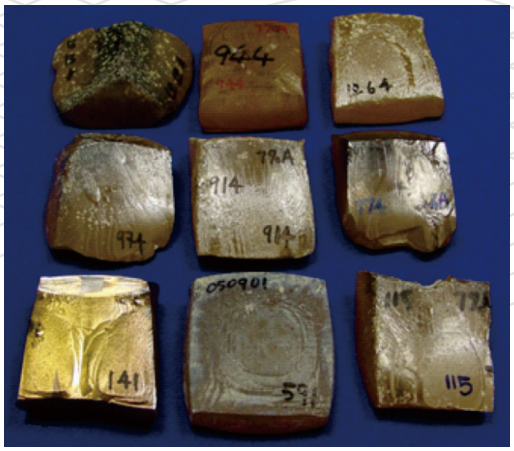
PZN-PT Single Crystal

PZN-(4.75-6.5)%PT Single Crystal Products



PROPERTIES AT A GLANCE

Crystal type	011P-32A	011P-32S	011P-31T	011P-33T	001P-31T-110L	001P-33(31)T-100L
%PT (Norminal)	x ≈ 5.5%	x ≈ 6%	x ≈ 6%	x ≈ 6%	x ≈ 6.5%	x ≈ 6.5%
ε_{33}^{T} (ε_0)	4000	5500	5500	5500	6100	6100
d_{ij} (pC/N)	-2600 (d_{32})	-3200 (d_{32})	1100 (d_{31})	1900 (d_{33})	-1200 (d_{31})	2400 (d_{33})/-1400 (d_{31})
E_c (kV/mm)	0.45	0.55	0.55	0.55	0.35	0.35
$E_{RO/RT}$ (kV/mm)	0.85 (E_{RO})	0.70 (E_{RO})	0.70 (E_{RO})	0.70 (E_{RO})	0.90 (E_{RT})	0.90 (E_{RT})
$\sigma_{RO/RT}$ (MPa)	12 (σ_{RO})	8 (σ_{RO})	>85	5 (σ_{RO})	80 (σ_{RT})	5 (σ_{RT}) / -
S (pm^2/N)	170 (S_{22}^{E})	180 (S_{22}^{E})	54 (S_{11}^{E})	12 (S_{33}^{D})	40 (S_{11}^{E})	16 (S_{33}^{D})/90 (S_{11}^{E})
d / s (C/m^2)	15	18	20	158	30	150(d_{33}/S_{33}^{D})/16(d_{31}/S_{11}^{E})
k_{ij}	0.90 (k_{32})	0.91 (k_{32})	0.75 (k_{31})	0.90 (k_{33})	080 (k_{31})	0.90 (k_{33})/0.50(k_{33})
$\mathbf{v}_{ii}$ (m/s)	850 ($\mathbf{v}_{22}^{E}$)	800 ($\mathbf{v}_{22}^{E}$)	1500 ($\mathbf{v}_{11}^{E}$)	3250 ($\mathbf{v}_{33}^{D}$)	1800 ($\mathbf{v}_{11}^{E}$)	2750 ($\mathbf{v}_{33}^{D}$)/1200 ($\mathbf{v}_{11}^{E}$)
$T_{RO/RT}$ (°C)	108 (T_{RO})	102 (T_{RO})	102 (T_{RO})	102 (T_{RO})	100 (T_{RT})	100 (T_{RT})
Main Application	Underwater projectors (with pressure release)	Hydrophone	Sensors & actuators of large transverse force	Sensors & Actuators	Sensors & Actuators of large transverse force	Sensors & Actuators

PZN-PT Single Crystal

k_{33} ≈ 0.90-0.93; k_{32} ≈ 0.89-0.92; k_{15} ≈ 0.92
d_{33} ≈ 1500-2500, d_{32} ≈ -(1800-3000), d_{15} ≈ 5000 (pC/N); K^{T} ≈ 4000-6000
E_c ≈ 0.3-0.6 kV/mm; T_{DP} > 150°C; ΔT_C value; high flexibility.

PZT Piezoelectric Ceramic

k_{33} ≈ 0.65-0.72; k_{31} ≈ 0.5; d_{33} ≈ 350-590, d_{31} < -275 (pC/N); K^{T} ≈ 1500-3500
E_c > 0.7 kV/mm; T_{DP} > 150°C; small ΔT_C value; low flexibility.

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FULL PROPERTY MATRICES OF $[011]_c$ poled rhombohedral PZN-(4.75-6.5)%PT single crystal.

Elastic stiffness constants: c_{ij}^E and c_{ij}^D (10^{10} N/m^2) — Piezoelectric constants: e_{ij} (C/m^2), g_{ij} (10^{-3} Vm/N)

PT%	c_{11}^E	c_{12}^E	c_{13}^E	c_{22}^E	c_{23}^E	c_{33}^E	c_{44}^E	c_{55}^E	c_{66}^E	e_{15}	e_{24}	e_{31}	e_{32}
4.75	6.36	3.45	1.76	7.42	8.99	14.05	6.81	0.36	0.79	14.53	9.13	4.66	-5.01
5.5	6.77	4.25	2.35	8.55	9.75	14.12	6.47	0.34	0.64	14.24	13.39	4.72	-4.65
6.5	7.14	4.59	2.64	8.39	10.26	16.08	6.65	0.30	0.59	14.61	8.05	6.35	-3.80

PT%	c_{11}^D	c_{12}^D	c_{13}^D	c_{22}^D	c_{23}^D	c_{33}^D	c_{44}^D	c_{55}^D	c_{66}^D	g_{15}	g_{24}	g_{31}	g_{32}
4.75	6.72	3.07	2.77	7.83	7.91	16.89	7.19	2.09	0.79	56.99	5.82	21.72	-53.63
5.5	7.20	3.82	3.53	8.97	8.59	17.33	7.21	1.64	0.64	55.63	7.67	24.23	-56.05
6.5	7.66	4.28	3.90	8.58	9.51	19.14	7.18	1.95	0.59	57.91	9.11	24.02	-52.80

Elastic compliance constants: s_{ij} and s_{ij} (10^{-12} N/m^2) — Piezoelectric constants: d_{ij} (10^{-12}C/N), h_{ij} (10^8 V/m)

PT%	s_{11}^E	s_{12}^E	s_{13}^E	s_{22}^E	s_{23}^E	s_{33}^E	s_{44}^E	s_{55}^E	s_{66}^E	d_{15}	d_{24}	d_{31}	d_{32}	d_{33}
4.75	34.26	-47.45	26.05	125.35	-74.22	51.32	14.68	277.78	125.98	4037	134	750	-1852	1185
5.5	39.04	-56.67	32.65	137.40	-85.47	60.68	15.46	294.12	155.29	4187	207	858	-1985	1319
6.5	46.99	-74.01	39.51	170.69	-96.76	61.47	15.04	333.33	169.08	4871	121	1191	-2618	1571

PT%	s_{11}^D	s_{12}^D	s_{13}^D	s_{22}^D	s_{23}^D	s_{33}^D	s_{44}^D	s_{55}^D	s_{66}^D	h_{15}	h_{24}	h_{31}	h_{32}	h_{33}
4.75	17.97	-7.23	0.31	26.03	-10.66	10.67	13.90	47.71	125.98	11.94	4.19	7.62	-8.19	21.58
5.5	18.25	-8.58	0.70	26.14	-11.55	11.53	13.87	61.20	155.29	9.11	5.53	9.14	-9.01	24.93
6.5	18.38	-11.13	1.78	32.46	-13.82	11.68	13.94	51.25	169.08	11.29	6.54	8.14	-4.87	19.81

Dielectric constants: ε_{ij} (ε_0), β_{ij} (10^{-4}/ ε_0)

PT%	ε_{11}^S	ε_{22}^S	ε_{33}^S	ε_{11}^T	ε_{22}^T	ε_{33}^T	β_{11}^S	β_{22}^S	β_{33}^S	β_{11}^T	β_{22}^T	β_{33}^T
4.75	1375	2462	691	8000	2600	3900	7.27	4.06	14.47	1.25	3.85	2.56
5.5	1766	2737	583	8500	3050	4000	5.66	3.65	17.15	1.18	3.28	2.50
6.5	1462	1390	881	9500	1500	5600	6.84	7.19	11.35	1.05	6.67	1.82

Electromechanical coupling factors: k_{ij} — Mechanical quality factors Q_{ij} — Coercive field strength E_c (kV/mm), density ρ (kg/m^3) and phase transformation temperatures: T_{RO} & T_C (°C)

PT%	k_{15}	k_{24}	k_{31}	k_{32}	k_{33}	k_t	Q_{33}	Q_{32}	Q_{31}	E_c	ρ	T_{RO}	T_C
4.75	0.91	0.23	0.69	0.89	0.89	0.41	90-180	100-200	100-200	0.32-0.45	8390	116-129	145-157
5.5	0.89	0.32	0.73	0.90	0.90	0.43	70-150	80-170	80-180	0.42-0.55	8375	103-116	152-164
6.5	0.92	0.27	0.78	0.90	0.90	0.40	50-120	60-150	50-150	0.46-0.60	8370	95-103	156-170

FULL PROPERTY MATRICES OF $[001]_c$ poled rhombohedral PZN-(4.75-6.5)%PT single crystal.

Elastic stiffness constants: c_{ij}^E and c_{ij}^D (10^{10} N/m^2)

PT%	c_{11}^E	c_{12}^E	c_{13}^E	c_{33}^E	c_{44}^E	c_{66}^E	c_{11}^D	c_{12}^D	c_{13}^D	c_{33}^D	c_{44}^D	c_{66}^D
4.75	10.98	10.09	9.94	10.61	6.71	7.46	11.24	10.35	9.01	13.96	6.93	7.46
5.5	11.18	10.35	10.30	10.83	6.70	5.75	11.40	10.57	9.42	14.45	6.98	5.75
6.5	11.40	10.61	10.55	10.91	6.54	5.04	11.50	10.71	9.92	14.75	6.84	5.04

Elastic compliance constants: s_{ij}^E and s_{ij}^D (10^{-12} N/m^2)

PT%	s_{11}^E	s_{12}^E	s_{13}^E	s_{33}^E	s_{44}^E	s_{66}^E	s_{11}^D	s_{12}^D	s_{13}^D	s_{33}^D	s_{44}^D	s_{66}^D
4.75	77.21	-35.97	-38.67	81.95	14.90	13.40	61.59	-51.59	-6.47	15.57	14.42	13.40
5.5	85.62	-34.16	-48.93	102.28	14.93	17.40	65.06	-54.72	-6.74	15.71	14.34	17.40
6.5	94.56	-32.30	-60.19	125.54	15.29	19.84	69.00	-57.86	-7.51	16.96	14.62	19.84

Piezoelectric constants: e_{ij} (C/m^2), d_{ij} (10^{-12} C/N), g_{ij} (10^{-3} Vm/N) and h_{ij} (10^8 V/m)

PT%	e_{15}	e_{31}	e_{33}	d_{15}	d_{31}	d_{33}	g_{15}	g_{31}	g_{33}	h_{15}	h_{31}	h_{33}
4.75	5.84	-4.23	15.30	87	-767	1581	5.54	-20.36	41.98	3.84	-6.06	21.90
5.5	6.70	-3.89	15.92	100	-979	2009	5.94	-21.00	43.10	4.15	-5.55	22.70
6.5	7.13	-2.76	16.71	109	-1179	2430	6.16	-21.68	44.68	4.21	-3.80	22.99

Dielectric constants ε_{ij} (ε_0), β_{ij} (10^{-4}/ ε_0) and electromechanical coupling factors k_{ij}

PT%	ε_{11}^S	ε_{33}^S	ε_{11}^T	ε_{33}^T	β_{11}^S	β_{33}^S	β_{11}^T	β_{33}^T	k_{15}	k_{31}	k_{33}	k_t
4.75	1716	789	1773	4254	5.83	12.67	5.64	2.35	0.18	0.45	0.90	0.49
5.5	1824	792	1900	5265	5.48	12.63	5.26	1.90	0.20	0.49	0.92	0.50
6.5	1912	821	2000	6142	5.23	12.18	5.00	1.63	0.21	0.52	0.93	0.51

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PZN-(5-7)%PT Single Crystal Products

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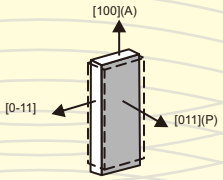
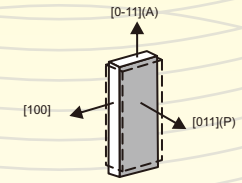
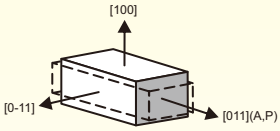
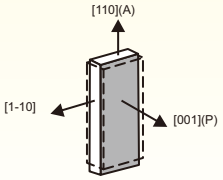
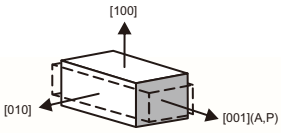
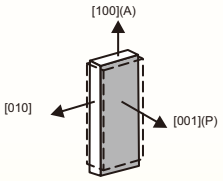
DESCRIPTION AND ORIENTATION OF VARIOUS PZN-(5-7)%PT CRYSTAL TYPES AND THIER SYMBOLS

011P-32A / 011P-32S		[011]-poled transverse (32) mode crystal of $[0\text{-}11]^{1}$ x $[100]^{2(A)}$ x $[011]^{3(P)}$. Type A is recommended for Actuator and Type S for Sensor applications, notably as motor section of underwater projectors and sensing elements of hydrophones respectively.
011P-31T		[011]-poled transverse (31) mode crystal of $[0\text{-}11]^{1(A)}$ x $[100]^{2}$ x $[011]^{3(P)}$ cut for transverse-mode transducers (31T) where high transverse loads are present.
011P-33T		[011]-poled longitudinal (33) mode crystal of $[0\text{-}11]^{1}$ x $[100]^{2}$ x $[011]^{3(A,P)}$ cut for longitudinal mode transducers (33T) when relatively high d_{33} and crystal stiffness are advantageous.
001P-31T-110T		[001]-poled crystal of $[110]^{1(A)}$ x $[1\text{-}10]^{2}$ x $[001]^{3(P)}$ cut as transverse-mode transducers (31T) where a high $d_{31}/s_{11}E$ value is advantageous.
001P-33T-100L		[001]-poled crystal of $[100]^{1}$ x $[010]^{2}$ x $[001]^{3(A,P)}$ cut as longitudinal mode transducer (33T). Said cut may also be used as transverse mode transducer (31T), i.e., $[100]^{1(A)}$ x $[010]^{2}$ x $[001]^{3(P)}$.
001P-31T-100L		

* For other crystal compositions and cuts, please kindly contact us with your request.

Key on crystal designation / symbols:

* 011P and 001P indicate poling direction being [011] and [001], respectively, which is also the 3-direction.
* 33, 32 and 31 denote the mode of actuation/sensing, 33 being the longitudinal mode, and 32 and 31 are the transverse modes with the active direction being along the 2- and 1-axis.
* A, S and T denote actuator, sensor and transducer, respectively.
* 100L and 110L indicate the active length directions in [001]-poled crystals.
* Superscripts (A) and (P) next to directional axes denote the active and poling direction respectively.

CRYSTAL DIMENSIONS AND TOLERANCES

Direction	Dimensional Range	Tolerances (+/-)
Thickness (i.e., poling direction) (mm)	0.3 - 3.0	0.015
Other two orthogonal directions (mm)	2.0 -25.0	0.030

Crystals can be supplied in either unpoled (either bare or electroded) or electroded and poled condition. Our standard electrode consists of a thin NiCr bond coat followed by a thicker AuPd electrode layer, both applied via the RF sputter-deposition technique.
Crystals of smaller dimensions, larger thickness in poling direction and/or tighter tolerances are available upon request.

Mircofine reserves the right to change specifications without notice.

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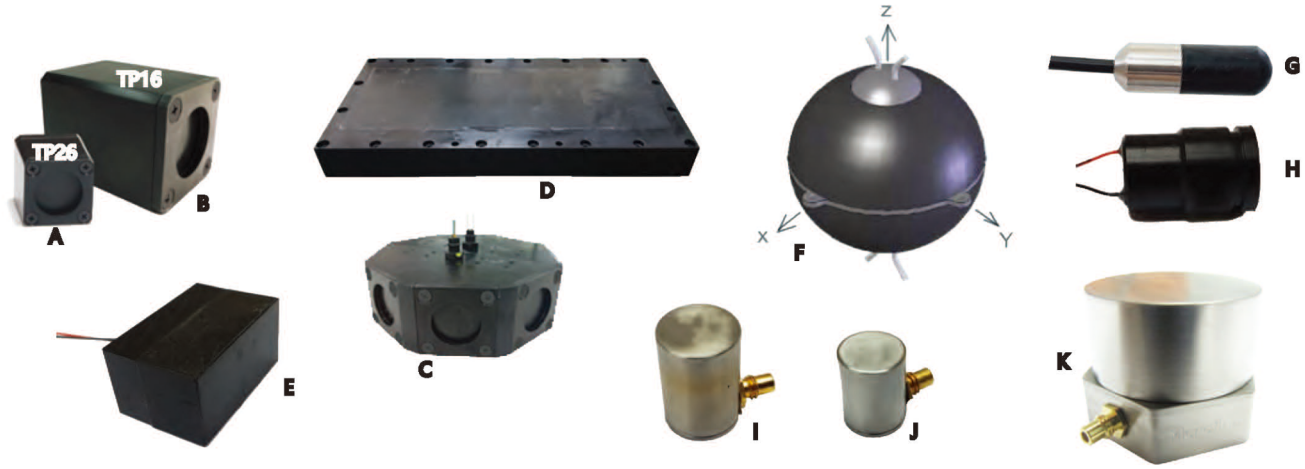
PZN-(4.75-6.5)%PT Single Crystal Products

MICROFINE
MATERIALS TECHNOLOGIES PTE LTD

The key performance and main application of PZN-(4.75-6.5)%PT single crystal

Poling Direction	<011>-poled			<001>-poled		
Property / Type	PZNT-A	PZNT-B	PZNT-C	PZNT-A	PZNT-B	PZNT-C
Composition	PZN-(4.5%)PT	PZN-(5.5%)PT	PZN-(6.5%)PT	PZN-(4.5%)PT	PZN-(5.5%)PT	PZN-(6.5%)PT
Density (g/cm^3)	8.39	8.375	8.37	8.39	8.375	8.37
K_3^T (1kHz)	2800-4500	3800-5000	4800-6500	4000-5600	5000-6700	6000-7800
tan δ (1kHz)	≤0.005	≤0.005	≤0.005	≤0.015	≤0.015	≤0.015
T_C (°C)	145-157	152-164	156-170	145-157	152-164	156-170
T_{RO} / T_{RT} (°C)	116-129 (T_{RO})	103-116 (T_{RO})	90-103 (T_{RO})	115-125 (T_{RT})	105-115 (T_{RT})	90-105 (T_{RT})
k_{33}	≥0.86	≥0.86	≥0.86	≥0.89	≥0.90	≥0.91
k_{32}	≥0.88	≥0.89	≥0.90			
k_{31}	≥0.60	≥0.65	≥0.70	≥0.41	≥0.45	≥0.50
d_{33} (pC/N)	900-1200	1100-1400	1500-1900	1380-2100	1900-2600	2400-3000
d_{32} (pC/N)	(-) 1500-2000	(-) 1800-2450	(-) 2200-3200			
d_{31} (pC/N)	600-900	800-1100	900-1250	(-) 700-1100	(-) 800-1300	(-) 900-1500
s_{33}^D (10^{-12}m^2/N)	10-14	10-14	10-14	14-21	14-21	14-21
s_{11}^D (10^{-12}m^2/N)	12-20	14-26	16-28	50-80	55-90	65-95
s_{22}^D (10^{-12}m^2/N)	18-30	18-35	18-40			
s_{22}^E (10^{-12}m^2/N)	115-140	130-165	150-215			
s_{11}^E (10^{-12}m^2/N)	25-40	35-50	40-55	70-100	75-110	80-120
s_{33}^E (10^{-12}m^2/N)	45-60	50-79	55-95	75-120	85-140	95-160
E_c (kV/cm)	3.2-4.5	4.2-5.5	4.6-6.0	2.5-3.5	3.0-4.0	3.0-4.0
Q_M (33-mode)	90-180	70-150	50-120	60-100	60-100	60-100
Q_M (32-mode)	100-200	80-170	60-150			
Q_M (31-mode)	100-200	80-180	50-150	40-100	40-100	40-100

Application:
- PZN-(4.75%)PT Suitable for various sensors, actuators and underwater devices that require high temperature stability.
- PZN-(5.5%)PT Suitable for all kinds of high-performance, broadband, resonant actuators and underwater transducer.
- PZN-(6.5%)PT Suitable for all kinds of high-sensitivity sensors and hydrophones.



A,B,C,D : compact size, low frequency, wide broadband projector; E: high frequency, broadband underwater transducer; F: compact size, high sensitivity vector sensors; G, H: hydrophone; IJK ultra-high sensitivity, accelerometer.

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