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Stretchable Conductive ink based on Polysiloxane curing system

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Abstract:

An electronic device need to be stretchable as well as flexible for its wider applications. The intrinsic problems with stretchable conductive ink remains despite attempt to designed the circuitary in meander-based shaped namely adhesion, compatible elastic modulus between the ink and substrate phases and the filler homogeneity in the ink matrix. Attempt was been made in this work to fabricate a polysiloxane based stretchable conductive circuit using dual curing system. The package presented a good adhesion between the conductive ink and the substrate. Optimum strain of the package obtainable was 120%. The elastic modulus between the two phases were comparable which militate against any local rupture during stretching. The conductivity (1/Ω) initially at 0.541 increased during stretching. However cyclic deformation at 50% strain affect a deterioration in conductivity. Stretchable antenna was fabricated using the formulated stretchable ink package displaying a bandwidth efficiency up to 25.6% which is suitable for service in satellite communication system.

Introduction

Printed circuit is popularly used in fabrication of sensors, actuators, radio-frequency identification (RFID) health care devices and display panel.[1-3] In this package, it is crucial for the package which is not only flexible but also stretchable so as to allow pervasive and unobtrusive sensing applications.[4] A popular approach is to design electrical circuit in a meander-based shape eg horse-shoe, serpentine and in the form of accordion.[5] It aimed in minimizing stress and strain concentrations during deformation. However the intrinsic problem with the stretchable conductive circuit package remains eg. adhesion to substrate, compatible elastic modulus between the ink and substrate phases as well as the homogeneity of conductive filler in the ink matrix. Fabrication of such a device ensure their conformal attachment to the skin beside a reliable and repeatable conductive performance. Adhesion between the substrate and commercially stretchable conductive ink is poor. This is partly attributed to different elastic modulus between the substrate and conductive film which result in local rupture during stretching. Further, introducing conductive fillers into the polymeric binder result in settling of the fillers to the bottom layer thus disrupt efficient electrical conductivity. Effect of blooming of conductive fillers during the course of curing of polymeric binder also affect conductivity. Previous medical devices use flexible substrate such as polyimide. These materials are non-stretchable and non-confocal towards the human body contour. Any slight movement induce stress and dislocation of the devices from the intended point of detection. In this work, a stretchable conductive ink package was fabricated based on polysiloxane. A dual curing system namely addition and condensation is utilized so as to optimize the crosslink density as well as the adhesion between the ink and the substrate. Silver is used as the conductive particulate as it has a high electrical conductivity as well as high dielectric constant.

Experimental

Stretchable conductive package: Two formulations were designed in fabricating the substrate and the conductive ink. They are presented as in the Table 1 below:

Table 1. Formulations for substrate and Conductive Ink.

Substrate	**Conductive Ink**
Hydroxy-terminated PDMS	Silver Powder
Trimethoxysilane	Hydrosilyl terminated PDMS
HCl (aq)	1,1,3,3-tetramethyldisiloxane
	Rhodium catalyst

For substrate formulation the compositions were mixed and manually stirred for 10 minutes followed by ultrsonication for another 30 mins. After treating under vacuum suction to remove air bubbles, it was cured under thermal curing at 60^{O}C over 40 mins. Likewise the formulation for conductive ink was prepared giving a viscosity of almost 50000 cP. This was squegee printed onto

Conductive
ink