About CTS | Ferroperm Piezoceramics

A leading supplier of sensing and monitoring systems measuring physical parameters in extreme environments, has operated through its antecedents since 1927 under the name of Ferroperm Piezoceramics, Lodge Ignition, Endevco, Sensorex, ECET, Vibro-Meter and Wilcoxon Research. We provide complete systems from multiple manufacturing sites around the world. Our unique yet wide portfolio includes high technology products and systems for civil and military aerospace and the energy, power generation, nuclear, oil and gas, industrial, laboratory measurement, automotive and space markets.

About CTS Corporation

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.

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 & defence, medical, industrial, communications, information technology, and transportation industries.

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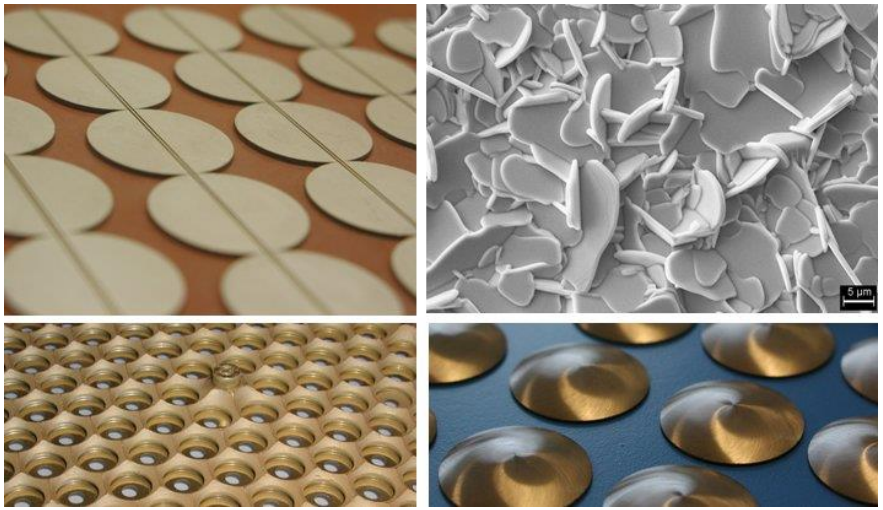
Your Partner in Smart Solutions

PiezoPaint™ Technology



CTS | Ferroperm

Highly active flexible piezoelectric material with ultra-low acoustic impedance

Highly active flexible piezoelectric material with ultra-low acoustic impedance

A new flexible piezoelectric material, PiezoPaint™, has been developed at CTS | Ferroperm primarily with the aim of compatibility with flexible substrates, including textile, plastic, paper etc., and ability to be applied to large areas. The PiezoPaint™ material is compatible with most of the commercial printing techniques available, including pad-, screen-, and stencil printing techniques and requires very low temperatures for curing (< 100 °C).

Nowadays, there are a number of piezoelectric polymer materials available (e.g. polyvinylidene fluoride family materials) that can be incorporated into textile or deposited onto large areas, however, such polymer materials typically show relatively low piezoelectric activity, high production cost, and other technological problems such as limited suitability for commercially available printing techniques.

In addition to having significantly higher sensitivity than PVDF-type polymer materials (piezoelectric charge coefficient d_{33} is more than 40 pC/N), the PiezoPaint™ material has extremely low acoustic impedance and therefore can be used in medical acoustics and other applications, where the acoustical matching is critical. The PiezoPaint™ material is also available in a lead-free version.

Thanks to the specific manufacturing technique developed, PiezoPaint™ combines high piezoelectric activity, flexibility in the cured state, and compatibility with most of the commercially available printing techniques. This opens new opportunities for the next generation of devices, including MEMS, for applications in a wide variety of fields, such as safety, health, non-destructive testing, structural health monitoring, and underwater acoustics.

Preliminary material specifications

Main characteristics of PiezoPaint™ material (preliminary, in a cured state) represent:

	Symbol	Unit	**PiezoPaint™**
Electrical Properties			
Relative dielectric permittivity[1)]	$K_{33}{}^{S}$		100
Dielectric dissipation factor (1 kHz)[1)]	tan δ	10^{-2}	2.5
Curie temperature (ceramic phase)	T_C >	°C	330
Recommended working range[2)]	<	°C	80
Electromechanical Properties			
Coupling factor, thickness	k_t	%	8.2
Piezoelectric charge coefficient[1)]	d_{33}	pC/N	45
Piezoelectric charge coefficient[1,2)]	d_{31}	pC/N	15
Frequency constant, thickness	N_t	Hz m	1410
Mechanical Properties			
Acoustic impedance	Z_a	MRayl	13.9
Density	ρ	g/cm³	5.0
Young's modulus[2)]	E	GPa	29
Poisson's ratio	ν		0.3

1) Semi-clamped, in the case of films printed onto alumina substrate.

2) Estimated value, under evaluation

Joint development of next generation of ultrasonic products

PiezoPaint™ material opens totally new opportunities in developing next generation of ultrasonic products for variety of applications.

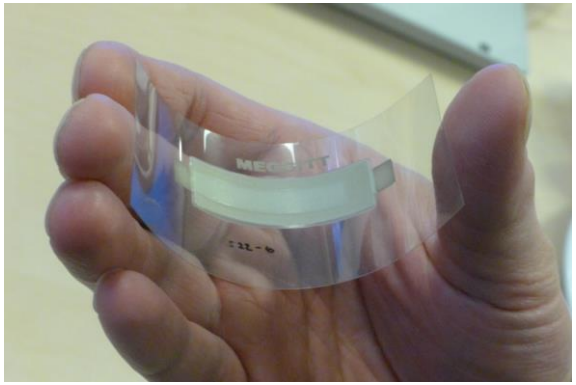
Since it requires joint development with potential end-users, we are open for collaboration with end-users, bringing the new products to the market together.

As a part of such development we also offer free test samples of PiezoPaint™ material. Test samples represent a round sandwich type structure, with silver top and bottom electrodes, and active PiezoPaint™ layer in between. The structure is printed on polyester substrate of 25 mm x 25 mm and 125 μm in thickness. A diameter of an active element is 6 mm.

PiezoPaint™ based test sample printed on Polyester substrate

Wide variety of applications

PiezoPaint™ material being compatible with variety of different substrate materials is suitable for a wide variety of applications, including Broadband Non-Destructive Testing (NDT), Structural Health Monitoring systems (SHM), Smart textiles, Medical ultrasound (therapeutic and imaging), and Underwater acoustics. You can find some of the examples below:



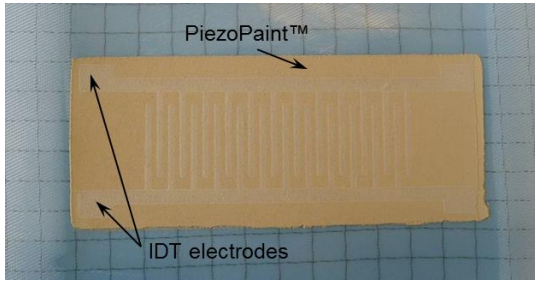
PiezoPaint™ based patch printed on Polyester substrate

Smart Textile

Smart textile materials become more and more popular nowadays and are widely used in various areas, allowing incorporation of built-in technological elements into everyday textiles and clothes. Development of new materials such as PiezoPaint™ material opens a new opportunity for smart textiles by incorporating active devices such as buzzing elements or motion sensors into the garments.

A number of prototypes, including the piezoelectric buzzers and motion sensors have been fabricated by CTS | Ferroperm on the basis of flexible PiezoPaint™ materials, printed onto different textiles.

The results obtained clearly show that the functional piezoelectric materials such as PiezoPaint™ that are compatible with textile production open new prospects in terms of developing intelligent clothing and smart garments.



PiezoPaint™ based motion sensor printed directly onto the lab coat (Polycotton)

Structural health monitoring (SHM)

Ultrasonic techniques are known to be very powerful and versatile for non-destructive testing of structural components. An ability to print PiezoPaint™ material directly onto aircraft wing and cover relatively large areas significantly simplifies an integration of modern SHM systems with aircraft structures. Such system, based on PiezoPaint™ material and imbedded into e.g. helicopter's tail boom or airplane's wings, allow: impact detection and localization at large areas; monitor the structural integrity (cracks, delamination of airplane covering etc.) and localization of the problems; reduce weight, reduce assembly cost, ability to cover large areas.

In recent years the use of composite materials based on CFRP (carbon-fibre reinforced polymer) has increased dramatically in the aerospace industry. Thanks to low curing temperature, PiezoPaint™ material is compatible with such structures as well and therefore can be deposited directly onto the CFRP structure, without compromising the properties of the structure.

We have successfully validated a feasibility of SHM system on the basis of PiezoPaint™ technology. PiezoPaint™ based distributed network of sensors has been demonstrated for the case of aluminum and CFRP structures, showing an ability of such system for impact detection and localization (*see Ref: K. Elkjaer et al., Integrated Sensor Arrays based on PiezoPaint™ for SHM Applications, Annual Conference of the PHM Society 2013 (PHM13), LA (USA), 14 October 2013*)

PiezoPaint™ based distributed network of sensors printed onto CFRP plate

Medical ultrasound

PiezoPaint™ material can be utilized for a number of applications in the field of medical ultrasound, including smart bandage (with active elements, helping the healing of wounds and/or penetration of the medicines into the wounds), auto sterilization uniform, active monitoring underwear etc. Thanks to the low acoustical impedance of PiezoPaint™ material, it is also simpler to do acoustical matching when developing ultrasonic transducers based on PiezoPaint™ technology in comparison with regular piezoelectric materials.

PiezoPaint™ material will be also available in the form of lead-free material that is biocompatible. This version of PiezoPaint™ material is currently under development.