A MEMS Electroquasistatic Induction Turbine-Generator

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Presented here is a microfabricated electroquasistatic (EQS) induction turbine-generator that has generated net electric power. A maximum power output of 192 µW was achieved under driven excitation. We believe that this is the first report of electric power generation by an EQS induction machine of any scale in the open literature. This work forms part of a program at MIT to fabricate a MEMS-scale gas turbine-generator system. Such a system converts the enthalpy of combustion of a hydrocarbon fuel into electric power. For even modest efficiency levels of the gas turbine engine cycle (10-15%), a small gas turbine would be a portable energy source with higher energy density than the best batteries available [1]. In MIT’s device, this small engine provides the shaft power needed to drive a small electric generator. Although magnetic machines are preferred at large scales, EQS machines become attractive at small scales, primarily because very small airgaps between the rotor and stator allow higher breakdown electric fields of approximately $10^8$ V/m. The generator comprises five silicon layers (Figure 1) fusion bonded together at 700°C. The stator is a platinum electrode structure formed on a thick 20 µm recessed oxide island. The rotor is a thin film of lightly doped polysilicon also residing on an oxide island, which is 10 µm thick. We also present a generalized state-space model for an EQS induction machine that takes into account the machine and its external electronics and parasitics. This model correlates well with measured performance, and was used to find the optimal drive conditions for all driven experiments. Figure 2 shows the results of an experiment under driven excitation. In this particular experiment, 108 µW was generated at 245krpm. Good correlation with the models is observed. In other experiments, self-excited operation was attained. In this case, the generator self-resonates and generates power without the use of any external drive electronics [3].

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