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Piezoelectric ceramics

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Piezo-composites composed of a piezoelectric ceramic and polymers are promising materials because of their excellent tailorable properties. The geometry for two-phase composites can be classified according to the connectivity of each phase (1, 2 or 3 dimensionally) into 10 structures; 0-0, 0-1, 0-2, 0-3, 1-1, 1-2, 1-3, 2-2, 2-3 and 3-3. In particular, a 1-3 piezo-composite, or PZT-rod / polymer-matrix composite is considered most useful. The advantages of this composite are high coupling factors, low acoustic impedance, good matching to water or human tissue, mechanical flexibility, broad bandwidth in combination with a low mechanical quality factor and the possibility of making undiced arrays by simply patterning the electrodes. The acoustic match to tissue or water (1.5 Mrayls) of the typical piezo-ceramics (20-30 Mrayls) is significantly improved when it is incorporated into such a composite structure, that is, by replacing some of the dense and stiff ceramic with a less dense, more pliant polymer. Piezoelectric composite materials are especially useful for underwater sonar and medical diagnostic ultrasonic transducer applications. In this presentation, other types of composites based on piezoelectric ceramics are also introduced. Piezoelectric energy harvesting devices comprised of 'Cymbal' have been applied for the engine vibration suppression and 1 W level energy harvesting in practice; while piezo-passive-dampers are comprised of a piezoelectric ceramic particle, polymer, and a carbon black, which suppress the noise vibration more effectively than traditional rubbers. Another type of composite with a magneto-strictive ceramic and a piezoelectric ceramic produces an intriguing product effect, the magnetoelectric effect in which an electric field is produced in the material in response to an applied magnetic field.

Recent Publications

1. S Nomura and K Uchino (1982) Crystal structure and physical properties of complex perovskite oxides. Solid State Phys. 18(2):71-86.
2. K Uchino (2010) The development of piezoelectric materials and the new perspective. Chapter 1, Advanced Piezoelectric Materials, Woodhead Publishing series, Cambridge, UK 1-85.
3. Li X, Schwacha M G, Chaudry I H and Choudhry M A (2008) Acute alcohol intoxication potentiates neutrophil-mediated intestinal tissue damage after burn injury. Shock 29(3):377-383.
4. J Kuwata, K Uchino and S Nomura (1982) Dielectric and piezoelectric properties of 0.91Pb $(Zn_{1/3}Nb_{2/3})O_{3-0.09}PbTiO_3$ single crystals. 21:1298-1302.
5. K Uchino (2014) Piezoelectric actuator renaissance. J. Energy Harvesting and Systems 1(1-2):45-56.

Biography

Kenji Uchino is the pioneer in "piezoelectric actuators", is the Founding Director of International Center for Actuators and Transducers, Professor of EE and MatSE, and Distinguished Faculty of Schreyer Honors College at The Penn State University. He was the Founder and Senior Vice President of Micromechatronics Inc., State College, PA from 2004 till 2010, and Associate Director at Office of Naval Research-Global from 2010 till 2014. After his PhD degree from Tokyo Institute of Technology, Japan, he became Research Associate in 1976 at this university. Then, he joined Sophia University, Japan as an Associate Professor in 1985. He was recruited from The Penn State in 1991. He has authored 570 papers, 75 books and 31 patents in the ceramic actuator area. 48 papers/books have been cited more than 100 times, leading to his average h-index 70. He is the Fellow of American Ceramic Society and IEEE. He is currently the IEEE UFFC Distinguished Lecturer.

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