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Supplementary Data

Elastocaloric Cooling: State-of-the-art and Future Challenges in Designing Regenerative Elastocaloric Devices

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Table S1 shows the basic elastocaloric properties for the most interesting elastocaloric materials published to date. In addition to adiabatic temperature changes (and their corresponding applied stress/strain), which are the most important elastocaloric parameters, Table S1 also shows other parameters such as sample preparation, microstructure and geometry of the sample, sample's history (stabilization and training), loading mode (tension or compression) and measuring technique (thermocouples or IR camera) that can all significantly affect the eCE. In Table S1, ΔT_{ad+} and ΔT_{ad-} stand for adiabatic temperature changes upon loading and unloading the elastocaloric material, respectively, and A_f stands for austenitic finish temperature of the material.

Table S1. *Overview of the most interesting elastocaloric materials*

Alloy (at.%)	Sample/ microstructure	Training	Thermal / Mechanical characterization	Stress[1] [MPa]	Strain %	A_f [°C]	ΔT_{ad+} [K]	ΔT_{ad-} [K]	Ref.
Shape-memory alloys (SMA)									
Ni-Ti based									
$Ni_{50.38}Ti_{49.62}$	[112] Single crystal aged sheets with 400 nm precipitates / Prepared by Bridgman technique	-	IR camera / RT[2] tension	-	-	0	-	13.3 (largest of first 3 cycles)	[1]
	[148] Single crystal aged sheets with 400 nm precipitates / Prepared by Bridgman technique			-	-		-	14.2 (largest of first 4 cycles)	
Ni-Ti	Polycrystalline wires of different diameters and lengths / manufactured by NDC[3]	-	Thermocouple (K-type) / RT tension	~<600[4]	8.5	-	25.5	17	[2]
			Thermocouple (K-type) / RT compression	~750	6.0		~7 (assuming RT:22 °C)	~13 (assuming RT:22 °C)	
$Ti_{51.1}Ni_{48.9}$	Commercial grade polycrystalline wire	400 cycles at different temperatures	Thermocouple (E-type), IR camera / Tension at different temperatures	~700	6.0	21.9	25 (Trained and tested at 48.9 °C)	21 (Trained and tested at 48.9 °C)	[3]
$Ni_{50.4}Ti_{49.6}$	Heat treated[5] DC magnetron sputtered film (20 μm thick)	-	IR camera / RT tension	-	-	20	17	16	[4]
$Ni_{50.5}Ti_{49.1}Fe_{0.4}$	Heat treated cold-rolled foil (30 μm thick)	-	IR camera / RT tension	-	-	6	22	17	[5]
$Ti_{47.25}Ni_{45}Cu_5V_{2.75}$	Polycrystalline ribbon (0.3 to 0.8 mm thick) / prepared by arc melting	40 cycles	IR camera / RT Tension	-	-	-	22 (at 40th cycle)	21 (at 40th cycle)	[6]
$Ni_{50}Ti_{45.3}V_{4.7}$	Polycrystalline square prism with large columnar grains and no texture / prepared by arc melting under Ar	30 cycles (5000 fatigue cycles)	IR camera / RT compression	-	-	14.7	-	~>10 (after training) ~<10 (after fatigue cycles)	[7]
$Ti_{59.4}Ni_{32.5}Cu_{12.6}$	Heat treated sputtered film (20 μm thick) with a grain size of 200 nm	1502 cycles	IR camera / tension at different temperatures	-	-	-	4.1 (cycle 1 at 73 °C)	6.1 (cycle 1 at 73 °C)	[8]
							4.6 (cycle 1502 at 73 °C)	6.2 (cycle 1502 at 73 °C)	
$Ni_{50.4}Ti_{49.6}$	Heat treated DC magnetron sputtered film (20 μm thick) with a grain size of 2.5 μm			-	-		9.0 (cycle 1 at 25 °C)	7.4 (cycle 1 25 °C)	
							5.1 (cycle 27 at 25 °C)	4.4 (cycle 27 at 25 °C)	

$Ti_{55}Ni_{29.6}Cu_{12.6}Co_{2.8}$	Heat treated DC magnetron sputtered films (20 μm thick)	-	IR camera / RT tension	-	-	-	9	12	[9]
$Ni_{50.4}Ti_{49.6}$						20	~17	16	
$TiNi_{44}Cu_5Al$	VIM[6] / hot-rolled, then cold-rolled and finally heat treated / sheet of 40 nm grain size	5000 cycles at 44.8 °C	Thermocouple (T-type) / tension at 44.8 °C and 64.9 °C	-	-	36.8	-	17.4 (cycle 1 at 44.9 °C)	[10]
							-	16.9 (cycle 5000 at 44.9 °C)	
$Ni_{50.8}Ti$	Cold-rolled and heat treated as above	10 cycles at 64.9 °C		-	-	54.9	-	25.3 (cycle 1 at 64.9 °C)	
							-	19.8 (cycle 10 at 64.9 °C)	
$TiNi_{44}Cu_5Al_1$	VIM / hot-rolled, then cold-rolled and finally heat treated / sheet of 40 nm grain size		Thermocouple (J-type) / tension at 53.9 °C	-	-	-	-	25.7 (at 53.9 °C)	[11]
Cu-based									
$Cu_{68.13}Zn_{15.74}Al_{16.13}$	Heat treated [100] single crystal sheet	-	Calculated based on entropy changes extracted from tension at different temperatures (indirect)	-	-	-	-	15	[12]
$Cu_{68}Zn_{16}Al_{16}$	Aged polycrystalline sheet / prepared by induction melting under N_2	100 cycles	Thermocouple (J-type) / RT tension	-	-	-	-	6	[13]
$Cu_{64.6}Zn_{33.7}Sn_{1.7}$	Single crystal sheet	-	Thermocouple (K-type) / RT tension	-	6.1	-30	12	12	[14]
			Thermocouple (K-type) / RT submerged tension	-	6.1		~8.5	~8.5	
$Cu_{83}Al_{14}Ni_3$	<001> Single crystal sheet	-	Thermocouple / RT submerged tension	-	-	-	14	~>14	[15]
$Cu_{71.5}Al_{17.5}Mn_{11}$	Directionally solidified sheet with columnar grains and strong <100> texture as-quenched	-	Thermocouple (T-type) / Tension at different temperatures	-	-	-9.2	-	12.8 (at RT)	[16]
	Above sample after aging			-	-	21.9	-	13 (at 41.9 °C)	

Fe-based									
$Fe_{68.8}Pd_{31.2}$	[001] single crystal square prism prepared by floating zone method from arc melted ingots	-	Thermocouple (T-type) / compression at 33.2 ^oC	200	-	-43.2	~>3.0 (at -33.2 ^oC)	~>3.0 (at -33.2 ^oC)	[17]
$Fe_{49}Rh_{51}$	0.27 mm thick heat treated polycrystalline	-	Thermocouple (T-type) / tension at 38 ^oC	-	-	-	-	5.17 (at 38 ^oC)	[18]
Magnetic shape-memory alloys (MSMA)									
$Ni_{54}Fe_{19}Ga_{27}$	[001] Single crystal sheet / Prepared by Bridgman technique	-	IR camera / RT tension	-	-	22	-	8.4 (av. of 1st 5 cycles)	[1]
	[011] Single crystal sheet / Prepared by Bridgman technique			-	-		-	7.6 (av. of 1st 3 cycles)	
$Ni_{54.9}Mn_{17.9}Ga_{27.2}$	Directionally solidified polycrystalline rectangular parallelepiped with columnar grains and $<001>_A$ texture	19 cycles	Thermocouple / RT tension	-	-	7.9	-	10.7 (1st cycle)	[19]
				-	-		-	8.5 (cycle 19, before sample's fracture)	
$Co_{40}Ni_{33.17}Al_{26.83}$	[115] Single crystal sheet / Prepared by Bridgman technique	-	IR camera / tension at 100 ^oC	-	-	45	-	3.1 (4 measurements at 100 ^oC)	[1]
$Ni_{50}Mn_{32}In_{16}Cr_2$	Textured polycrystalline parallelepipeds with columnar grains prepared by arc melting under Ar	-	Thermocouple (K-type) / RT Compression along different directions	100	-	21.9	4.8 Along [001] of austenite	3.9 Along [001] of austenite	[20]
				100	-		2.0 Along [111] of austenite	2.0 Along [111] of austenite	
				100	-		1.3 Along [011]of austenite	1.3 Along [011]of austenite	
$Ni_{50}Mn_{31.5}Ti_{18.5}B_{0.2}$	Heat treated polycrystalline columnar grained samples with <001> texture / prepared by arc melting	-	Thermocouple / RT compression	700	-	-	26.9	31.5	[21]
$Ni_{45}Mn_{37}In_{13}Co_5$	Square prism / polycrystalline without precipitates / prepared by induction melting under Ar	-	Thermocouple (T-type) / RT compression	80	-	52.9	2.1 (at 59.9 ^oC)	1.9 (at 59.9 ^oC)	[22]
$Ni_{45}Mn_{36}In_{13}Co_5Cr$	Square prism/ polycrystalline with precipitates along grain boundary / prepared by induction melting under Ar			300	-	39.9	6.7 (at 49.9 ^oC)	5.8 (at 49.9 ^oC)	

Shape-memory polymers (SMP)									
Natural rubber (NR)	Commercial grade film of 100 μm thickness	Several cycles to 600 % strain	Thermocouple / tension at different temperatures	$\sim$1 (at 10 ^{o}C)	600 (at 10 ^{o}C)	n/a	-	12 (at 10 ^{o}C)	[23]
Poly(cyclooctene) PCO	sheet	-	IR camera / tension at 70 ^{o}C	$\sim$0.35	300	n/a	2.8 (at 70 ^{o}C)	2.8 (at 70 ^{o}C)	[24]
Polyvinylidene di-fluoride based PVDF	0.3 mm thick hot-pressed sheet (for tensile test)	-	Calculated based on the results of tension at different temperatures (indirect)	-	-	n/a	-	1.8 (at 24.9 ^{o}C)	[25]
Poly(vinylidene fluoride-trifluoroethylene-chlorotrifluoroethylene) terpolymer P(VDF-TrFE-CTFE)	40 μm thick solution casted annealed film	-	IR camera / RT tension	$\sim$140	12	n/a	-	2.15	[26]

[1] Stress and strain values which are mentioned are reached under adiabatic loading. Values reached by isothermal loading are not mentioned.
[2] RT stands for room temperature.
[3] Nitinol Devices and Components, Inc.
[4] The values which are marked by “$\sim$” are the ones which are estimated form the graphs and figures of the cited references and are not directly mentioned by the authors of the cited references.
[5] Heat treatment might have been referred to as annealing by the authors of the cited references.
[6] Prepared by Vacuum Induction Melting (VIM).

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