

Textured Tape Cast Piezoelectric Materials Utilizing Templated Grain Growth (TGG)

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ABSTRACT

Textured piezoelectric ceramic material may be the next generation piezoelectric material to bridge the gap between traditional (i.e. PZT ceramic materials) and single crystal (i.e. PMN-PT materials) piezoelectric materials in terms of performance and price point.

TEXTURED TAPE CAST: HIGH PERFORMANCE, LOW PRICE POINT

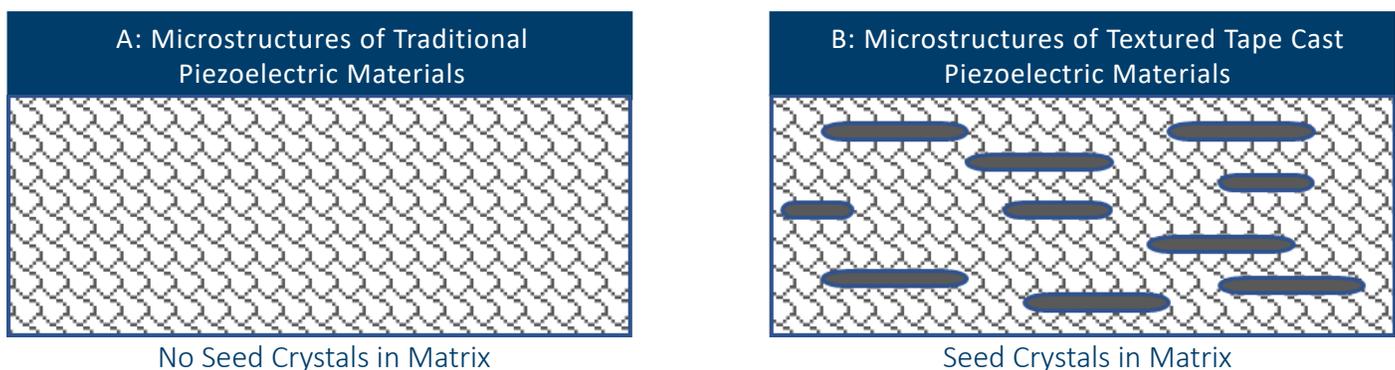
CTS is known for high-quality and high-performance traditional piezoelectric materials. Additionally, CTS manufactures next-generation piezoelectric single crystal materials, which have higher performance than traditional piezoelectric ceramic materials. Our current major markets utilizing single crystal materials are within medical (specifically ultrasound transducers) and defense (specifically sonar transducers) applications.

Single crystal materials grown in our CTS Lisle Plant require sensitive processes and very precise parameters, as well as adequate time to grow the single crystal. Textured materials eliminate single crystal growth complexity while providing close to single crystal piezoelectric performance in the longitudinal direction. Piezoelectric properties (d_{33} , d_{31}) can be modified by engineering the texturing process.

CTS TAPE CAST PROCESS

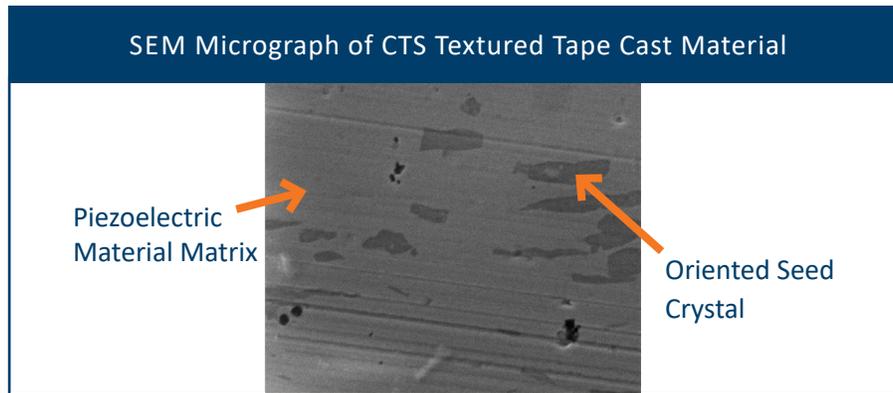
CTS' new high-performance textured material utilizes traditional ceramic manufacturing and tape cast processes. The tape cast process consists of casting a thin layer of piezoelectric material at a specified thickness from a slurry of piezoelectric ceramic powder. Texturing of the tape cast piezoelectric ceramic is achieved by adding seed crystals to the piezoelectric powder slurry. During the tape casting process, the seeds align to provide templates for oriented grain growth during sintering, creating a dense material of highly oriented single crystal grains. The result is a textured ceramic that has a high piezoelectric coefficient in the longitudinal direction. Figure 1 below provides theoretical representation of (A) traditional and (B) textured tape cast piezoelectric material microstructures.

FIGURE 1



A scanning electron microscope (SEM) analysis is used to assess orienting seed crystal material's success during the tape cast process. Figure 2 below shows an SEM micrograph of CTS internally developed textured tape cast material. SEM micrographs can distinguish the oriented single crystal seeds from matrix piezoelectric material by color contrast (darker gray regions are oriented single crystal seeds).

FIGURE 2



MARKETS & APPLICATIONS

Current major markets utilizing single crystal materials are within medical (specifically ultrasound transducers) and defense (specifically sonar transducers) applications. The medical market has successfully created premium ultrasound transducer systems with single crystal materials that sell at a premium price point. Still, the defense market has not yet been able to do so. With our newly developing high-performance textured tape cast piezoelectric material technology, we address this gap with higher performance than traditional piezoelectric ceramic materials but at a better price point than single crystal material.

Transducers utilizing textured piezoelectric ceramics show simultaneously high $d \times g$ values in the range of 30,000 to 50,000 $10^{-15} \text{ m}^2/\text{N}$ providing very encouraging results.¹ Also, experimental models show significant increase in in-water electromechanical coupling coefficient when textured piezoelectric material replaces traditional PZT material (k_{eff} increase from 0.68 to 0.73 by ~7%).²

TEXTURED PIEZOELECTRIC MATERIAL ADVANTAGES

Textured piezoelectric materials are promising next-generation materials that provide advantages over traditional polycrystalline piezoelectric material and single crystal piezoelectric materials. Textured piezoelectric materials rely on traditional cost-efficient piezoelectric material processes, resulting in highly homogeneous structures while providing mechanical properties close to traditional ceramics. As a result, textured piezoelectric ceramics can be machined and assembled easier than single crystal piezoelectric materials. These advantages over polycrystalline piezoelectric material (PZT) and single crystal piezoelectric materials will provide transducer design engineers the edge they need for designing their next-generation transducers.

1. S. Nemena, "Textured Ceramics: The Next Generation of High Performance Transducer Materials," Abstract, UDT 2019

2. K.H. Brosnan, "Processing, Properties and Application of Textured Ceramics," M.S. Thesis, Penn State, 2007

MATERIAL PROPERTIES

CTS two generations of textured piezoelectric material properties are summarized in the table below.

Property	Symbol	Textured 1 st Gen	Textured 2 nd Gen*
		Value	Value
Dielectric Constant	K^T_{33}	1,700	1,870
Coupling Coefficient	K_{31}	0.38	0.40 - 0.46
	K_{33}	0.7	0.79 - 0.85
	K_t	0.45	0.49 - 0.54
Piezoelectric Charge	d_{33} (pm/V)	600	Contact CTS
	d_{31} (pm/V)	-190	Contact CTS
Loss Factor	$\tan\delta$	<0.5%	<0.5%
Curie Temperature	T_{curie}	115 °C	203 °C
Coercive Field	E_c (kV/cm)	4.8	~7.0

Maximum dimensions: 60 mm Length, 60 mm Width, 3mm Thickness

Shapes: Squares, Rectangles, Discs, Rings

*2nd Gen Textured Material developed for high-volume processing

ABOUT CTS

CTS Corporation is a leading developer and manufacturer of high-performance piezoelectric materials for a wide range of applications, including medical, defense, inkjet, industrial, oil and gas and automotive markets. Available in a variety of material compositions, these piezoelectric materials can be produced in various geometries in a comprehensive range of dimensions and in high volumes to support end-product specifications. CTS offers a market leading level of possibilities for product customization of bulk products according to specific customer requirements. With foundries in Europe and North America and additional finishing facilities in Asia and Mexico, CTS' global footprint is uniquely positioned to produce large volume programs and provide quality and reliable products to customers worldwide.

CONTACT INFORMATION

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