Supporting Information

Stretchable Strain Sensor based on Metal Nanoparticle Thin Film for Human Motion Detection

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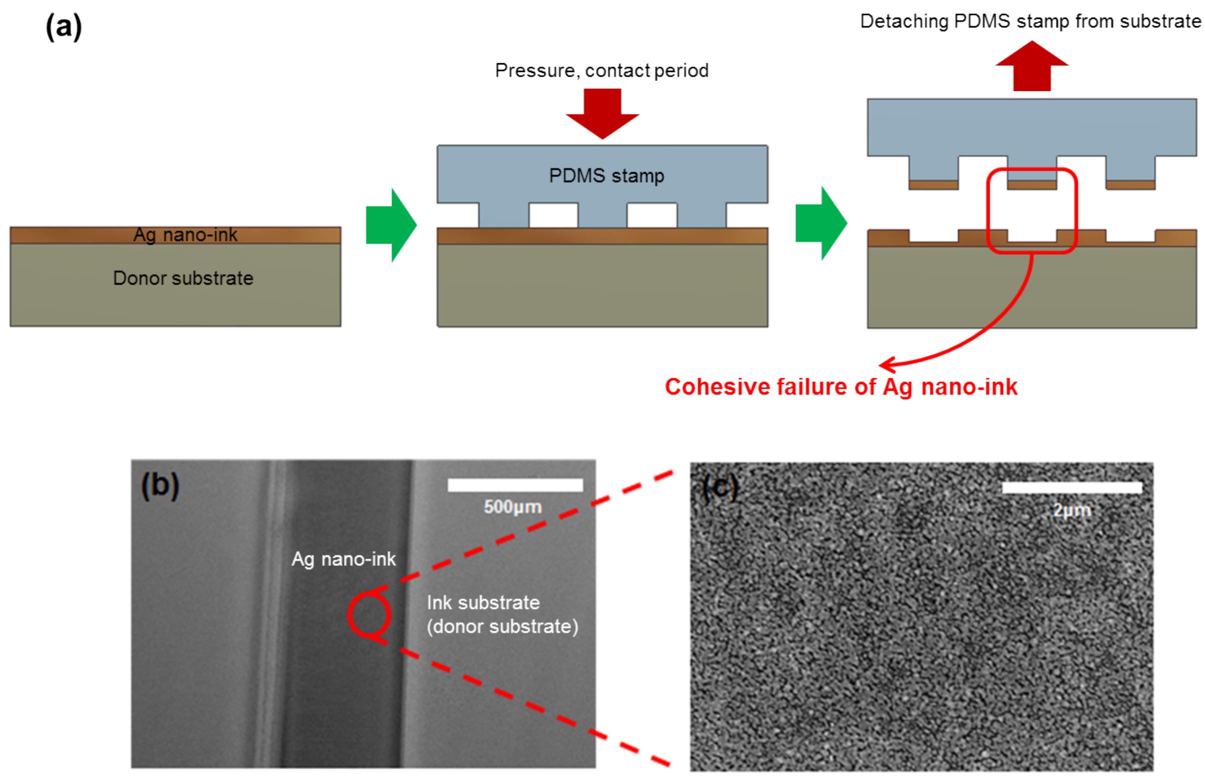

Fig. S1. (a) Schematic diagram for the mechanism of Ag nano-ink transfer from the donor substrate to the microstructured PDMS stamp. (b-c) SEM images of donor substrate after transfer step, showing Ag NP thin films remaining on the substrate.

Fig. S1 shows mechanism of transfer of Ag nano-ink from donor substrate to the micro-structured PDMS stamp and SEM images of donor substrate after transfer step. Since the cohesive energy of inner Ag nano-ink is lower than the adhesive energy between donor substrate and the Ag nano-ink and also between PDMS stamp and Ag nano-ink, cohesive failure of Ag nano-ink occurred, resulting in partial transfer of Ag nano-ink.

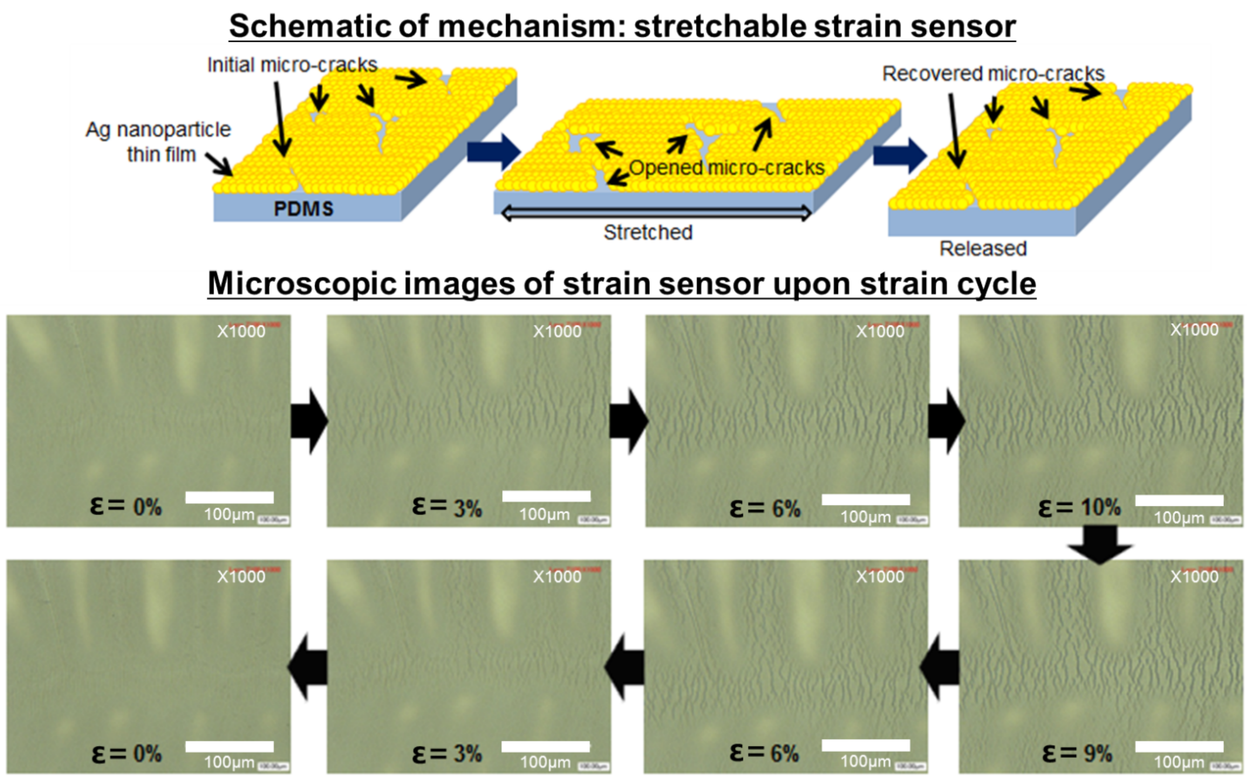

Fig. S2. Working principle of strain sensor and microscopic images of micro-cracks on AgNP thin film under elongation/relaxation cycle.

Fig. S2 shows the schematic and microscopic images of Ag NP thin film surface with micro cracks under elongation/relaxation cycle. During the stretching process, enlarged initial micro cracks and newly created micro-cracks were observed. However, the width of micro cracks were significantly reduced during the releasing process and recovered to the initial state at ε=0 %.

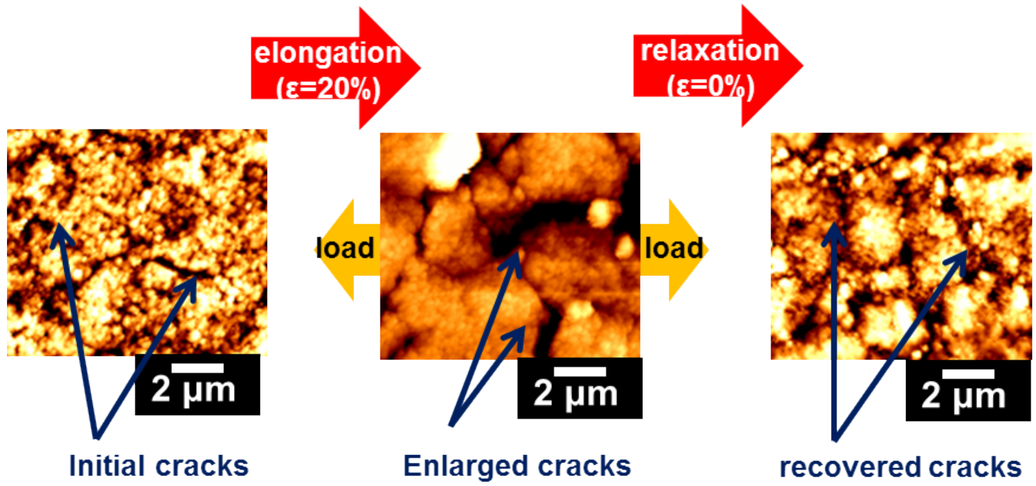

Fig. S3. AFM images of surface of strain sensor on the PDMS substrate during an elongation/relaxation cycle (not same location).

Fig. S3 shows the atomic force microscopy (AFM) images of the micro-cracks on the Ag NP films during an elongation/relaxation cycle. Before the elongation, the initial-cracks were observed on the surface of the Ag NP thin films. At ε = 20 %, micro-cracks were opened with larger width by tensile load. Then, micro-cracks were closed and recovered to the initial state after relaxation process. These results show good agreement with the opening/closure working principle of the micro-cracks on Ag NP films.

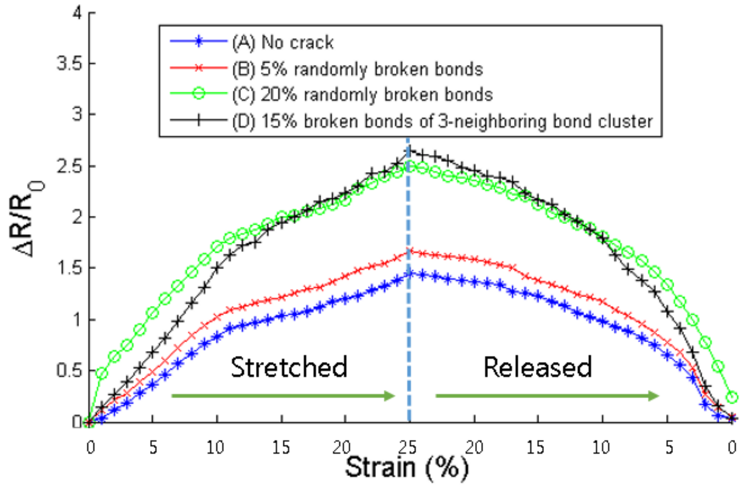

Fig. S4. Numerical simulation results of the relative change of electrical resistance of Ag NP thin films following four cases; without cracks (A), 5 % of randomly broken bonds (B), 20 % of randomly broken bonds (C), and 15 % of broken bonds where clusters of 3 neighboring bonds are broken together (D).

Fig. S4 shows the numerical simulation results of the relative change of electrical resistance of Ag NP thin films following four cases: without cracks (A), 5 % of randomly broken bonds (B), 20 % of randomly broken bonds (C), and 15 % of broken bonds where we always break a cluster of 3 neighboring bonds together (D). During the entire stretching/releasing process, the rates of change in the resistance of (C) was larger than those of (A) and (B). Also, (D) showed higher $\Delta R/R_0$ than those of (A) and (B). The maximum $\Delta R/R_0$ at ε=25 % were 1.45 (A), 1.67 (B), 2.50 (C), and 2.64 (D), respectively.

Adam's apple: swallowing

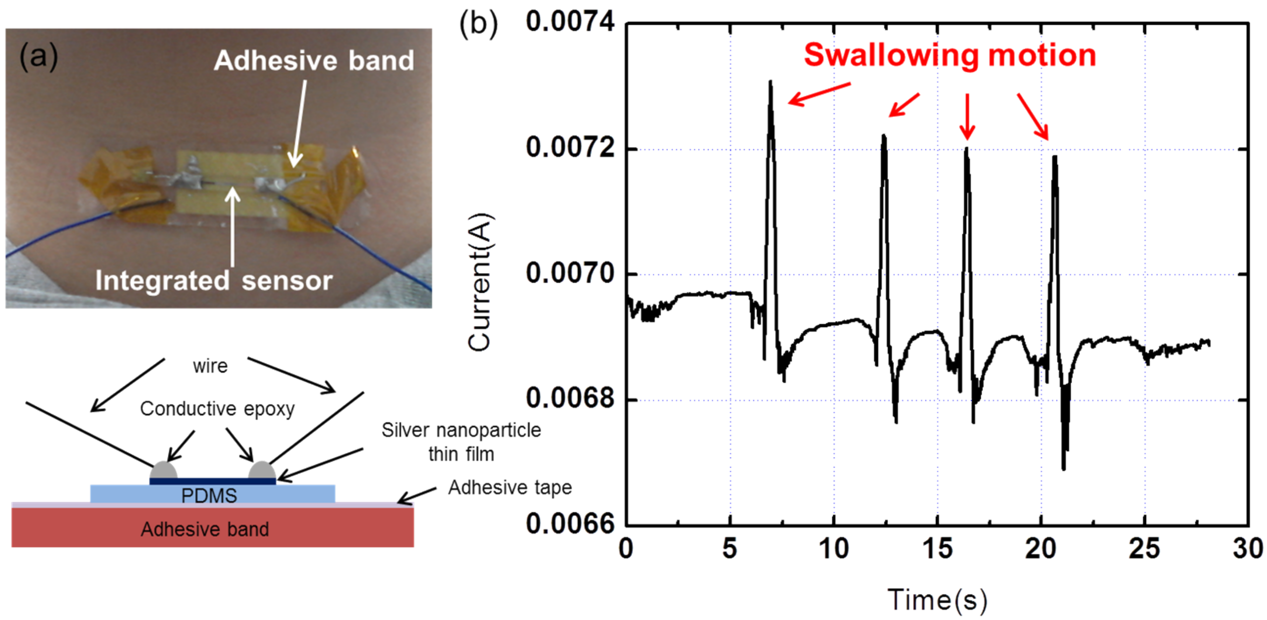

Fig. S5. (a) Photograph and schematic image of the motion detection sensor on adhesive band (b) Sensing performance of the strain sensor attached on Adam's apple by swallowing motion

We used our strains sensor for detecting the tiny motion of Adam's apple by swallowing. The sensor was tightly adhered to the Adam's apple with induced tensile strain as shown in Fig. S5 (a). Fig. S5 (b) shows the sensing performance of the sensor under repeated motions of spittle swallowing. When Adam's apple moved up by spittle swallowing, skin contraction induced the reduction of the electrical resistance of the sensor. On the other hand, the electrical resistance was recovered when the Adam's apple moved back to the original position. From this result, we verified that the strain sensor can detect tiny or inconspicuous motions.