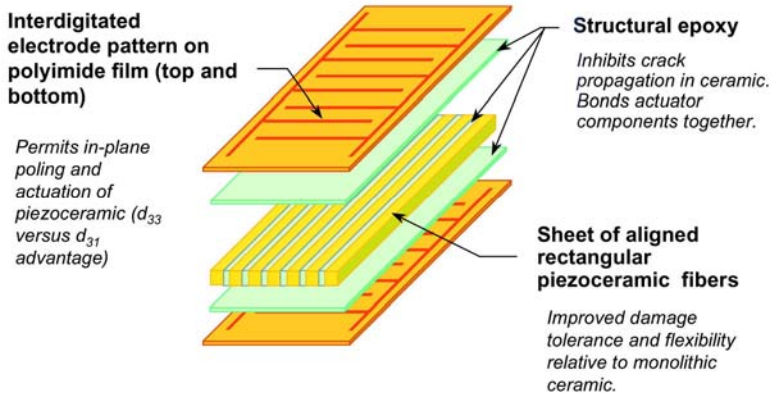
What is a Macro Fiber Composite ?

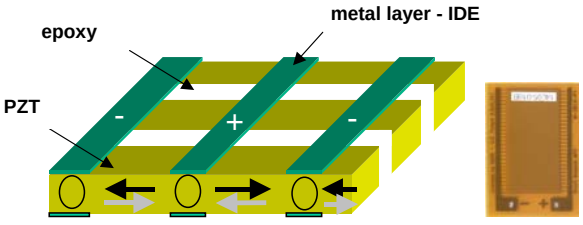
The Macro Fiber Composite (MFC) is an innovative actuator that offers high performance and flexibility in a cost-competitive device. The MFC was originally developed at NASA's Langley Research Center for aerospace applications. The MFC consists of rectangular piezo ceramic rods sandwiched between layers of adhesive and electroded polyimide film.



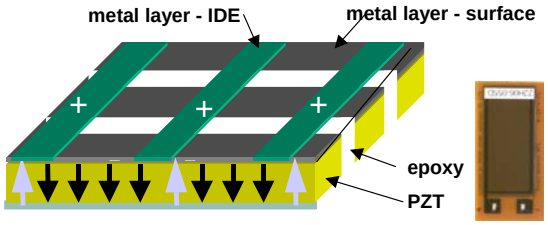
This film contains interdigitated electrodes that transfer the applied voltage directly to and from the ribbon shaped rods. This assembly enables in-plane poling, actuation, and sensing in a sealed, durable, ready-to-use package. When embedded in a surface or attached to flexible structures, the MFC provides distributed solid-state deflection and vibration control or strain measurements.

Available MFC Types

P1 Type (d_{33} effect)



P2 Type (d_{31} effect)



Possible Applications

- high performance actuators
- noise and vibration cancellation
- low frequency ultrasound transducers
- high sensitivity microphones (health monitoring)
- strain sensors
- generators for energy harvesting

Technology licensed by National Aeronautics and Space Administration under contract # FE 339, DN 1010.

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General Technical Information

High-field (|E| > 1kV/mm), biased-voltage-operation piezoelectric constants:		
d33*	4.6E+02 pC/N	4.6E+02 pm/V
d31**	-2.1E+02 pC/N	-2.1E+02 pm/V
Low-field (|E| < 1kV/mm), unbiased-operation piezoelectric constants		
d33*	4.0E+02 pC/N	4.0E+02 pm/V
d31**	-1.7E+02 pC/N	-1.7E+02 pm/V
Free-strain* per volt (low-field - high-field) for d33 MFC (P1)	~ 0.75 - 0.9 ppm/V	~ 0.75 - 0.9 ppm/V
Free-strain* per volt (low-field - high-field) for d31 MFC (P2)	~ 1.1 - 1.3 ppm/V	~ 1.1 - 1.3 ppm/V
Free-strain hysteresis*	~ 0.2	~ 0.2
DC poling voltage, Vpol for d33 MFC (P1)	+1500 V	+1500 V
DC poling voltage, Vpol for d31 MFC (P2)	+450 V	+450 V
Poled capacitance @ 1kHz, room temp, Cpol for d33 MFC (P1)	~ 0.42 nF/cm²	~ 2.7 nF/ in²
Poled capacitance @ 1kHz, room temp, Cpol for d31 MFC (P2)	~ 4.6 nF/cm²	~ 29 nF/ in²
Orthotropic Linear Elastic Properties (constant electric field):		
Tensile modulus, E1*	30.336 GPa	4.4E+06 psi
Tensile modulus, E1**	15.857 GPa	2.3E+06 psi
Poisson's ratio, v12	0.31	0.31
Poisson's ratio, v21	0.16	0.16
Shear modulus, G12***	5.515 GPa	8.0E+05 psi
Operational Parameters:		
Maximum operational positive voltage, Vmax for d33 MFC (P1)	+1500 V	+1500 V
Maximum operational positive voltage, Vmax for d31 MFC (P2)	+360 V	+360 V
Maximum operational negative voltage, Vmin for d33 MFC (P1)	-500 V	-500 V
Maximum operational negative voltage, Vmin for d31 MFC (P2)	-60 V	-60 V
Linear-elastic tensile strain limit	1000 ppm	1000 ppm
Maximum operational tensile strain	< 4500 ppm	< 4500 ppm
Peak work-energy density	~1000 in-lb/in3	~1000 in-lb/in3
Maximum operating temperature - Standard Version	< 80°C	< 176°F
Maximum operating temperature - HT Version	< 130°C	< 266 °F
Operational lifetime (@ 1kVp-p)	> 10E+09 cycles	> 10E+09 cycles
Operational lifetime (@ 2kVp-p, 500VDC)	> 10E+07 cycles	> 10E+07 cycles
Operational bandwidth	0Hz up to 10 kHz	0Hz up to 10 kHz

* Rod direction
** Electrode direction
*** Rules-of-mixture estimate

MFC Type Overview

P1 / F1 Types (d_{33} effect actuators)

model	active length	active width	overall length	overall width	Capa-citance	free strain	blocking force
	mm	mm	mm	mm	nF	ppm	N
P1-Types (0° fiber orientation)							
M-2503-P1	25	3	46	10	0.25	1050	28
M-2807-P1	28	7	40	18	0.33	1380	87
M-2814-P1	28	14	47	25	0.61	1550	195
M-4010-P1	40	10	54	22	1.00	1400	126
M-4312-P1	43	12	60	21	1.83	1500	162
M-8503-P1	85	3	110	14	0.68	1050	28
M-8507-P1	85	7	105	16	1.53	1380	87
M-8528-P1	85	28	112	40	5.70	1800	454
M-8557-P1	85	57	110	73	9.30	1800	923
M-14003-P1	140	3	160	10	1.45	1050	28
F1-Types (45° fiber orientation)							
M-8528-F1	85	28	112	43	6.30	1350	485 calc.
M-8557-F1	85	57	112	75	12.70	1750	945 calc.
M-14028-F1	140	28	175	40	8.00	1350	485 calc.
M-43015-F1	430	15	460	23	10.7	1280	253 calc.

P2 / P3 Types (d_{31} effect actuators)

model	active length	active width	overall length	overall width	Capa-citance	free strain	blocking force
	mm	mm	mm	mm	nF	ppm	N
P2-Types (anisotropic)							
M-2807-P2	28	7	42	14	12.4	-650	-40
M-2814-P2	28	14	36	16	25.7	-700	-85
M-5628-P2	56	28	70	34	113.0	-820	-205
M-8503-P2	85	3	113	8	12.3	-480	-13
M-8507-P2	85	7	108	11	38.4	-670	-42
M-8528-P2	85	28	106	34	172.0	-820	-205
M-17007-P2	170	7	186	12	91.0	-670	-42
P3-Types (orthotropic)							
M-2814-P3	28	14	36	16	29.5	-750	-110
M-5628-P3	56	28	70	34	121.7	-900	-265

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