MATERIAL PROPERTIES

2012

Applications	Material group	Material	Compare with	Free (Clamped) Dielectric Constant K^T_3	Longitudinal Coupling Coefficient k_{33}	Shear Coupling Coefficient k_{15}	Thickness Coupling Coefficient k_t	Planar Coupling Coefficient $k_p(k_{31})$	Piezoelectric Charge Constants pm/V, or pC/N $d_{33}(d_h)$	d_{15}	d_{31}	Piezoelectric Voltage Constants mV·m/N g_{33}	g_{15}	g_{31}	Curie Temperature, °C T_C	Young's Modulus Y_{33}^E	Mechanical Quality Factor (@ 4 MHz) $Q_{m,t}$	Dissipation Factor (max., @1 kHz),% $\tan\delta$	Thickness Frequency Constant, Hz·m (kHz·in) N_t	Frequency Constants Hz·m (kHz·in) N_p	N_{15}	Density, 10^3kg/m³ ρ	Sound Velocity under E=0, km/sec $V_L(V_S)$	Acoustic Impedance under E=0, MRayl Z_L	Thermal Coefficient of Expansion, 10^{-6}/°C α
High temperature applications — ultrahigh temperature (up to 700°C) accelerometers, pressure, knock, flow and NDT transducers.	Bismuth Titanate	K-12		140 (133)	0.12	0.07	0.21	0.045 (0.027)	12 (7)	10	-2.5	10	7	-2	820	10.5	3500	0.5	2317 (91)	2868 (113)	1420 (56)	7	4.62 (2.84)	32	9
	Bismuth Titanate	K-15		140 (133)	0.15	0.08	0.23	0.025 (0.015)	18 (14)	14	-2	15	10	-1.6	600	12	1800	3	2010 (79)	2515 (99)	1250 (49)	7.1	4.00 (2.50)	28	9
Very stable parameters under time, temperature and pressure variations, low acoustic impedance, low aging, and Q-factor. Used in flaw detectors, thickness gauges, accelerometers, HF hydrophones; and to measure acoustic emissions, pressure, knock, flow, level, and well logging under high pressure and temperature (up to 300°C).	Modified Lead Metaniobate	K-81		300 (270)	0.33	0.25	0.33	0.04 (0.02)	85 (71)	95	-7	32	31	-2.6	460	5.5	20	1	1570 (62)	1970 (78)	940 (37)	6.2	3.10 (1.87)	19	1.3
Its low dielectric constant coupled with a high frequency constant results in a lower capacitance for higher frequency driving and low acoustic impedance.	Modified Lead Metaniobate	K-83		185 (150)	0.42	0.25	0.41	0.18 (0.12)	56 (26)	54	-15	34	22	-9	200	13	700	2	2690 (105)	3440 (135)	1700 (67)	4.6	5.42 (3.35)	24	1.5
Higher signal to noise ratio with low Q and low acoustic impedance.	Modified Lead Metaniobate	K-85		800 (625)	0.47	0.39	0.43	0.19 (0.12)	200 (114)	210	-43	25	25	-6	300	4.6	20	2	1650 (65)	2120 (83)	990 (39)	5.7	3.40 (1.94)	19	1.6
Shear and compressional resonance applications at medium to high frequencies, small diameter transducers, pulse-echo, NDT and imaging devices. Low dielectric constant with high shear coupling and high temperature stability. Large diameter and/or high frequency, high power radiators, such as sonar, medical therapy and HIFU. Highly resistant to depoling under severe mechanical stress and electric drive, low dielectric losses at high electric fields. High power acoustic transducers, for ultrasonic cleaning, welding and sonar, high voltage generators, medical therapy and HIFU. K-300 excels in high power applications, where high sensitivity, high mechanical quality and low dissipation factors are required. Extremely high piezoactivity k^2Q under strong electrical and mechanical fields with low dielectric losses. High power applications, HIFU. Advanced high drive materials for high power transducers, small HIFU elements, imaging/therapy.	Modified Lead Zirconate-Titanate (PZT)	K-180	PZT-7A	425 (225)	0.68	0.68	0.53	0.52 (0.30)	165 (45)	350	-60	43	50	-15	350	7.1	700	3	2060 (81)	2390 (94)	1010 (40)	7.7	4.13 (1.96)	32	3.6
	Modified Lead Zirconate-Titanate (PZT)	K-182	PZT-2	590 (330)	0.65	0.62	0.48	0.50 (0.23)	190 (30)	330	-80	37	48	-16	330	8.1	700	0.4	2180 (85)	2490 (98)	1050 (41)	7.6	4.23 (2.02)	34	3.1
	Modified Lead Zirconate-Titanate (PZT)	K-270	PZT-4, Navy I	1260 (650)	0.70	0.69	0.48	0.57 (0.33)	320 (80)	490	-120	29	36	-10	325	6.5	600	0.8	2010 (79)	2250 (87)	950 (37)	7.6	3.98 (1.85)	30	3.6
	Modified Lead Zirconate-Titanate (PZT)	K-278	PZT-8, Navy III	1100 (650)	0.64	0.58	0.46	0.51 (0.30)	300 (100)	325	-100	29	30	-10	300	7.4	1000	0.4	2035 (80)	2320 (92)	970 (38)	7.6	3.99 (1.88)	30	3.6
	Modified Lead Zirconate-Titanate (PZT)	K-300	PZT-4D	1500 (740)	0.71	0.70	0.49	0.56 (0.33)	320 (40)	490	-140	25	35	-11	300	5.5	900	0.4	2075 (81)	2280 (90)	950 (37)	7.7	4.08 (1.84)	31	6.8
	Modified Lead Zirconate-Titanate (PZT)	K-320		1450 (790)	0.67	0.67	0.50	0.54 (0.32)	320 (60)	470	-130	25	33	-10	275	5.5	1800	0.6	2100 (83)	2290 (90)	1010 (40)	7.8	4.12 (1.94)	32	6.8
	Modified Lead Zirconate-Titanate (PZT)	K-340		3060 (1660)	0.67	0.65	0.47	0.54 (0.32)	430 (70)	630	-180	16	25	-7	180	5.5	900	0.4	2133 (84)	2300 (91)	954 (38)	7.7	3.95 (1.87)	31	6.8
Widely used for general purposes, hydrophones, accelerometers, level sensors, acoustic emission, pressure, flow, NDT, medical, knock, sonar, igniters.	Modified Lead Zirconate-Titanate (PZT)	K-350	PZT-5A, Navy II	1750 (795)	0.72	0.67	0.50	0.61 (0.34)	390 (40)	570	-175	25	40	-11	360	5.4	140	2	1960 (77)	1997 (79)	950 (37)	7.7	3.92 (1.88)	30	3.6
K-500 has high dielectric constant and stable piezoelectric constants, similar to K-350, good for arrays and composites.	Modified Lead Zirconate-Titanate (PZT)	K-500	PZT-5J, Navy V	3000 (1200)	0.73	0.65	0.54	0.63 (0.37)	580 (140)	700	-220	21	31	-9	240	4.5	170	2	1940 (78)	2050 (81)	910 (36)	7.7	3.96 (1.76)	30	9.5
This material has high coupling and dielectric constants. Good for 1-3 composites, arrays, actuators, sensitive receivers and line hydrophone applications.	Modified Lead Zirconate-Titanate (PZT)	K-600	PZT-5H, Navy VI	3200 (1300)	0.74	0.68	0.54	0.65 (0.38)	650 (150)	730	-250	23	32	-9	220	5	160	2	1990 (78)	1963 (77)	920 (36)	7.7	3.98 (1.80)	31	9.5
Higher permittivity and piezoelectric constant make it an excellent choice for 1-3 composites, multi-element arrays, and actuator applications.	Modified Lead Zirconate-Titanate (PZT)	K-740		3850 (1750)	0.71	0.69	0.54	0.63 (0.37)	740 (160)	730	-290	21	27	-9	205	5	150	2	2010 (79)	2020 (79)	940 (37)	7.8	4.00 (1.84)	31	9
High frequency range transducers, for medical imaging, therapy, HIFU, and NDT — where low losses and high piezoelectric anisotropy are critical.	PT	Nova 3B		205 (148)	0.51	0.37	0.51	0.05 (0.03)	61 (54)	78	-3.5	34	35	-2	350	12	1700	1.5	2135 (84)	2710 (107)	1360 (54)	7.6	4.19 (2.71)	32	along: polar-+ planar-

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Notes:

1. All values are determined on standard samples for material characterization 10 days after poling, and are typical and nominal. All measurements are made in accordance with all relevant Military and Industry Standards, including IEEE, IEC, ANSI. Actual readings, measurements and calculations will vary with part geometry and product type depending on the manufacturing process and control conditions.
2. Typical maximum working temperature ~ (0.6...0.8) Tc, °C, maximum DC field ~ 0.55 MV/m (0.2 MV/m for K-12 and K-15). Typical static compressive strength—300 MPa, expansional ~ 18 MPa, bending ~ 50 MPa, dynamic strength ~ 15 MPa. Microstructure grain size 2-7 μ for other types.
3. Typical tolerances ±20% for dielectric constant, ± 10% for piezoelectric coefficients, and ± 10% for elastic frequency constants under normal conditions and low excitation level.
4. The sign of thermal expansion depends on polarization direction. Specific heat capacity ~ 350 J/kg-K. Thermal conductivity ~1 W/m-K. Pyroelectric coefficient ~ 10 μC/m²-K.
5. Resonance characteristics of low Q < 25 materials were determined with loss correction procedure. Data for d_{33} piezocoefficient determined by quasi-static method.