

Table S3: Slip System, corresponding Schmid factors and calculated mechanical properties on nanoindentation along different crystallographic directions.

Direction	Slip System	Maximum Schmid Factor	h_{max} (nm)	Hardness, *H* (GPa)	Elastic Modulus, E (GPa)
[010]	$\{\bar{1}10\}\langle 001\rangle$	0.09	326	3.7 ± 0.04	81 ± 0.7
$[\bar{1}20]$		0.35	346	3.3 ± 0.05	69.2 ± 0.7
$[\bar{1}\,\bar{2}1]$		0.45	360	3.2 ± 0.03	64.8 ± 0.6
[232]		0.49	377	2.9 ± 0.06	58.9 ± 0.8