Powerful Drive Elements from Piezoelectric Materials: Future Technology in Medical Engineering

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Demands on components increase with the advancing miniaturization in medical engineering. However, an important prerequisite for such advancement is the choice of the matching drive. Piezo-based drive solutions have thrived for quite some time in the semiconductor, biotechnology, and metrology industries. In addition, piezo-based drives are being used more often in medical engineering. Piezo elements and piezo actuators are ideal for medical applications because they generate linear motions very precisely without detours, and they are easily matched to the relevant application environment. Their small size means that not only laboratory applications can be realized, but also an increasing number of mobile solutions, be it in mobile measuring instruments, portable laboratories, infusion devices, or therapeutic equipment.

Precision and Reliability: Piezoceramic Diversity

Piezo [1] ceramic actuators and drives have many characteristics that make them suitable for a wide range of common methods in medical engineering. For instance, they are fast, compact, vacuum compatible, and unaffected by magnetic fields. Their reliability, long working life, and low energy consumption make them the ideal drive for medical engineering. Although size and force, along with actuator travel and position resolution vary depending on what is required, many positive properties are apparent. For instance, Piezo actuators are maintenance-free due to a lack of moving parts. Instead, the motion is based on crystalline solid-state effects, meaning there are no mechanisms to rotate or produce friction.

Active ceramic components,including piezoceramic sensors and actuators, are now frequently used in medical engineering as ultrasonic generators in dentistry and for laser beam control in ophthalmology, dermatology, or cosmetics. PI Ceramic, Lederhose offers a wide range of piezoelectric components in numerous shapes that are both standard and custom-made. Also available are piezo actuators with and without preload in different sizes (Fig. 1), which have already been tested in numerous applications.

Figure 1: Piezo elements from PI Ceramic. Since a wide variety of different designs can be produced, a customized solution can be found for almost every application.

Efficient Aerosol Production with Piezo Elements
The treatment of respiratory diseases often involves medication being directly applied with atomizers. Conventionally, pressurized air atomizes the inhalation solution into minute droplets. An alternative method is to generate minute droplets with the aid of piezo technology. Specially shaped piezo disks act as ultrasonic transducers, and provoke a stainless-steel diaphragm with several thousand holes to execute ultrasonic vibrations at more than 100 kilohertz, producing homogeneous aerosols. The production is advantageous for precise dosing since the administration of high-quality drugs can be better targeted, allowing access to new therapeutic concepts. Not only are side effects reduced, but piezo technology also decreases the time required to atomize medications by up to 50% compared to conventional systems. Consequently, there is an increase in the quality of life, especially for patients with chronic respiratory diseases.

The special hygiene requirements that come with medical engineering applications are performed by piezo ceramics, and the aerosol generators can be professionally sterilized in autoclaves. Furthermore, the ultrasonic operation is noiseless for humans, while the low power consumption of the piezo component also allows battery operation.

Piezoelectric Drives in Microfluidics
Although it is not simple to precisely target the dosing of miniscule amounts and volumes of a few microliters or nanoliters, micropumps or microvalves, also called microdispensers can help. Piezo elements or piezo actuators make ideal pump drives; accurately generate the linear motions required, and can also be matched to the relevant application environment.

Micro-diaphragm pumps are used to transport liquids or gases, which are separated

from the drive by a diaphragm. The drive, therefore, cannot exert any adverse effects on the pumped elements. Highly dynamic and disk-shaped piezo elements are mounted directly onto a metal diaphragm, and lend themselves to the miniaturized version of the of pump.

Typical specifications for the dosing of liquids in micro-diaphragm pumps are a flow rate up to 80 ml/min at switching frequencies between 25 and 120 Hz, along with a potential back pressure between 200 and 500 mbar. When dosing gases, the values are between 0.1 and 250 ml/min, 100 to 500 Hz, and 100 mbar. Therefore, the possible applications cover a broad spectrum, ranging from laboratory technology to medical engineering, through which they can be used in analyses for the transport of reagents. They can also be utilized in the removal of reaction gases, via chemistry and pharmaceuticals right to mechanical engineering, in which lubricants or coolants can be accurately applied.

Their compact dimensions also make these dosing devices suitable for lab-on-a-chip applications. Reliable analyses with very small amounts, in research or routine on-site investigations, for example, can be carried out quickly and safely.

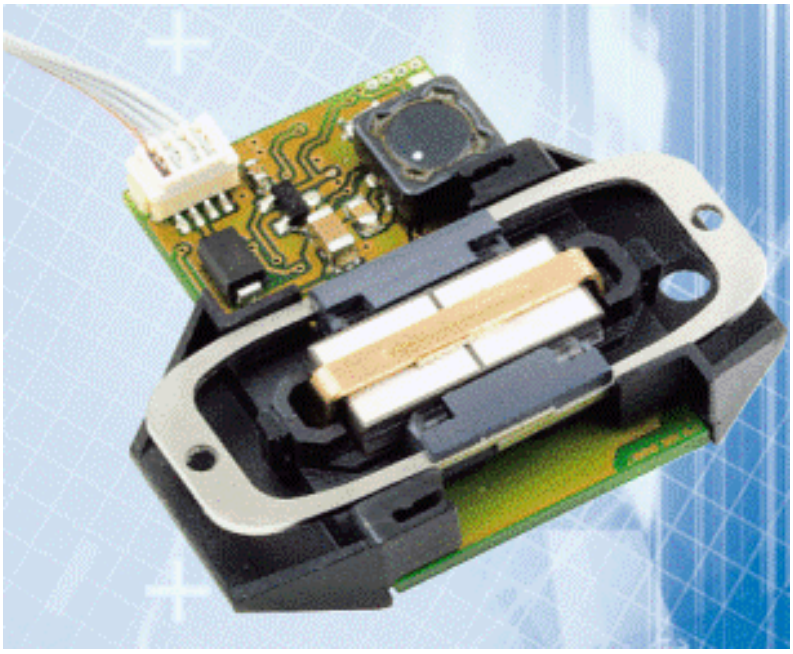

Figure 2: Fully functional even on the smallest space: The miniature piezo motor is directly mounted on the board of the drive electronics, with exceptional performance characteristics: 100 mm/s velocity, 4 mm travel range, 0.7 N force at minimal power consumption

Ultrasonic Microdrives for Dosing Valves

Dosing tasks cannot only be carried out with conventional diaphragm pumps; in fact, microvalves are preferred when more viscous liquids requiring higher forces have to be dosed. Depending on the drop size and the required diaphragm displacement, they can be driven directly with piezo actuators or by means of

levered systems.
As an alternative, piezo motors can take on dosing tasks. The motors offer all the advantages of piezo technology, including low space requirement and energy consumption, which are combined with the longer travel range of a linear motor. Moreover, the drive does not need to be supplied with power to hold its position. Consequently, it does not produce heat, and it has no positional jitter.
Although ultrasonic miniature motors measure only a few millimeters or centimeters, they are especially suitable for microdosing. As a tried and tested positioning system with a moving part directly driven by an oscillating ceramic, the motor thus fits into almost any installation space (Fig. 2). In addition to dosing tasks, the robust miniature motor is ideally suited for mechanical manipulations of any type, the positioning of small objects, and the operation of switches.

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