4CF14-2014-000132

Abstract for an Invited Paper
for the 4CF14 Meeting of
the American Physical Society

Development of Mid-Audio Thermoacoustic Energy Converter

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Mid-audio frequency thermoacoustic energy conversion shows much promise for a variety of applications where heat is converted to electricity. Recent developments of such devices have dealt with issues of tuning, array configuration, interfacing with heat source, and general optimization for raising the power output. In devices presented here, heat or waste heat is converted to sound when a sufficiently large temperature gradient is developed along a large surface area unit, called the stack, and it is located inside a quarter wave resonator. The heat-generated sound is coupled to an acoustic cavity where a piezoelectric device converts the sound to electricity. Operating at one atmosphere of air in the audio to ultrasonic frequency range of 2 kHz to 24 kHz, the quarter wave resonators are about 4 cm to 3 mm in length. Conversion of sound to electricity is by a PZT piezoelectric unimorph device. The electric load is either a resistor, or a set of LEDS, or a supercapacitor. Important issues that were addressed and studied were the tuning of the piezoelectric device to the heat engine (both are resonant systems), thermal coupling of the device to the source of heat (constant temperature or constant temperature temperature difference), impedance matching of various components, and synchronization for array configuration. The latter development is important because the devices are small handling relatively small powers even though they have high power density; synchronized multiple units provide considerable increase in power output. This has also led to the development of units operating in the ultrasonic range with heat engines volumes as small as 2.7 cubic millimeters. Although typically the power of a single unit has been low, a few milliwatts, all the fine tunings presented above have led to the development of heat to electricity converters which have significant power output.