Material parameters of the FWM#1 superelastic NiTi wire

(evaluated at IP ASCR)

NiTi wire	Cold work	Heat treatment FWM	Diameter	Surface	Spool
FWM #1	?	Straight annealed	0.1mm	oxide	FWMIOP17S1.0039

No.	Material parameter	Symbol	unit	value
1	R-phase start	R_s	^oC	25
2	R-phase finish	R_f	^oC	5
3	Martensite start	M_s	^oC	-
4	Martensite finish	M_f	^oC	-
5	Austenite start	A_s	^oC	-
6	Austenite finish	A_f	^oC	-
7	Young modulus of austenite	E^A	GPa	53.6
8	Young modulus of martensite	E^M	GPa	21.1
9	Transformation Yield stress of austenite at RT	σ^{tr}	MPa	555
10	Maximum recoverable transformation strain	ε^{tr}	%	5.2
11	Ultimate tensile strength	σ^{UTS}	MPa	1590
12	Yield stress	σ^{Y}	MPa	1330
13	Strain at failure	ε^{f}	%	13
14	Pseudoelastic stress hysteresis	Δh^{σ}	MPa	336
15	Accumulated nonrecovered strain for N=100	ε_{ac}	%	0.47
16	Cyclic accumulated transformation stress change for N=100	$\Delta\sigma^{tr}_{ac}$	%	24.5
17	Cyclic accumulated pseudoelastic hysteresis change for N=100	Δh^{σ}_{ac}	%	24.0
18	Effective martensite start temperature	M'_s	^oC	-72
19	Effective austenite finish temperature	A'_f	^oC	-0.4
20	Temperature dependence of transformation stress for A-R	s_{A-R}	MPa/^oC	15.9
21	Temperature dependence of transformation stress for A-M	s_{A-M}	MPa/^oC	5.57
22	Reorientation yield stress of martensite	σ^{re}	MPa	-

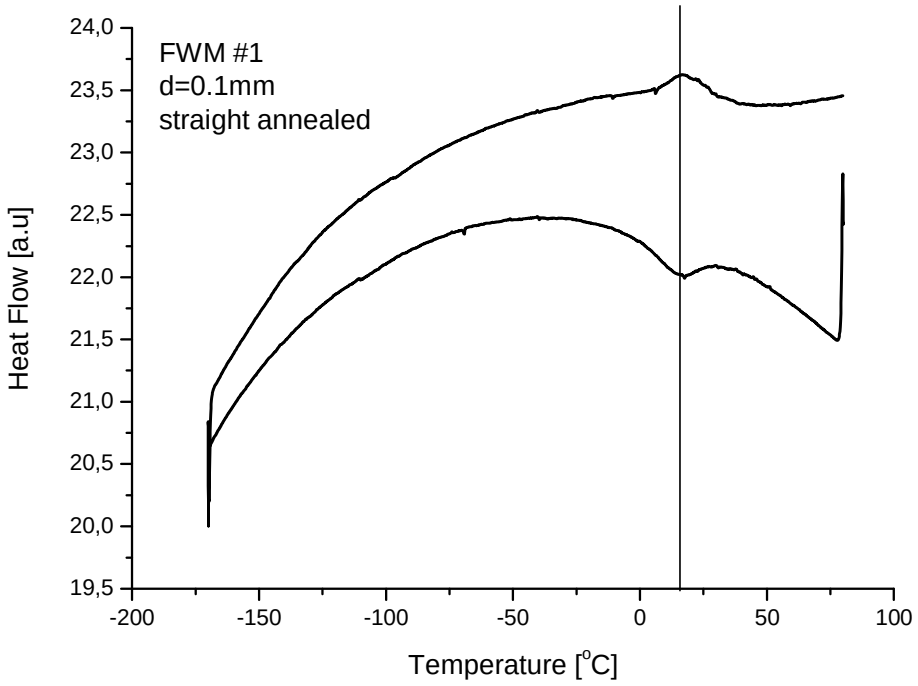

Figure 1 : DSC thermal cycle

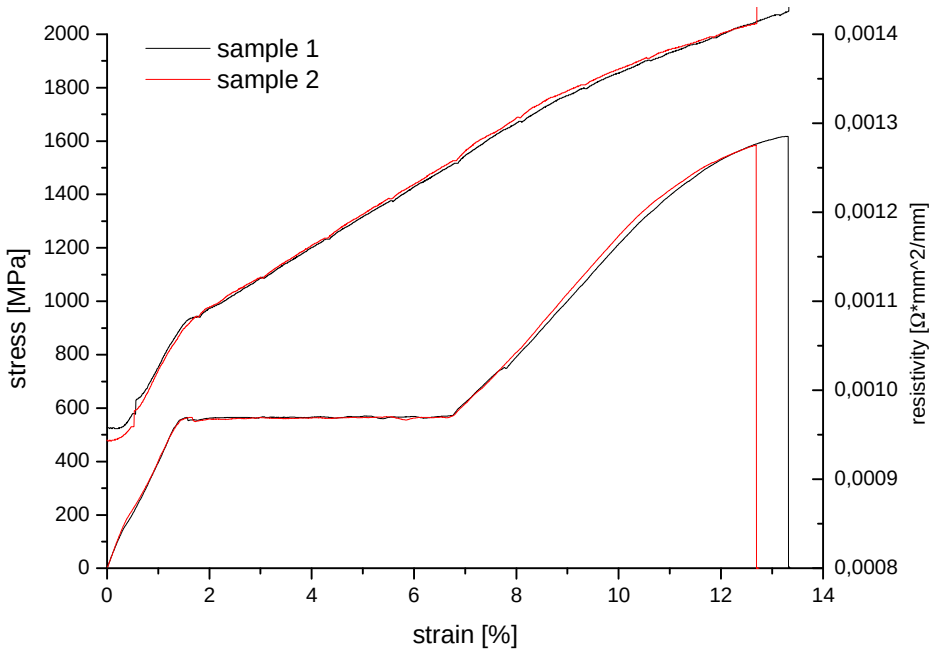

Figure 2 : Tensile test till rupture at room temperature, l_0=50 mm, strain rate=0.1 s^{-1}

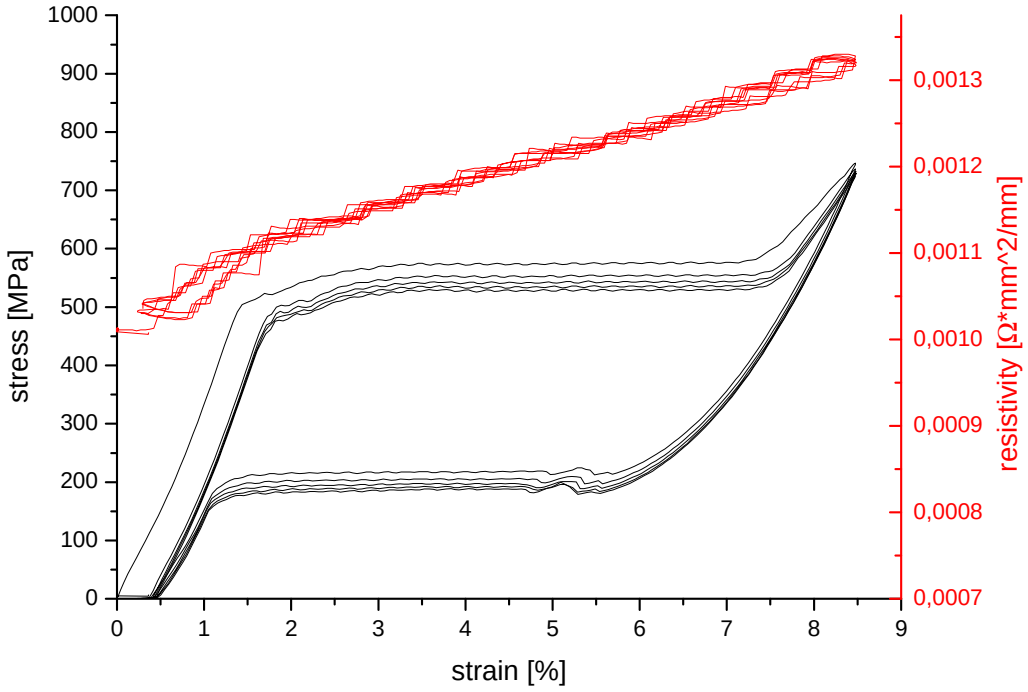

Figure 3 : Five tensile loading cycles at room temperature, l_0=50mm, strain rate=0.5 s^{-1}

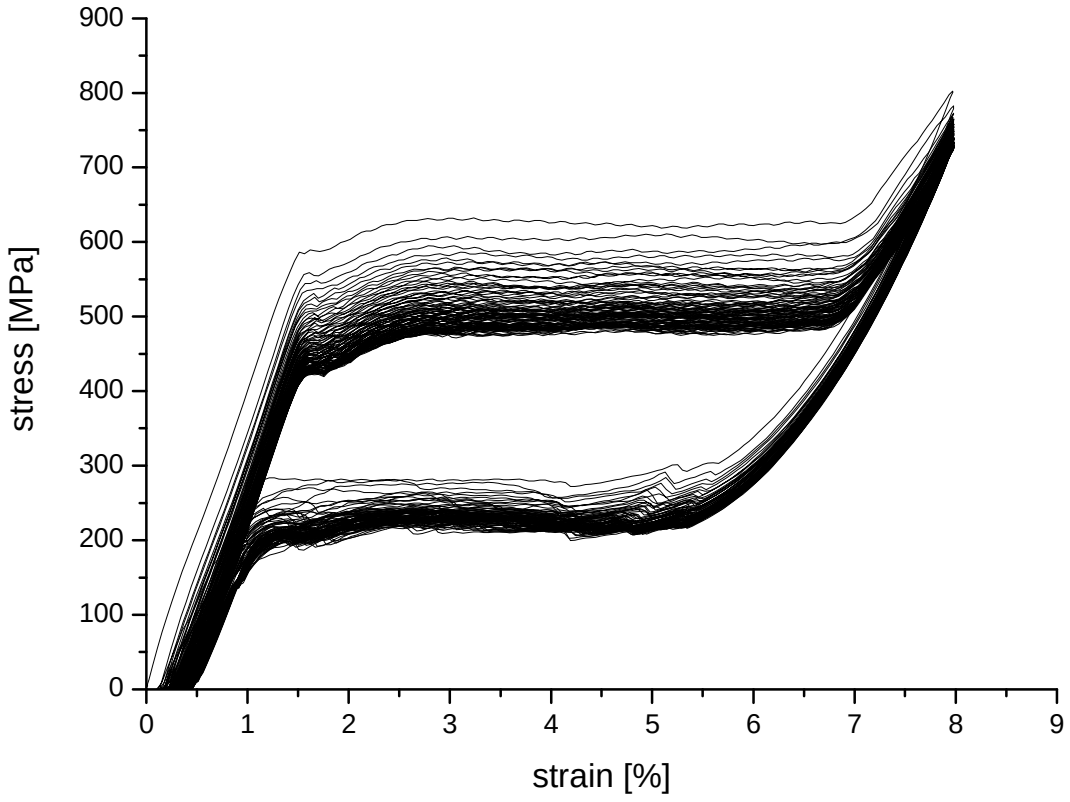

Figure 4: Cyclic tensile test (100 cycles) at room temperature, l_0=50mm, strain rate=0.5 s^{-1}

TESTING PROCEDURES

There are 22 material parameters characterizing the functional thermomechanical behaviour of NiTi superelastic wires in tension obtained 4 different types of tests

1. DSC (ERC) **…6 parameters (Table 1)**
2. Tensile test till rupture **…7 parameters (Table 2)**
3. Cyclic tensile superelastic test (N=100 cycles) **…3 parameters (Table 3)**
4. Thermomechanical tests **…6 parameters (Table 4)**

Table 1: Material parameters of superelastic NiTi wires (B2→R→B19') obtained from DSC (ERC) – transformation temperatures

Forward transformation temperatures [^{o}C]				Reverse transformation temperatures [^{o}C]	
R-phase start	R-phase finish	Martensite start	Martensite finish	Austenite start	Austenite finish
R_s	**R_f**	**M_s**	**M_f**	**A_s**	**A_f**

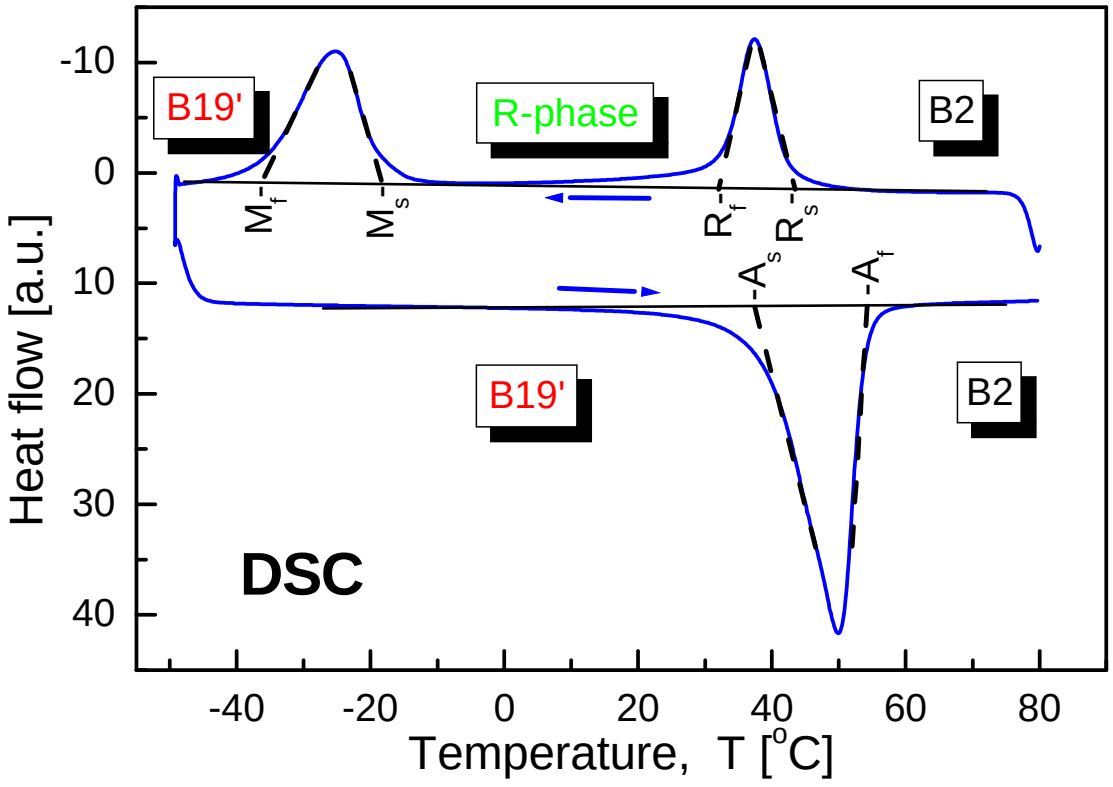

Table 2: Material parameters of superelastic NiTi wires (B2→R→B19') obtained from tensile tests till rupture

Young modulus of austenite	Young modulus of martensite	Transformation Yield stress of austenite at RT	Maximum recoverable transformation strain	Ultimate tensile strength	Yield stress	Strain at failure
E^A	E^M	σ^{tr}	ε^{tr}	σ^{UTC}	σ^{Y}	ε^{f}
[GPa]	[GPa]	[MPa]	1	[MPa]	[MPa]	1

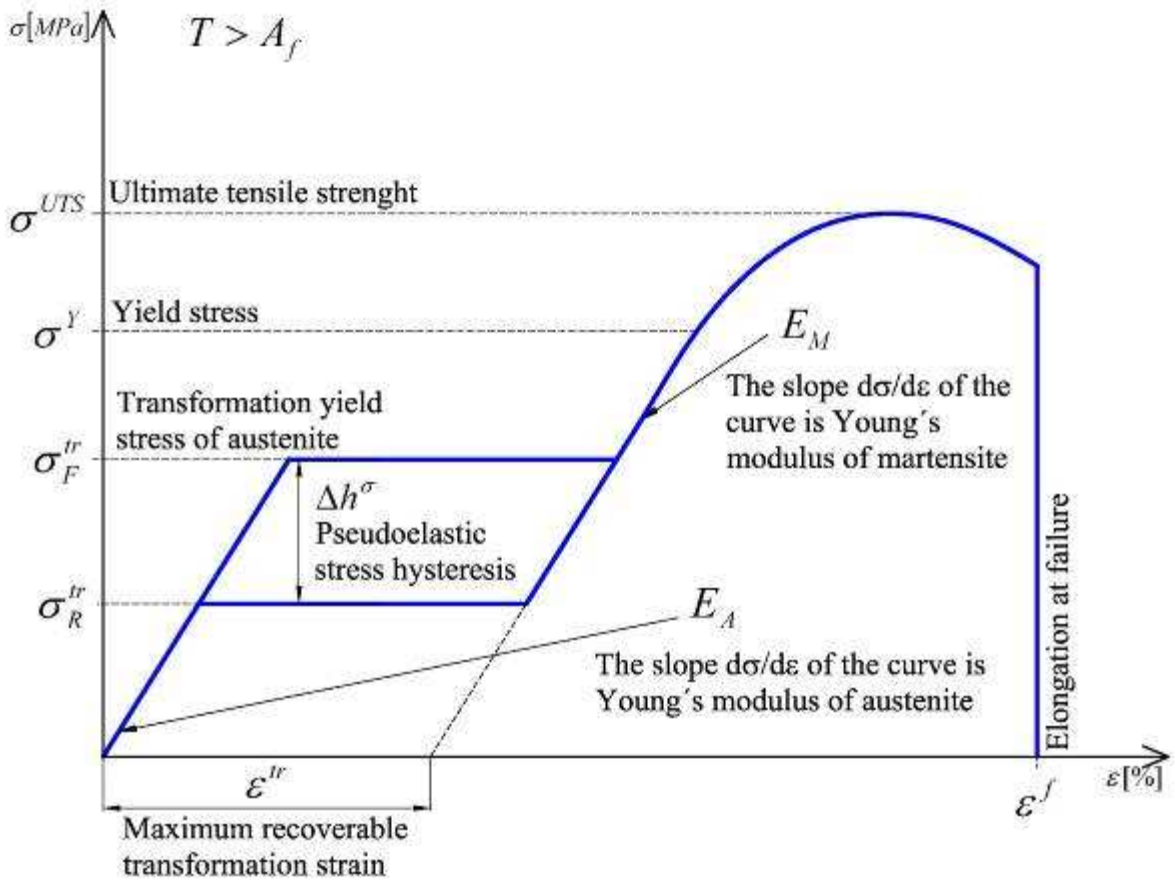

Table 3: Material parameters of superelastic NiTi wires (B2→R→B19') obtained from cyclic tensile tests at RT

Accumulated nonrecovered strain for N=100	Cyclic accumulated transformation stress change for N=100	Cyclic accumulated pseudoelastic hysteresis change for N=100
$\boldsymbol{\varepsilon_{ac}}$	$\boldsymbol{\Delta\sigma^{tr}_{ac}}$	$\boldsymbol{\Delta h^{\sigma}_{ac}}$
	$\Delta\sigma^{tr}_{ac} = \frac{\sigma^{tr}_{ac}(N=100) - \sigma^{tr}_{ac}(N=1)}{\sigma^{tr}_{ac}(N=1)} * 100$	$\Delta h^{\sigma}_{ac} = \frac{\Delta h^{\sigma}_{ac}(N=100) - \Delta h^{\sigma}_{ac}(N=1)}{\Delta h^{\sigma}_{ac}(N=1)} * 100$
1	[%]	[%]

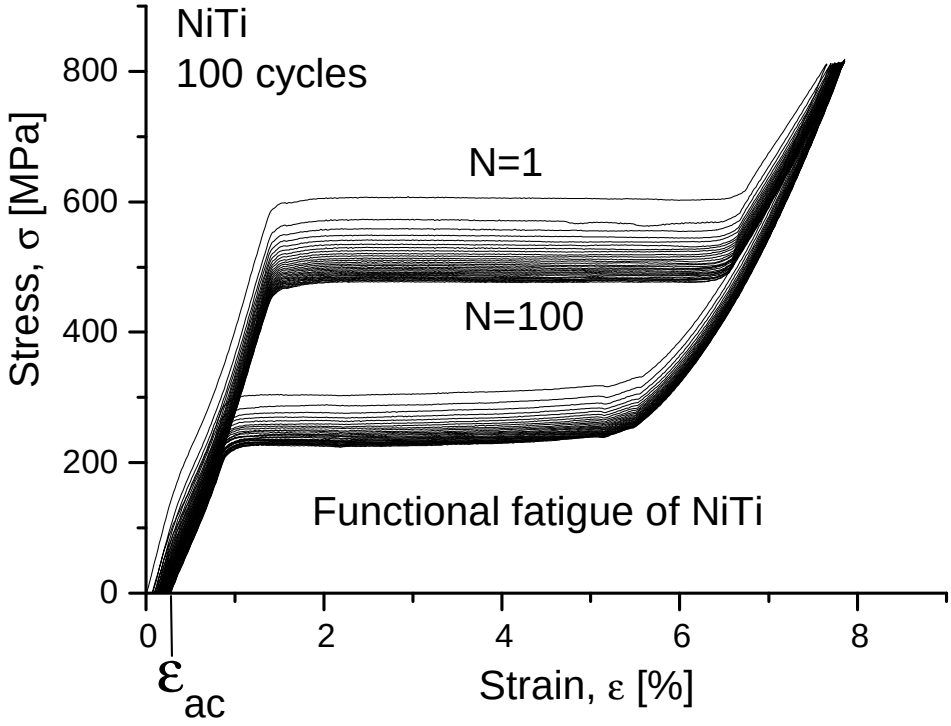

Table 4: Material parameters of superelastic NiTi wires (B2→R→B19') obtained from thermomechanical tensile tests

Effective martensite start temperature	Effective austenite finish temperature	Pseudoelastic stress hysteresis	Temperature dependence of transformation stress for A-R	Temperature dependence of transformation stress for A-M	Reorientation yield stress of martensite
M'_s	A'_f	Δh^{σ}	s_{A-R}	s_{A-M}	σ^{re}
[°C]	[°C]	[MPa]	[MPa/°C]	[MPa/°C]	[MPa]