Investigation of MEMS piezoelectric transformer with PVDF thin layer

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Abstract. This paper presents the results of experimental work on the thin piezoelectric polyvinylidene fluoride (PVDF) film, which is used as piezoelectric transformer. The piezoelectric PVDF film was deposited by spray deposition technique on flexible polyethylene terephthalate (PET) substrate and its thickness was measured to be 2 µm. For electrodes is deposited aluminum (Al) by thermal evaporation in vacuum. The voltage gain characteristics were measured at different frequencies. It was observed that at input frequency 1 MHz, the voltage gain characteristic started to decrease.

1. Introduction

Piezoelectric and ferroelectric materials play an important role for Micro-electro-mechanical systems (MEMS) and Nano-electro-mechanical systems (NEMS). They are widely used in many areas of technology and science. Piezoelectrics are a class of materials that can transfer mechanical energy to electrical energy and vice versa. One of these piezoelectric materials is polyvinylidene fluoride (PVDF). This material is very interesting for the engineering applications because of its favorable chemical and mechanical behavior. Properties, such as high piezoelectric coefficient, good flexibility, biocompatibility, low acoustic and mechanical impedance, and light weight, are especially unique for MEMS applications [1]. One of the MEMS applications is as piezoelectric transformer. Piezoelectric transformers convert the parameters of the electrical energy at its output in comparison with the input ones by using acoustic energy. These devices are typically manufactured using piezoelectric ceramic materials that vibrate in resonance. The requirements of minimizing the size and weight of electronic devices have awoken the high potential of piezoelectric transformer in small power range applications [2] and the piezoelectric polymers, like PVDF, are of interest to be used in these applications.

2. Experimental work

2.1 Deposition and obtaining of the sample

The experimental work begins with the choice of the substrate. For preparing of the sample, a substrate of polyethylene terephtalate (PET) was chosen, which is stable at temperatures to 110°C. This feature is necessary for the next deposition steps. On the substrate 200 nm aluminum (Al) bottom electrode was deposited by thermal evaporation in vacuum chamber A400-VL Leybold Heraeus at vacuum level 10^{-5} Torr. The same material and technique are used for obtaining of the top electrode, too (Fig. 1).

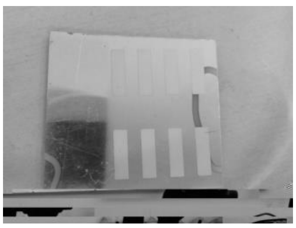

Fig.1 2µm PVDF layer on PET substrate with Al top and bottom electrodes [4]

The thickness of the electrodes was 200nm, measured by Alfastep Tencor 100. The next step, after receiving the bottom electrode, was deposition of thin polyvinylidene fluoride layer (PVDF). The layer is obtained by spray deposition technique. The receiving of the thin PVDF layer was done by experimental setup with atomizer, working with pressure and heater, which heats the samples during the process [3]. The deposition of the PVDF and solved in methyl-ethyl ketone (MEK), is performed by atomizer with possibility to regulate the diameter of the nozzle [3]. The thickness of the received thin PVDF layer was 2µm. The top aluminum electrodes have sizes 3x6mm and they are all equal (4 segments) [4].

2.2 Measuring

Before starting of the procedure, the polyvinylidene fluoride thin layer, deposited on PET substrate was polarized at 3.5V with stabilized DC power supply. The experimental set consists of functional generator, oscilloscope and measuring stand with metal probes and microscope. It is shown in Fig.2. On Fig. 3 it is shown the input and the output voltage signals from the samples, as the input signal is top curve and the output signal is bottom curve.

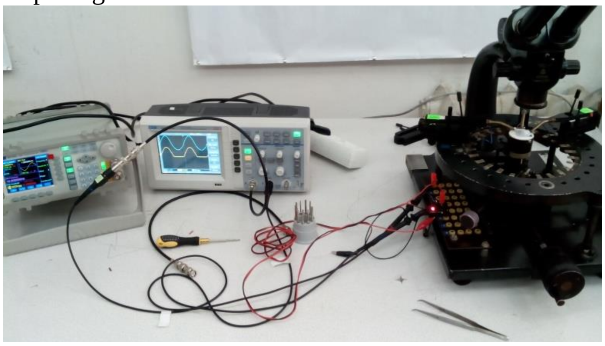

Fig.2 The experimental set

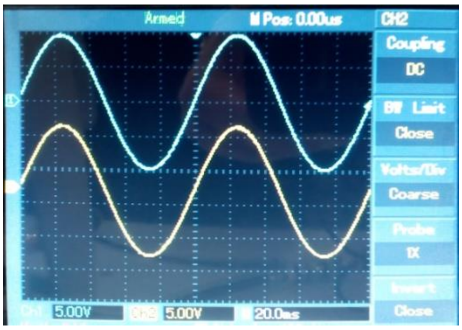

Fig.3 The input and the output voltage signals of the samples.

The functional generator is connected to the common bottom and one of the top electrodes of the sample. This is the input. Next to that, the output is the common bottom electrode and other top electrode. Voltage gain characteristics of the PVDF transformer were measured for different frequencies. During the measurement phase shift between the input and output signals was observed. It occurs at input frequencies higher than 500 kHz. The voltage gain characteristic is shown in Fig. 4.

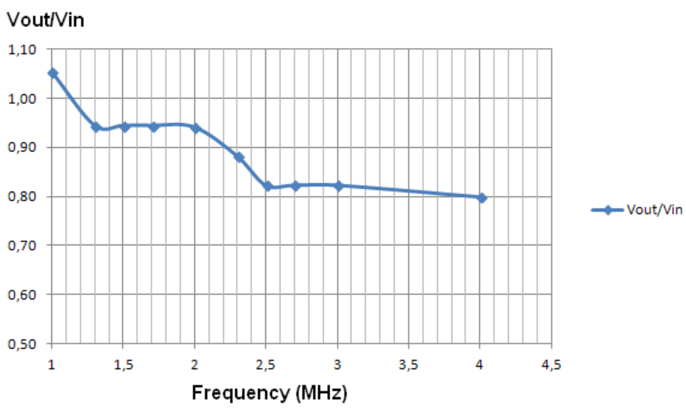

Fig.4 Voltage gain characteristic

3. Acknowledgement

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