PbTiO3/P(VDF-TrFE) nanocomposites for flexible skin

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I. INTRODUCTION

Large area electronics is mainly driven by the display industry [1]. Advanced technology schemes, like electronic skin for flexible, full body tactile sensors in robotics etc. have emerged recently [2]. In general, large area electronic surfaces consist of a backplane including transistor matrices and a frontplane, giving functionality to the electronic surface. Frontplanes may benefit from functional electrets in memories [3] and in sensors for monitoring changes in ambient pressure or temperature [4, 5].

Here we show that composites of ferroelectric ceramics and ferroelectric polymers can be tailored to exhibit exclusively piezoelectric or pyroelectric responses depending on the poling process applied [6].

Composites of 70/30 Poly(vinylidene fluoride–trifluoroethylene) P(VDF-TrFE) and 30% $PbTiO_3$ nanopowder have been prepared. Poling is performed in a two step process. In the first poling sequence above the Curie temperature of the ferroelectric polymer only the ceramic inclusions are poled. Then the composite is cooled to room temperature under short circuit conditions. With an ac-poling technique, the ferroelectric copolymer matrix is finally poled with an orientation of the polarization vector parallel or antiparallel to the poling vector in the ceramic. Thereby, either piezo- or pyroelectricity is cancelled in the copolymer samples.

The copolymer films serve as frontplane in a flexible electronic surface, based on amorphous silicon or organic pentacene field effect transistors.

II. PROOF OF PRINCIPLE

Bi-functional composite frontplanes have been combined with flexible field-effect transistor backplanes as schematically shown in Figure 1. The sensor elements have been characterized by measuring the drain source current of the field effect transistors, when a pressure signal with an amplitude of ~100 bar is applied, and when a temperature signal with a signal of ~ 10K is applied. The measurements show that the pyroelectric cell is largely insensitive to pressure changes and vice versa.

III CONCLUSION

In summary we have shown that bi-functional composite frontplanes can be combined with flexible backplanes in electronic skin applications for sensing transient pressure and temperature signals.

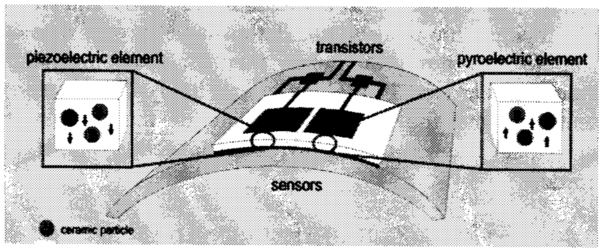

Figure 1: Scheme of a two element sensor array with a bi-functional ferroelectric polymer – ferroelectric ceramic composite and a flexible thin film field-effect transistor backplane.

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REFERENCES

[1] R. H. Reuss, D. G. Hopper, and J.-G. Park, Macroelectronics, MRS Bulletin **31**, 447-454 (2006) and articles on Macroelectronics in this special issue.

[2] A. Bonfiglio, I. Manunza, P. Cossedu, and E. Orgiu, Chapter 6 on "Detection of chemical and physical parameters by means of organic field-effect transistors" pp. 185- 212 in D. A. Bernards, R. M. Owens, and G. G. Malliaras, "Organic Semiconductors in Sensors Applications", Springer Series in Materials Science 107, Springer, Berlin 2008.

[3] Th. B. Singh, N. Marjanovic G. J. Matt, N. S. Sariciftci, R. Schwödiauer, and S. Bauer ,"Nonvolatile organic field-effect transistor memory element with a polymeric gate electret", *Appl. Phys. Lett.* Vol. 85, pp. 5409-5411, 2004.

[4] I. Graz, M. Kaltenbrunner, C. Keplinger, R. Schwödiauer, S. Bauer, S. Lacour, and S. Wagner, „Flexible ferroelectret field-effect transistor for large-area sensor skins and microphones", *Appl. Phys. Lett.*, vol. 89, 073501, 2006.

[5] M. Zirkl et al., „Low-voltage organic thin-film transistors with high-*k* nanocomposite gate dielectrics for flexible electronics and optothermal sensors", *Advanced Materials*, vol. 19, pp. 2241-2245, 2007.

[6] B. Ploss, B. Ploss, F. G. Shin, L. W. Chan, Cl Choy, "Pyroelectric or piezoelectric compensated ferroelectric composites", *Appl. Phys. Lett.*, vol. 76, pp. 2776-2778, 2000.

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