Advances in Piezoelectric Materials for Sensing and energy applications

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Recent advances in piezoelectric materials include submicron grain size ceramics and improvement in specific properties. $Pb(Zr,Ti)O_3$ (PZT) ceramics with submicron grain sizes (~ 0.5 μm) have been fabricated with properties comparable to conventional, coarse grained (~ 3 to 5 μm) ceramics. The fine grain ceramics exhibit improved electro-mechanical properties, thermal and electrical stability. An attempt has been made to fabricate sensor elements and evaluate for structural health monitoring and underwater transducer applications. The yields and performance for such applications are found to be better with fine grain ceramic than with conventional materials.

The current generation of vibration sensor structures featuring piezoelectric materials is generally fabricated with PZT based materials with higher sensitivity. The sensor structure will easily accomodate embedded piezo sensor components, mechanical elements and electronic circuits. When the sensor experiences external force/accleration, the mass is displaced and the relative strain in piezo material gives information of the excited acceleration in the form of voltage or charge signals. Wide frequency response, good linearity and higher sensitivity are the vital parameters of piezoelectric based vibration sensors. Presently, worldwide defence researchers are focusing on power sources for weapon applications. Especially on self power needs during the flight for electronic fuzing applications. It reduces the dependence on the battteries and increases the shelf-life of the amunition.

Another captivating area which has gained attention is ferroelectric materials for pulse power generators. Ferroelectric energy storage ceramics are of recent interest for explosively driven compact power supplies. PZT 95/5 ferroelectric ceramics along with minor additions of Nb or Ta has been studied to enforce a ferroelectric to anti-ferroeelctric phase transition driven by explosive shock wave. Structural and electrical properties of PZT 95/5 ceramics will be discussed in comparison with existing conventional materials. Because of the significant energy storage capabilities of the material, 200-500 kilowatts of power will be genrated during phase transition in a short period of time. These materials will be integrated into a new class of electromagnetic pulse weapons designed to damage electronics across significant ranges.

Biodata

Dr. Praveen Kumar B, is a Scientist working in Centre for Functional Materials, Young Scientist Centre, ARDE Pune. Over the past 15 years he has been working in DRDO, in the field of Processing and characterization of various Piezomaterials and its related devices. His current research interests are Advance functional materials, Organic ferroelectrics, porous ceramics and sensor devices. He earned his B.E. from NIT Trichy and Ph. D. from IIT Madras, in the field of Sensor materials and devices. He has published about 20 papers in peer reviewed journals and about 15 papers in conference proceedings. He has been awarded DRDO Young Scientist Award recently.