Optimization of a Novel Transducer Design for a Pavement Embedded Energy Harvesting Application

G. Yesner[1*], A. Jasim[2], H. Wang[2], B. Basily[2], A. Maher[2], and A. Safari[1]
[1]Department of Materials Science and Engineering, Rutgers University
607 Taylor Rd, Piscataway, New Jersey, 08854
[2]Department of Civil and Environmental Engineering, Rutgers University
96 Frelinghuysen Road, Piscataway, New Jersey, 08854
[*]Gregory Yesner: gyesner@gmail.com

Non-resonant sources of mechanical energy, such as the stress induced in pavement from the loading of a vehicle, can be harvested using a novel piezoelectric transducer. The challenge of capturing the energy from this type of loading is matching the elastic modulus of the piezoelectric transducer to that of the road surface in order to facilitate efficient transfer of stress into the piezoelectric. Transducers such as the cymbal have medium stiffness and can be further fine-tuned to match the stiffness road surface by changing the end cap material and geometry.

A novel transducer was designed utilizing a unique electrode pattern that enabled the square ceramic plate to be poled along the length (Figure 1). The new transducer is a rectangular version of the cymbal transducer, also known as a bridge transducer due to its shape (Figure 2). Use of steel end caps greatly enhanced the effective d_{33} coefficient to (19,000pC/N), which is double the value of the conventional poled transducer.
Transducers of the new design were fabricated and used to prototype a piezoelectric generator. A module containing 64 transducers was assembled and loaded with a force comparative to a small vehicle using a pneumatic loading system specially build for that purpose, which can repeatedly apply a load of up to 800lb at a frequency up to 5Hz to simulate traffic. The piezoelectric generator embedded in the pavement of a road would be an excellent source of power for off-grid sensors and electronics.

In this work, optimization of the novel bridge transducer will be investigated through modification of the electrode design, end cap shape, and physical parameters. FEA will be implemented to maximize energy output within the failure stress criteria through variation of transducer/endcap shape and geometry. The electrode pattern can be optimized for energy-harvesting application to increase effective d_{33} as well as the capacitance in order to increase the output current of the transducer. Reducing the electrode width and the inter-electrode spacing, in order to pack more electroded segments, will increase output energy. However, poling the ceramic using surface electrodes becomes less effective as the inter-electrode spacing decreases.

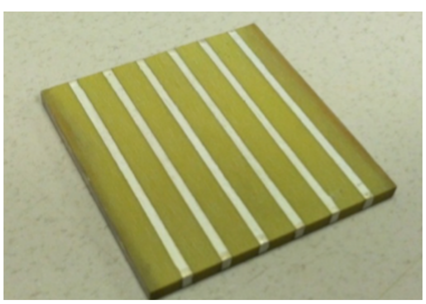

Figure 1. Square PZT plate (32 x 32 x 2 mm) with six 1 mm thick surface electrodes.

Figure 2. Novel bridge transducer.