Piezoelectric PZT thin-film transformers with a ring-dot structure

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A transformer is one of the indispensable devices in the electric circuits to adjust the operation voltage from the power source. Particularly, the piezoelectric transformers have been attracting technical interests since they are known to be feasible in small-sized applications and simultaneously to exhibit high power densities. Several types of piezoelectric transformers have already been produced as commercial products. However, because they are composed of bulk ceramics, size and weight are still too large to be integrated into microdevices. In order to achieve the requirements as a component in microdevices, it should be precedent to manipulate the materials which have been utilized in the devices into thin-film figuration.

In this study, we present modeling, fabrication, and characterization of ring-dot structured piezoelectric thin-film transformers (PTFTs). The PTFTs were composed of PZT thin films on Si, which is possible to downsize significantly by microfabrication techniques as demonstrated in figure 1. Through the processes, PTFTs with the dimensional parameters that we modelled, were prepared (figure 2). Meanwhile, from the devices above, it was found that resonance frequencies definitely exist as predicted from FEM simulations. At those resonant points, the performances as a transformer such as voltage gain and conversion efficiency were evaluated (figure 3). Furthermore, calculated conversion efficiencies based on the equivalent circuit analyses were offered in figure 3, as well.

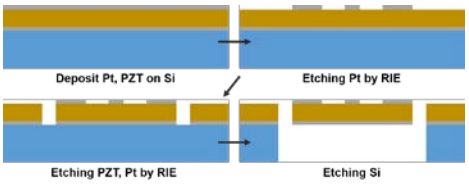

Figure 1. Microfabrication processes for ring-dot structured PTFTs.

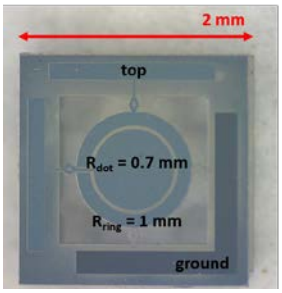

Figure 2. Optical microscopic view of a PTFT device.

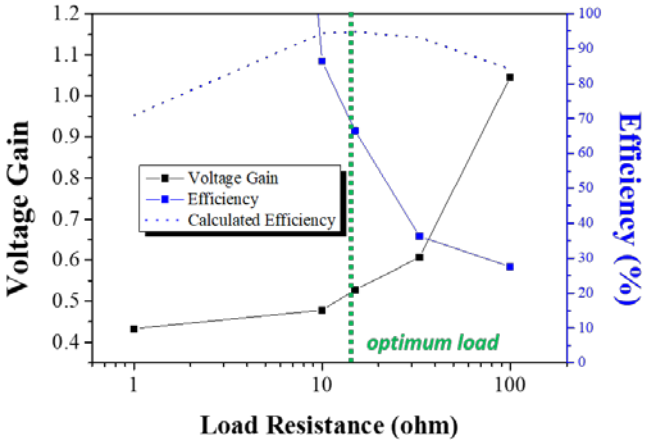

Figure 3. Solid lines represent the experimental results of performances of a PTFT device (voltage gain & efficiency) vs. load resistance. Dotted line indicates the calculated efficiencies based on equivalent circuit analyses. From the calculation, the optimum load was given as 14.9 ohm.