Piezoelectric Tape Cast Materials

Sense

Move

CTS Your Partner in Smart Solutions

Tape cast processing of polycrystalline materials is widely used for the production of single or multilayered piezoelectric materials. These materials are ideal for micro-actuator applications.

CTS Corporation offers this production capability in addition to press processing to meet the diverse needs of our customers.

Tape Cast Processing for Multilayered Piezoelectric Actuators

» Any shape of multilayered piezoelectric actuator can be manufactured. Surfaces can be encapsulated for cleanliness or insulation.

» Individual layers of the actuator are equipped with electrodes and laminated. As with standard actuators, the ceramic is sintered to the inner electrodes using a co-firing process.

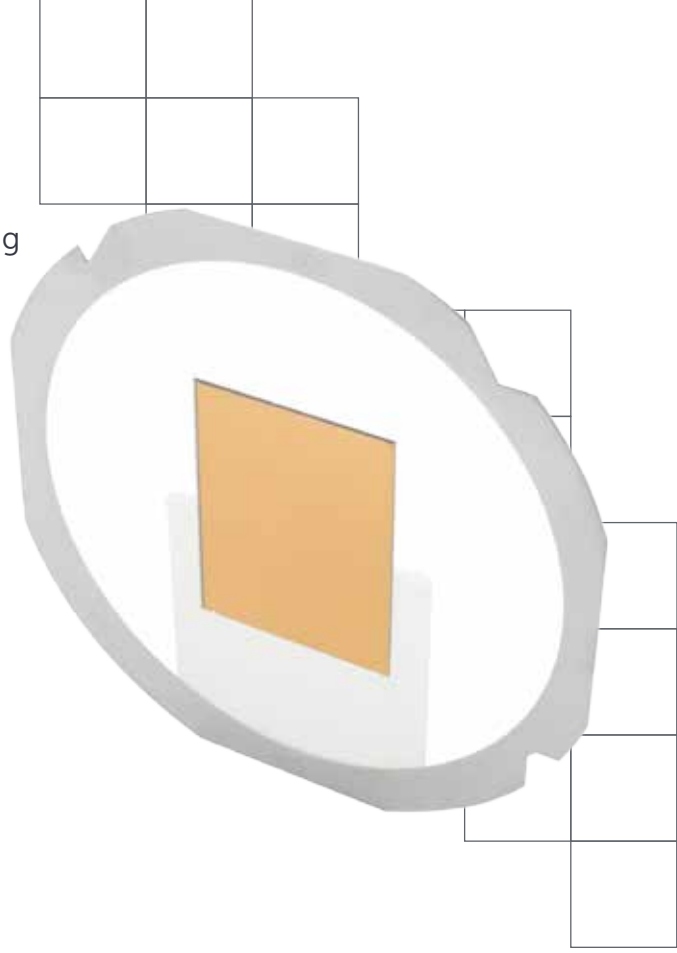
» The more fine-grained the ceramic material used, the thinner the layers that can be produced. The thickness of the active layers can be as small as 20 to 30 µm for bender actuators.

» For high-dynamics applications, multilayered actuators are equipped with electrodes for high currents. Combined with a high-power piezo amplifier, high operating frequencies in the kHz range can be attained. The rise times for nominal displacement are a few tens of microseconds.

» The multilayer technology is a particularly innovative manufacturing process. The first step is to cast tapes of piezoceramic materials which are then provided with electrodes while still in the green state. Many single tapes are laminated together to give a piezo element, which is then sintered together with contact electrodes in a single process step.

» The design comprises an all-ceramic outer layer of the actuator, which acts as insulation. Any further coatings, made of polymer materials for example, are therefore not required. This increases the lifetime and reliability of the component.

The Tape Casting Process



Step 1 — Slurry Preparation and Tape Casting

- Piezoelectric material formulations for lower sintering temperatures
- Tape thickness as low as 10 µm

Step 2 — Screen Printing, Stacking and Pressing

- Ag-Pd or Pt inner electrodes available
- Up to several hundred layers
- Laminating by isostatic pressing

Step 3 — Cutting and Green Shaping

- Automated cutting
- Flexible contours by milling, drilling or punching

Step 4 — Binder Burnout and Sintering

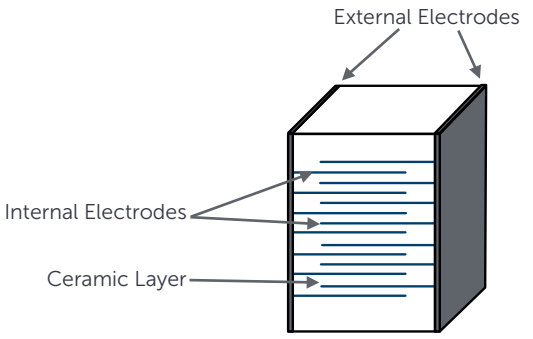
- Slow binder burnout up to 500 °C
- Co-firing temperatures ranging from 1100 °C to 1300 °C, depending on material

Step 5 — Layer Interconnection

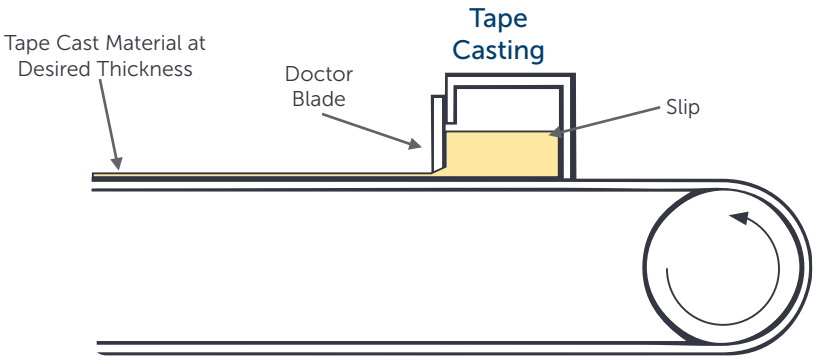
- Via holes
- Termination screen printing or sputtering
- Soldering of the contact strip

Step 6 — Poling, Assembly and Final Inspection

- Poling at room temperature
- Assembly according to customer requirements



Multilayer Tape Cast Design



The Tape Cast Production Process

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PZT 5A & 5H Materials (Soft PZT)

Property	Symbol	Units	Material Type	
			3195STD	3203STD
Dielectric Constant (1kHz)	K^T_3		1800	3250
Dielectric Loss Factor (1kHz)	$\tan\delta_e$		0.02	0.02
Dielectric Constant (1kHz)	K^T_1		1500	2800
Clamped Dielectric Constant	K^S_3		875	775
Density	ρ	g/cm^3	7.7	7.7
Curie Point	T_c	ºC	350	225
Mechanical Quality Factor	Q_m		80	50
Coercive Field (Measured < 1 Hz)	E_c	kV/cm	14.9	10.6
Remanent Polarization	P_r	$\mu Coul/cm^2$	39.2	37.2
Coupling Coefficients	k_p		0.63	0.69
	k_{33}		0.70	0.70
	k_{31}		0.35	0.41
	k_t		0.49	0.56
	k_{15}		0.56	0.72
Piezoelectric Charge (Displacement Coefficient)	d_{31}	Coul/N x 10^{-12} (or) m/V x 10^{-12}	-175	-270
	d_{33}		350	530
	d_{15}		360	790
Piezoelectric Voltage Coefficient (Voltage Coefficient)	g_{31}	V·m/N x 10^{-3}	-11.0	-9.4
	g_{33}		24.2	18.4
	g_{15}		27.1	31.9
Frequency Constants Radial	N_r	Hz·m	2020	1920
Resonant Thickness	N_{tr}	Hz·m	2025	1870
Anti-Resonant Thickness	N_{ta}	Hz·m	2250	2220
	N_{31}	Hz·m	1420	1400
Poisson's Ratio	υ		0.32	0.34
Elastic Constants Short Circuit	S^E_{11}	x $10^{-12} m^2/N$	15.6	16.7
	S^E_{33}		18.6	19.7
	S^E_{12}		-5.3	-5.6
	S^E_{13}		-6.8	-7.6
	S^E_{55}		37.0	48.5
Elastic Constants Open Circuit	S^D_{11}	$10^{-12} m^2/N$	13.7	13.9
	S^D_{33}		9.4	10.0
	S^D_{55}		25.4	23.4
Elastic Constants Short Circuit	Y^E_{11}	x $10^{10} N/m^2$	6.4	5.9
	Y^E_{33}		5.4	5.1
Elastic Constants Open Circuit	Y^D_{11}	x 10^{10} N/m²	7.3	7.2
	Y^D_{33}		10.6	10.0

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