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論 文 内 容 の 要 旨
Abstract of Dissertation

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Nowadays, energy harvesting methods are being developed from natural renewable energy resources owing to the demand for sustainable energy. Especially, piezoelectric, triboelectric, and pyroelectric nanogenerators that convert thermal and mechanical energies could be produced by adding a small-scale physical change into electricity with the usage of digitally enhanced applications.

A novel electro-thermodynamic power generation method that uses Diode and two Switches circuit (DSW circuit) with higher power generation is more efficient than the Olsen electro-thermodynamic cycle method. The temperature differences and the behavior of the external electric field are very important parameters to optimize the amount of generating power. Therefore, the purpose of this study is to improve pyroelectric power generation by using waste heat energy as a renewable energy source in combination with pyroelectric nanogenerators and an external pulse electric field. Under optimal conditions, the maximum power can be accumulated by applying different pulses of the external electric field at temperature variations on the surface of the pyroelectric body since there is no reported pyroelectric power generation experiment in any materials. The experimental process is performed for measuring and calculating to power generation of the pyroelectric body using a newly developed experimental setup based on the modified DSW circuit.

A standard Fuji ceramic C-9 sample was employed to generate pyroelectric power in an environment with continuous temperature variation from low (120 °C) to high (140 °C), with a temperature difference of 20 °C. The continuous temperature variation frequency was 0.05 Hz, and the pulsed electric field was applied when the temperature rose. The pulse width of the electric field 10, 20, 50, 100, and 200 ms pulses were applied to the sample under single pulse and multi-pulse conditions. And the amplitude of the pulses was 250, 500, 1000, and 1500 V/mm. Finally, the maximum power generation condition was evaluated by comparing single-pulse and multi-pulse trains.

The maximum power generated through the application of an external pulsed electric field under the above conditions was evaluated. Finally, a technique for generating pyroelectric energy was devised by applying a pulsed electric field using a pyroelectric body. This power production system had the highest power density of 0.204 mJcm-2°C-1kV-1 in the C-9 sample. Also, for the lowest input power, the maximum power generation condition was a 10 ms pulse width and an amplitude of 250 Vmm-1 in the applied electric field. When applying the multi-pulse to the sample, the power generation density was maximum for the

highest number of pulses at the low voltage (250 V/mm) input of the pulse electric field. Furthermore, all the results showed that the power generation rate decreased as the pulsed electric field input voltage rose. The greatest power generating capability ratio (η) value for a 250 V/mm pulse electric field was 7.834 at the highest number of pulses. The results show that the η ratio is greatest for a high number of pulses in a low voltage (250, 500 V/mm) input pulsed electric field. Finally, it was determined that a multi-pulse electric field might enhance the performance of the pyroelectric power generating system.

Consequently, this condition might be used to power smart sensor modules, Internet of Things devices, automobiles, and other waste heat energy applications. When the sample is subjected to nano-pulse electric field application, the input power may be lowered to its lowest level depending on the net-producing power. As a result, new researchers can exploit the net-generation power efficiency to develop a large-scale power generation source employing several arrays of pyroelectric materials.