(353)

Development of High Temperature Capable Piezoelectric Sensors

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Transducer technology is an in-demand resource particularly in the fields of ultrasonic non-destructive evaluation (UNDE) and structural health monitoring (SHM). For years, transducers have been used to characterize various types of materials, ranging from metals to composites and even organics as well as to establish the integrity of structural components such as bridge struts, subterranean pipelines, and vehicle bodies. Transducers can even be used to find defects, cracks, delaminations, etc on the micro- and nano-scales. Most of these processes occur at room temperature or only slightly elevated temperatures (<100 ^{o}C). This means that the physical components have little to fear from the stress and strain of thermal expansion as well as the process of oxidation. However, when higher temperature (>400 ^{o}C) capabilities are necessary, only a select few piezoelectric materials can make the cut. The piezoelectric material must be combined with the right components from the casing, to the waveguide, to the coupling, to the matching layer, as well as the backing material and work together cohesively with a lead wire to produce the most consistent acoustic signals and data possible for their particular application.

The objective of the project is to investigate the influence of the temperature effect on ultrasonic transducers based on a comparison of the effects of high temperature conditions versus those of high temperature and irradiation on the transducer system. There will also be a preliminary move towards the establishment of the means for optimizing the bulk single crystal transducer fabrication process in order to achieve peak efficiency and maximum effectiveness in both irradiated and non-irradiated high temperature applications. Optimization of the material components within the transducer will greatly increase non-destructive testing abilities for industry, structural health monitoring, and so much more.

Here is presented a progress report on the testing several different piezoelectric materials under high temperature conditions. The viability of aluminum nitride (AlN) as a transducer material in high temperature conditions has been previously explored (Parks, et al, 2010) and has been further tested to ensure reliability. Bismuth titanate (BiT) has been tested and has displayed excellent effectiveness for high temperature application. Zinc oxide (ZnO) will also be explored as it has shown promising results in the past.

Acknowledgements:

I would like to thank Pennsylvania State University for providing funding and materials for this project.

Reference:

1. D. A. Parks, Tittmann, B. T., Kropf M. M., “Aluminum Nitride as a High Temperature Transducer”, AIP Conf. Proc. 1211, 1029 (2010).