THE 7TH INTERNATIONAL CONFERENCE ON SMART MATERIALS AND NANOTECHNOLOGY IN ENGINEERING (SMN2019)

A stretchable, flexible, self-healing interdigitated electrode plate for electrostatic adhesion

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Keywords: stretchable, flexible, self-healing, electrostatic adhesion

Abstract

Electrostatic adhesion has great potential to be extensively applied in various fields such as suction cups [1], grippers [2], electroadhesive clutch [3], and wall climbing robots [4], because of its light weight, strong force, and quick response. Most of the previous electroadhesive pads composed of thin metal foils and insulation cover layers, are flexible but not stretchable, and hence they can not adhere to complex shapes. More severely, the electroadhesive pad is susceptible to electrical breakdown, and after the breakdown, the device is accidentally short-circuited, and the electrostatic adhesion force vanishes. These problems .the extensive applications of electrostatic adhesion.

In this paper, we utilize conductive fluid (carbon nanotube suspension) and soft elastomer (Ecoflex 00-30) to replace the metal foils and stiff plastics respectively such as the one shown in Fig. 1. Since both the electrodes and the insulation are stretchable, the electroadhesive devices is highly deformable and adaptive. Moreover, the pad is very robust -- no matter electrostatic breakdown or physically penetration happens, the electroadhesive pad can still survive and work well.

The experimental results demonstrates that the electrostatic adhesion force on the substrate of paper, acrylic, and metal can reached to 2.91 N, 8.28 N, 3.49 N respectively (effective electrostatic adsorption area is 50 cm * 40 cm) when 3000 V voltage is applied (see Fig.2). The breakdown voltage of this electrode plate is about 4000 V, and after the electrical breakdown, the adhesive pad can recover back and can still work, since the fluid electrode is flowable and the soft elastomer cover layer is squeezable as shown in Fig. 3. Similarly, physical cutting or penetration does not affect too much the circuit connection and the adhesive force. Therefore, the stretchable adhesive pad proposed here is robust enough for more practical and harsh scenarios.

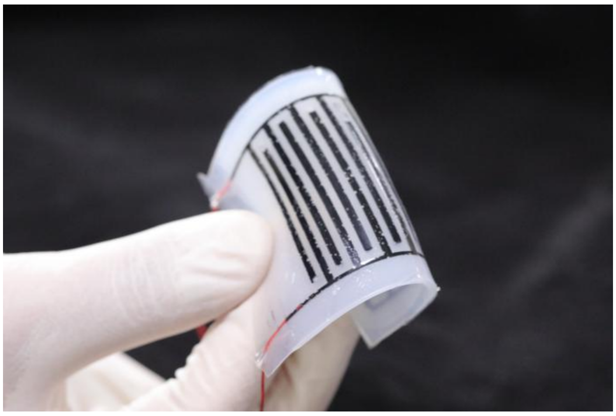


Fig. 1. Fabricated stretchable electroadhesive pad

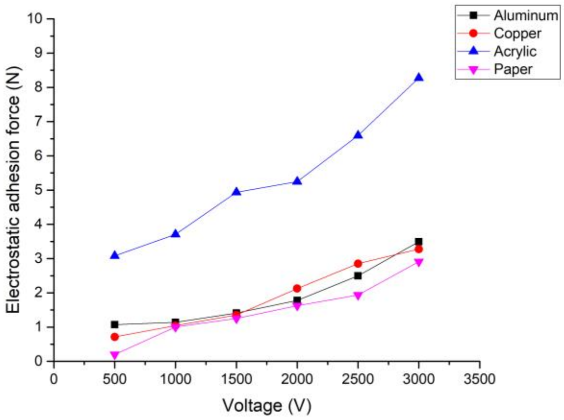
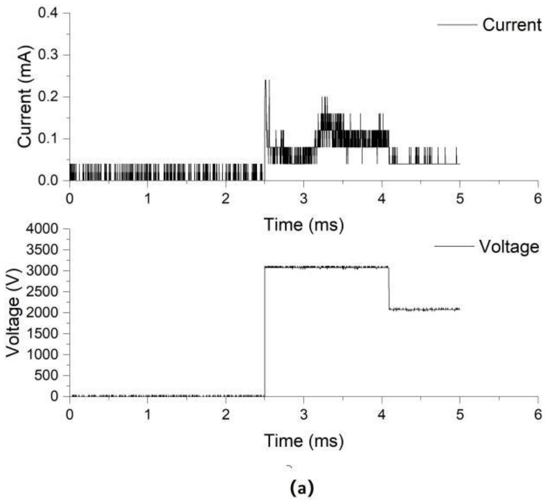


Fig. 2. Electrostatic adhesion force on different substrates



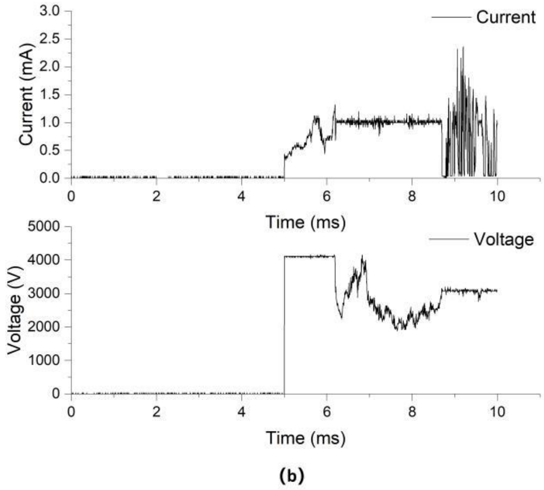


Fig. 3. Current and voltage change when applied high voltage. (a) normal state decrease voltage from 3000V to 2000V without breakdown (b) at 4000V breakdown then change voltage to 3000V.

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