A Review of PDMS-based Electronic Skin and Self-healing Property

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Introduction

Electronic skin or e-skin refers to soft, flexible, stretchable electronics, that mimic functions of human skins, with sensing capabilities that respond to changes of the environment. Pressure sensing is the most common function of current research.

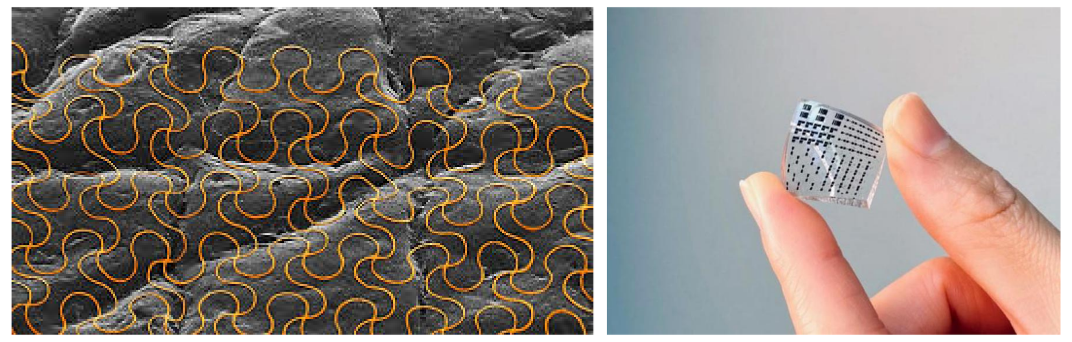

Figure 1. microscope image and an example of electronic skin

PDMS (polydimethylsiloxane) is a silicon-based viscoelastic organic polymer. PDMS is stable, non-toxic, flexible and easy shaped with high mechanical strength. It is a popular and widely used material to substitute human tissue.

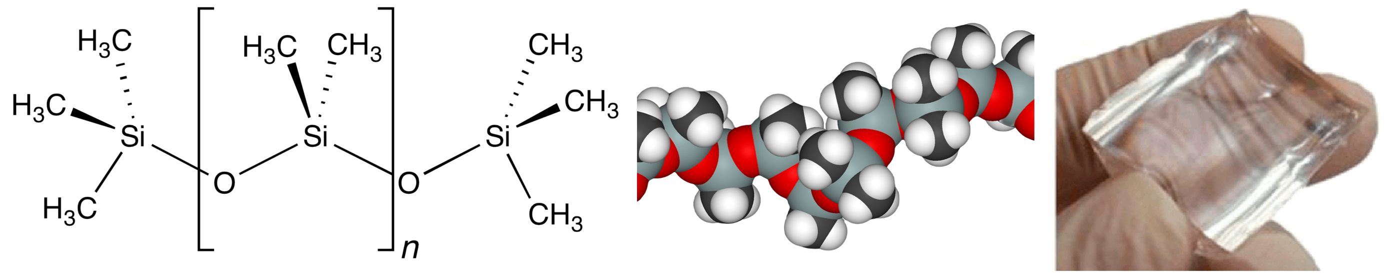

Figure 2. formula, structure and picture(crosslinked) of PDMS

Typical structure of e-skin

Generally, e-skins are a multi-layer-structure electronic. It is imperative to make every functional layer stretchable.

- **electrodes** often metallic, collect information and output signals
- **semiconductor** active layer, achieve electronic functions with stretchability
- **dielectrics** respond to pressure change and transduce into electrical signals
- **substrate** produce deformation

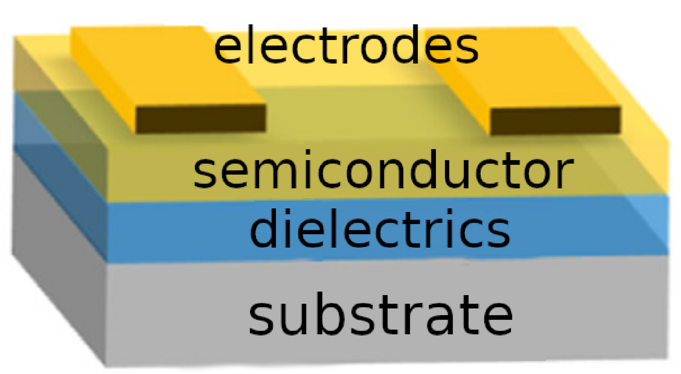

Figure 3. e-skin and its components

PDMS-based e-skins

1. **Multifunctional e-skin with micropillars for signal monitoring**
   - **a double-layered structure**
   - **upper** : PDMS with micropillars fabricated with PMMA template
     surface casting : silver nanowires (AgNWs)
   - **bottom** : solid PDMS

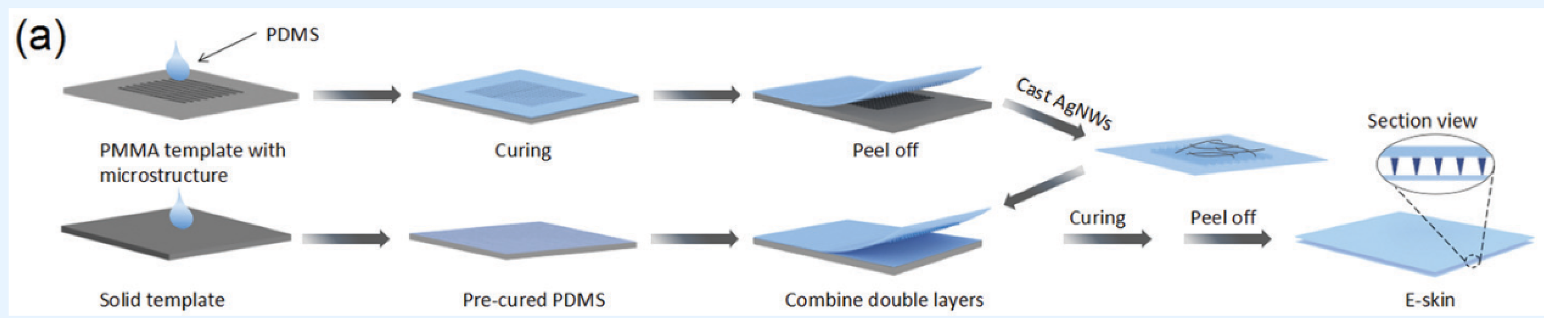

Figure 4. The fabrication process of the e-skin

2. **Self-Powered Electronic Skin Sensor**
   - **active layer** : Graphite/PDMS composite film
   - **electrode layer**: Al/PET, ITO/PET
   - **electrolyte layer** : PDMS spacer filled with NaCl solution
   - detect **dynamic/static** forces **without** external power supply

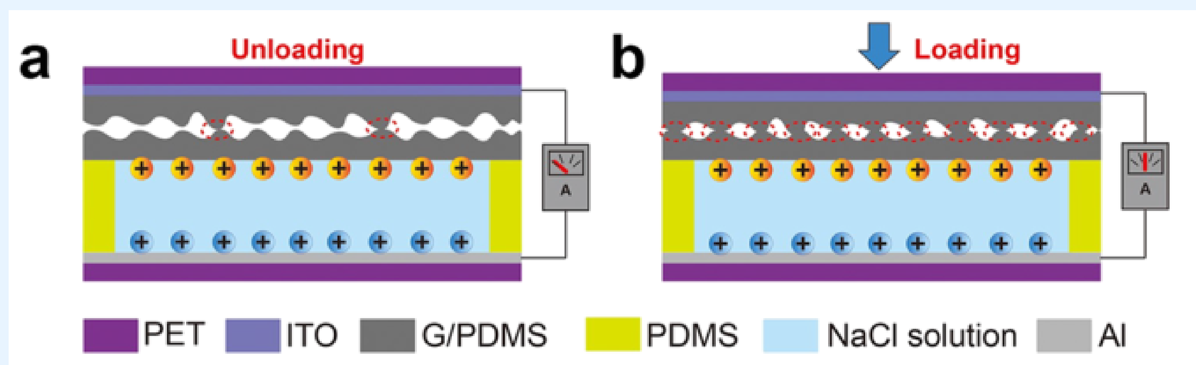

Figure 5. Sensing mechanism of the self-powered skin sensors

3. **Flexible Tactile Electronic Skin Sensor with 3D Force Detection**
   - based on **CNTs/PDMS** nanocomposites
   - detect **3D force** with **ultra-low response time**

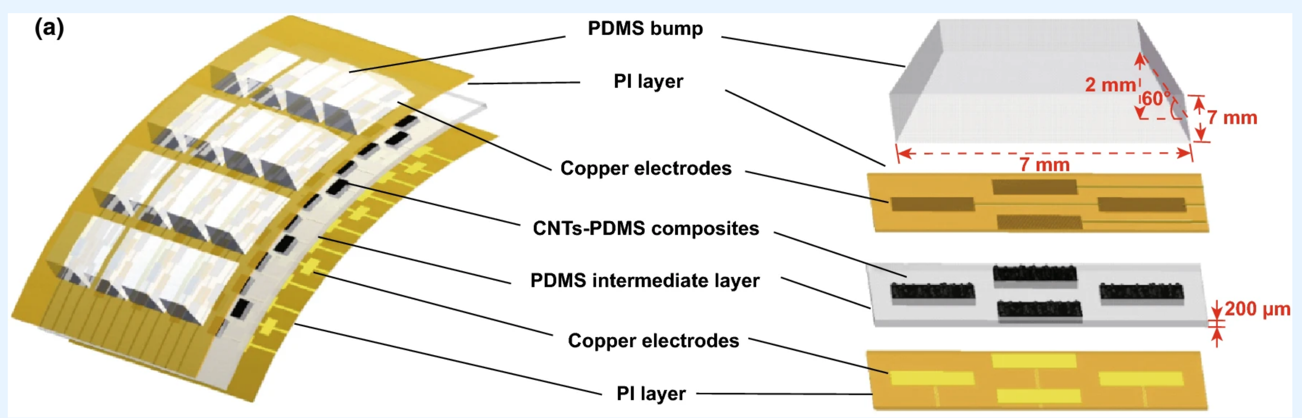

Figure 6. Dismantling structure of the tactile sensor array and one single element

Self-healing property

Self-healing abilities are of great importance of mimicking human skin, which also endow e-skin with long-term reliability.

1. **Mechanisms of self-healing**
   - Healing by agents Microcapsules contain self-healing agents that release and polymerize at damage region to restore.
     Limited to the availability of agents
   - Dynamic bond formation Polymer chains diffuse into damage region and reform bonds.
     Suitable for self-healing e-skins
2. **Healing efficiency** $\text{Healing efficiency} = \frac{\text{Property value(healed)}}{\text{Property value(pristine)}} \times 100\%$
3. **Self-healing of PDMS**
   - incorporation at cross-linking site
   - copolymerize with ionized monomer

Summary and Outlook

- **PDMS** is a promising material for the**substrate** for e-skins and the**matrix** of flexible functional composites.
- **Suitable additives and fillers**, such as CNTs, nanowires and inorganic particles, are to be found to improve the performance of PDMS composites.
- **New processing methods** should be invented to better fabricate e-skins.
- Self-healing materials are still **limited to application in e-skins**.
- Self-healing complex circuits and devices **have not been developed** yet.

References

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