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Effect of pre-stressed P(VDF-TrFE) thick film on flexible substrate

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ABSTRACT– This paper evaluates and compare the pre-stressed and non-pre-stressed P(VDF-TrFE) piezoelectric thick film for its electrical properties and sensitivity in sensing applications. The paper covered design of pre-stressed structure, fabrication, measurement of electrical properties and sensitivity of the thick film. The results show the output voltage of pre-stressed P(VDF-TrFE) thick film is higher than non-pre-stressed thick film and more sensitivity in sensing application. As a result of pre-stressed P(VDF-TrFE) thick film show significant of enhancement for electrical properties in energy harvesting applications.

1. INTRODUCTION

Most of the piezoelectric applications fabricated in non-pre-stressed condition where the structure of piezoelectric is flat in shape. Piezoelectric coefficient, d31 can be enhanced using composite material piezoelectric and structure improvement with proof mass or length of the structure. In the recent years, pre-stressed piezoelectric have been reported that possibility of enhancement of piezoelectric coefficient, d31 due to residual stress presence during the fabrication proses For an example of commercial piezoelectric device used pre-stressed structure like THUNDER and RAINBOW for enhancing of piezoelectric performance [1-5].

The aim of this paper to present fabrication of pre-stressed P(VDF-TrFE) thick film and evaluation of pre-stressed and non-pre-stressed P(VDF-TrFE) thick film for the performance of electrical properties and sensitivity of the devices as enhancement mode for piezoelectric energy harvesting applications.

2. METHODOLOGY

In the previous work, the P(VDF-TrFE) thick film was prepared using conventional method where the piezoelectric thick film is non pre-stressed condition during the fabrication process [6]. The pre-stressed P(VDF-TrFE) thick film is a residual stress during fabrication process. Then, the pre-coated bottom electrode of flexible PET substrate was prepared using screen-printed and followed by solution casting method for P(VDF-TrFE) thick film. Once the thick film were cured inside oven for 4 hours to eliminate the residual of solvent. Then, top electrode layer was sandwiched in between the bottom electrode and P(VDF-TrFE) layer before it can be pre-stressed in oven. Figure 1 show pre-stressed method where the device was clamped at two ends of the substrate using custom made stainless steel clamper under oven for 20 mins at temperature of thermal glass, T_g about 60°C so that residual stress can be maintained at the substrate. The radius of curvature of the PET substrate was calculated using Equation (1),

$$r = \frac{h}{2} + \frac{S^2}{8h} \quad (1)$$

where h and S are measured as shown in Figure 2 [7]. In Figure 3 show the final fabricated device for pre-stressed and non-pre-stressed P(VDF-TrFE) thick film.

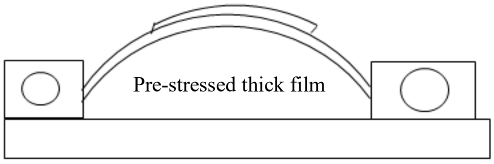

Figure 1 Experiment setup for pre-stressed

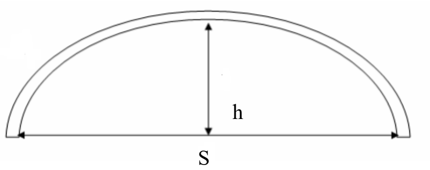

Figure 2 Schematic diagram of curve height

To verify the electrical properties for pre-stressed and non-pre-stressed of P(VDF-TrFE) thick film, the device was mounted in such way that it directly hit by blades of rotating D.C fan motor. The output voltage for both sample were captured using digital oscilloscope and portable digital vibrometer, (PDV-100, Polytec) for the speed of rotational blades as shown in Figure 4.

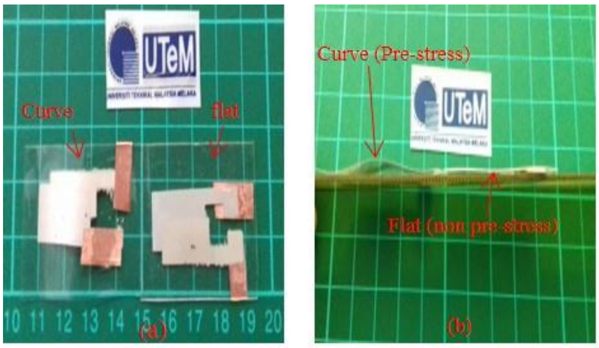

Figure 3 (a) Top view and (b) Side view of fabricated P(VDF-TrFE) device

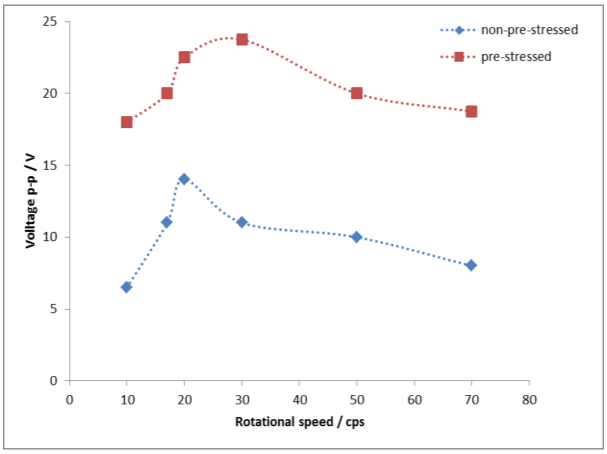

Figure 4 Output voltage of pre-stressed and non-pre –stressed

3. RESULT AND DISCUSSION

The output voltage of pre-stressed thick film show enhancement of output about twice from non-pre-stressed thick film where the maximum voltage peak-to peak of pre-stressed is 24 V whereas the non-pre-stressed was able to generate about maximum voltage of 14V at the optimum speed of blades fan in 20 cps. The pre-stressed thick film has an internal bending force due to the effect of the curvature structure and larger bonding area of PVDF layer which resulted higher strain energy and associated with higher output voltage from the device. Based on these results, the pre-stressed thick film can be generated much higher output voltage than conventional flat thick film as non-pre-stressed which mainly due to internal pre-stress force of the curvature structure.

4. CONCLUSION

The effect of pre-stressed and non-pre-stressed P(VDF-TrFE) thick film have been designed, fabricated and evaluated. The results concluded that the effect of pre-stressed P(VDF-TrFE) thick film show enhancement of electrical properties in terms of output voltage and sensitivity about twice as compared with non-pre-stressed P(VDF-TrFE) thick film. This pre-stressed P(VDF-TrFE) show an alternative solution for structure improvement without complicated composite of piezoelectric material and low-cost fabrication for energy harvesting applications. Future work will be carried out to examine the optimum high of curvature for the pre-stressed fabrication process to obtain maximum the output voltage and good sensitivity in energy harvesting applications.

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