Medical Ultrasound Imaging

Piezoelectric transducers for ultrasound scanners

In fields such as obstetrics, piezoelectric transducers are used in ultrasound scanners for medical imaging (ultrasonography) to monitor fetal development during pregnancy. This technology enables the sonographer to generate real-time images of the fetus inside the womb, allowing practicians to make evaluations safely and easily.

HOW IT WORKS

The scanner sends out ultrasound waves via a piezoelectric transducer, at a frequency typically between 3 and 5 MHz. The transducer is placed on the patient's abdomen, and sound waves are sent through the tissue and into the womb. These sound waves, reflected by structures such as muscles and internal organs, are captured by several individual piezo elements of the transducer. Then, they are analyzed, and results are displayed on a screen as an image. The most common systems utilize a 1D array, providing a slice image. Using beamforming techniques, it is possible to determine where the reflected sound comes from, and locate the structures in the plane.

WHICH PIEZO ELEMENTS CAN BE USED FOR AN ULTRASONIC SCANNER?

Devices for medical imaging are usually fitted with an array of individually controlled piezo elements. Systems typically contain 64, 128, or 256 elements, made from soft-doped bulk piezo ceramics. Soft-doped ceramics provide a low quality factor for a large bandwidth, as well as high piezoelectric coefficients for high sensitivity. More advanced ultrasonic systems employ piezo single crystals. These crystals provide higher electromechanical coupling factors and broader bandwidth, allowing higher-resolution imaging. Individual elements are relatively small, and operate at a high frequency but low duty cycle, therefore low average power. A transducer can, for example, be built out of thin (0.1mm) plates of our PMN-PT or PIN-PMN-PT crystal materials with typical dimensions 10*50mm.

Features of bulk ceramics and single crystals for medical ultrasound imaging:

Bulk Ceramics	Single Crystal
• High density material for high performance in 2D imaging applications • Fine grain size enabling micro-machining of features • Uniform electrical properties, wafer-to-wafer and across the wafer • Cost-effective solution • Part length up to 150mm	• Material formulations offering superior piezoelectric properties • Enabling broader bandwidth and higher sensitivity • Improved performance for 3D, 4D, and HD/5D imaging • Machining through dicing, grinding, and etching • Part length up to 90mm

The main properties of materials recommended for medical ultrasound imaging applications are summarized below:

Property	Recommended materials for medical ultrasound imaging				
	Bulk ceramics for classical 2D imaging			Single crystal for high performance 2D, 3D, and 4D imaging	
	General purpose	⟷	High sensitivity	High drive	High sensitivity
	3203HD	3257HD	3265HD	PIN-PMN-PT	PMN-PT
Dielectric constant K^T_3	3800	5700	6500	3700-6500	4500-7500
Coupling coefficient k_t	0.55	0.50	0.49	>0.53	>0.54
Piezolectric coefficient d_{33}	650	730	750	1000-2000	1100-2100

CTS CUSTOM CAPABILITIES

Each company that CTS partners with has unique needs that require custom solutions. Our internal team of engineers and subject matter experts work directly with customers, designing solutions that meet demanding specifications. Typical customization opportunities for piezoelectric elements in medical ultrasound imaging applications are:

- Electrode material and thickness. Typical thin film electrode materials for imaging applications are a thin sputtered NiCr adhesion layer followed by Au, and film thickness varies from 1000 Å to 12500 Å. The selection is a trade-off between cost and adaptation to the contacting method.
- Special electrode design. CTS supports advanced electrode designs with features sized down to 25µm. For imaging applications, a wrap-around electrode is sometimes preferred to be able to contact the elements from the same side.
- Narrow thickness frequency tolerance. CTS' expertise in the precision grinding process enables the manufacturing of components with a tight frequency tolerance of ±2% for consistent operation of interchangeable transducers.
- Surface roughness. Finer surfaces are generally better for operation, but some roughness may be needed to improve bonding. We stock different grinding wheels to accommodate customer needs.

PIEZOELECTRIC EXPERTISE

A leading developer and manufacturer of high-performance piezoelectric materials and components, CTS' piezo products come in a variety of compositions, geometries, and dimensions with high quality standards to meet demanding requirements. Our portfolio encompasses bulk and multilayer ceramics, single crystal, as well as sub-assemblies, composites, and transducers based on these products.

ABOUT CTS

CTS is a leading designer and manufacturer of products that Sense, Connect, and Move. We manufacture sensors, actuators, and electronic components in North America, Europe, and Asia, and provide solutions to OEMs in the in the aerospace & defense, medical, industrial, communications, information technology, and transportation industries.

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