Reducing Time to Market for Critical Medical Ultrasonic Sensors & Transducers

Ultrasonics is a powerful technology for medical devices with unique benefits in critical patient applications. In order to design new, innovative ultrasonic sensors and transducers the use of advanced multi-physics numerical computer modelling is advised. These modelling tools depend heavily on repeatable fundamental piezoceramic material properties to avoid designing by a trial-and-error approach.

Plochingen, August 2023 – Piezoceramic material and mechanical properties need to be kept under surveillance through tight quality control of incoming raw materials as well as the many process steps involved in going from powders to finished machined ceramic. A lack of control in the design process or in piezoceramic manufacturing will ultimately lead to increased product development times and costs as well as in ultimate unit costs when the product is released for volume production.

Growing Use of Ultrasonic Technology for Medical Applications

Ultrasonic technology has become pervasive in the medical devices market from surgical instruments to nebulisers to hospital and home dialysis machines. Ultrasonics is used for both diagnostic applications such as ultrasound imaging as well as therapeutics, including HIFU (high intensity focused ultrasound) which is reported to reach $486M in market size by 2027. The largest single market for ultrasonic technology is ultrasound imaging which had a market size of $7.9Bn in 2021 and is projected to grow to $14.5Bn by 2030. Another key growth market is ultrasonic electrosurgical instruments which had revenues of $3.86Bn in 2021.

Ultrasonic technology is widely used in haemodialysis and peritoneal dialysis. In the USA, according to the CDC one in seven adults is affected by chronic kidney disease. Home dialysis is also becoming a key growth area, as according to WHO the world's population aged over 60 will reach 2 billion by 2050 from 900 million in 2015. Ultrasonic technology is particularly powerful for fluid management in medical equipment and is often the preferred solution in medical applications over optical, mechanical or a capacitive sensing technology.

Why Numerical Computer Modelling in Ultrasonics is important

Ultrasonic devices are based on piezoelectric materials, a ceramic material which has the ability to generate an electric field in response to a mechanical stress and vice versa. Piezoelectric components are typically operated in

resonant mode as this is the frequency that electrical energy is most efficiently converted into mechanical energy. However, when exciting piezoelectric plates and discs into resonance a number of different resonant modes can be created in the mechanical system. Therefore, computer modelling is essential to optimise the desired resonance mode and discriminate against other resonances. A multi-physics approach to numerical modelling needs to be taken as for example an ultrasonic transducer assembly will consist of piezoceramic discs as well as metal or plastic components. Therefore, the use of the latest numerical computer modelling software is a key element of reducing product development times for ultrasonic sensors and transducers. The modelling must take into account the different domains involved – electrical signals, piezoelectric effects (conversion of electrical signals into mechanical stress) and the thermo-mechanical behaviour of the entire mechanical system.

All of these parameters will be dependent on the piezoceramic manufacturing process itself. Computer models not calibrated against manufacturing performance will increase product development lead times as a trial-and-error approach would have to be used rather than accurate modelling and first-time success.

Control of Piezoceramic Materials and Manufacturing plays a key role

Piezoceramic materials are complex mixtures of powders, binders and additives that are fine tuned to give the desired performance in terms of component piezoelectric sensitivity, capacitance, dielectric losses, and power handling. Lead zirconate titanate (PZT) is the most commonly used piezoceramic for electronic applications. PZT materials offer good sensitivity and temperature performance as well as being mechanically robust for a wide variety of electronic applications for markets including medical, automotive, industrial and defence. The manufacturing process to create PZT plates, cylinders and discs consists of many steps. These include grinding, sintering, shaping and machining, firing at elevated temperatures (above 1000°C), metallization to form electrodes, and high voltage polarization to enable piezoelectric behaviour. The purity and control of raw materials is critical as well the mixing of materials to enable the correct final ceramic material homogeneity and morphology.If proper control is not maintained over these manufacturing steps or the incoming raw materials, a significant variation in piezoceramic performance will be observed. The resultant effect would be increased manufacturing costs due to lower process yields. Ideally, an ultrasonic sensor or transducer supplier to the medical market should have complete control of the product process from modelling/design to piezoceramic manufacture to product assembly and test to final mass production.

Picture material
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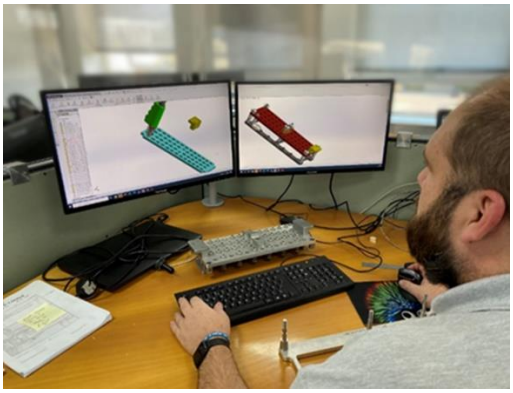
CeramTec_Ultrasonic Pic 1.jpg
Ultrasound technology is ubiquitous in the medical device market – from surgical instruments to nebulizers to dialysis machines for use in hospitals and at home.
Source: CeramTec

CeramTec_Ultrasonic Pic 2.jpg
Ultrasound technology is often the preferred solution medical applications over optical, mechanical or capacitive sensor technology.
Source: CeramTec



CeramTec_Ultrasonic Pic 3.jpg
The use of numerical multiphysics computer models enables rapid development of ultrasonic sensors and transducers.
Source: CeramTec

CeramTec_Ultrasonic Pic 4.jpg
Piezoceramics can be manufactured in a variety of shapes, including discs, plates, domes and cylinders, depending on the specific medical application.
Source: CeramTec

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About CeramTec

CeramTec is a leading global med-tech platform with a focus on highperformance ceramics ("HPC") solutions, and is specialised in the development, manufacturing and sale of parts, components and products made from ceramic materials. With over a century of developmental and production experience in the HPC industry, CeramTec is a global leader in the manufacturing of advanced ceramics and engineers these materials for use in a wide variety of applications. HPC from CeramTec are used in a range of areas, including critical medical applications such as hip replacements, other orthopaedic implants, dental implants and medical equipment, and industries including mobility, electronics and also in other industrial applications. As of September 30, 2021, CeramTec's portfolio comprised over 200 trademarks and over 600 patents, along with a wide variety of ceramic materials. With production sites and subsidiaries in Europe, North and South America as well as Asia, CeramTec maintains its presence around the globe as a manufacturer and supplier. CeramTec is headquartered at Plochingen, near Stuttgart (Germany).

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