Supporting Information for

Strain-Insensitive Hierarchically Structured Stretchable Microstrip Antennas for Robust Wireless Communication

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S1 Transmission Line Model for Microstrip Antennas

The resonance frequency f of the microstrip patch antenna with a width and length of w and L in the patch can be designed as a function of the effective dielectric constant ε_{eff} and the effective length L_{eff} as in Eq. 1. The effective dielectric constant ε_{eff} and the effective length L_{eff} can be obtained from

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1 + 12\left(\frac{h}{w}\right)\right)^{-\frac{1}{2}}, \quad \text{(S1)}$$

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{w}{h}+0.8)}, \quad \text{(S2)}$$

$$L_{eff} = L + 2\Delta L, \quad \text{(S3)}$$

where ε_r and h are the relative dielectric constant and dielectric layer thickness, respectively. The effective length L_{eff} is large than the physical length L of microstrip patch antennas due to the fringing effect.

S2 Supplementary Figures

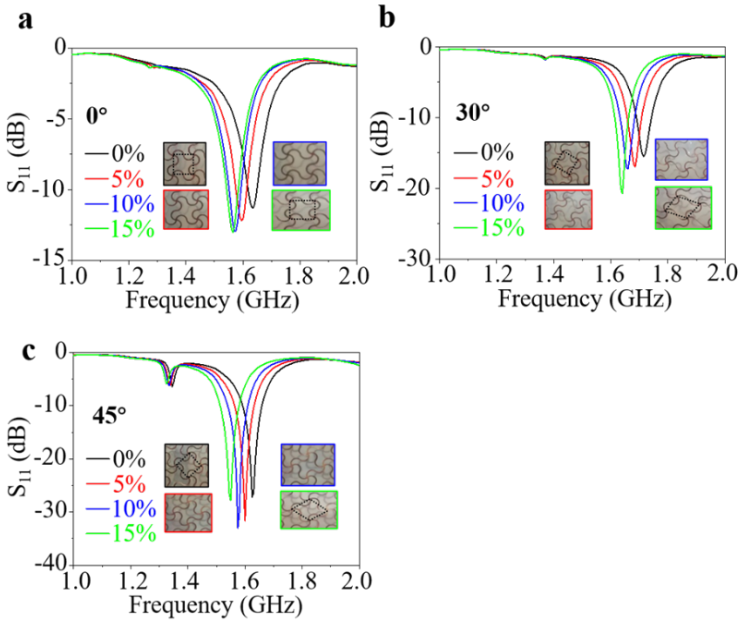

Fig. S1 Measured S_{11} curves of the meshed microstrip antenna with different orientations (0˚, 30˚, and 45˚) upon stretching. The unit cell of the mesh is orientated along the **(a)** 0˚, **(b)** 30˚, and **(c)** 45˚. The optical images in the inset show the deformed meshed structure upon stretching.

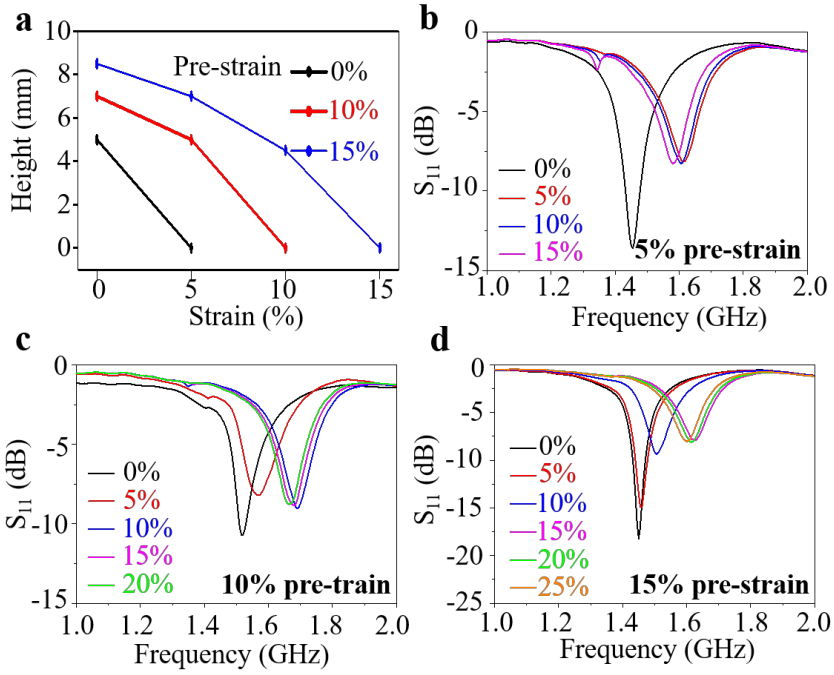

Fig. S2 Mechanical-electromagnetic properties of the hierarchically structured microstrip antenna with a single arch. **a** Height of the arched patch as a function of the applied tensile strain. **b-d.** Measured S_{11} curves of the hierarchically structured microstrip antenna with a single arch for a pre-strain of **b** 5%, **c** 10%, and **d** 15% upon stretching

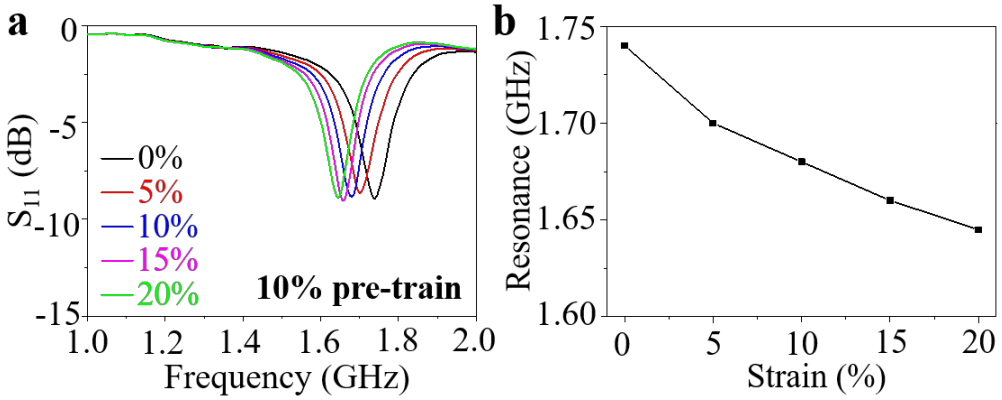

Fig. S3 Mechanical-electromagnetic properties of stretchable microstrip antennas with a wavy patch and ground (pre-strain of 10%)

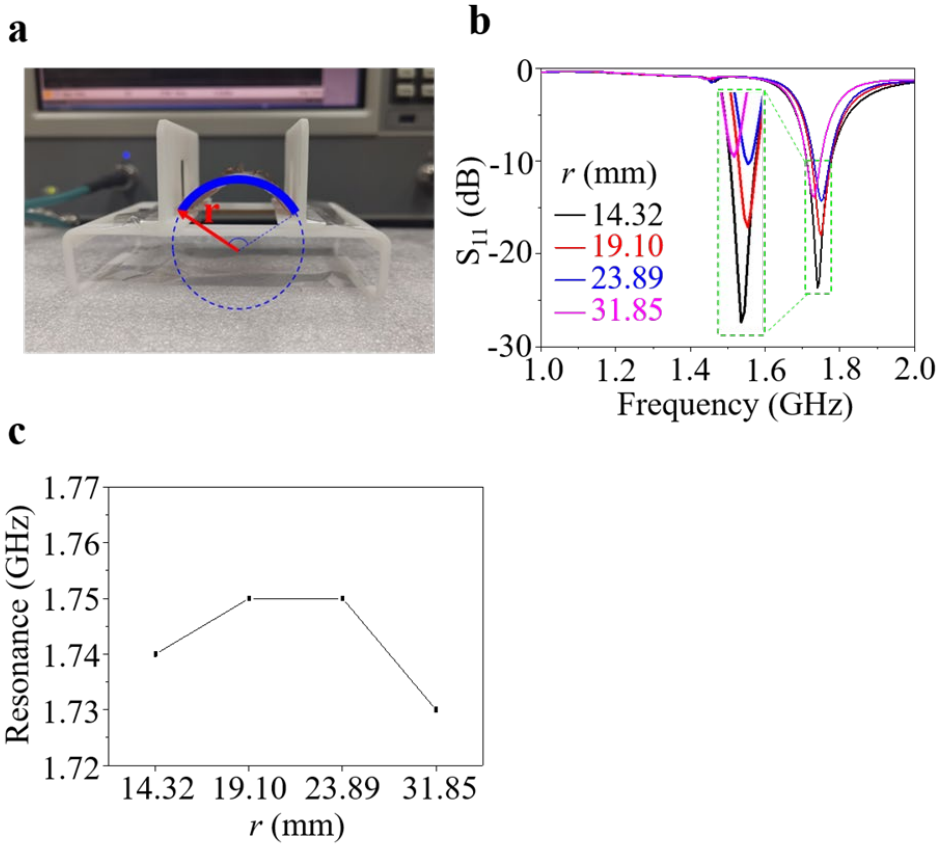

Fig. S4 Bending performance of the hierarchically structured microstrip antenna with a double-arched patch for a pre-strain of 15%. **a** Experimental setup for the bending test. **b** Measured S_{11} curves of the hierarchically structured microstrip antenna with a double-arched patch upon bending deformation for different radii. **c.** Measured resonance frequency as a function of the bending radius from the hierarchically structured microstrip antenna with a double-arched patch

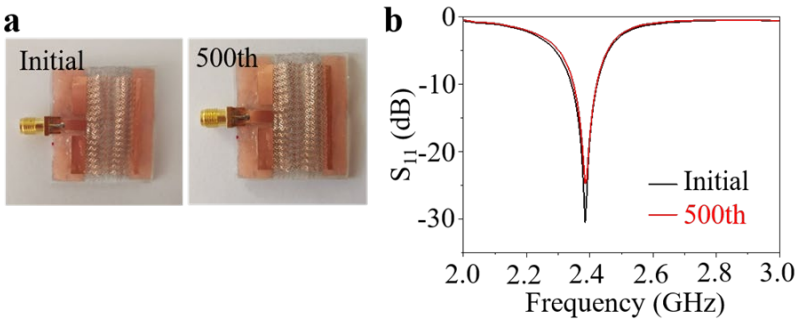

Fig. S5 (**a**) Optical images and (**b**) S_{11} curves of hierarchically structured microstrip antennas with a double-arched patch before and after 500 bending cycles

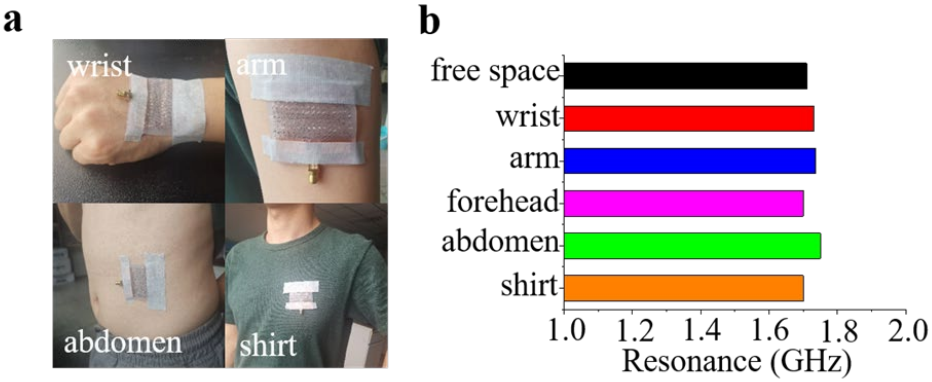

Fig. S6 On-body electromagnetic properties of the hierarchically structured microstrip antenna with a double-arched patch. **a.** Optical images of the hierarchically structured microstrip antenna with a double-arched patch attached to different parts of human bodies, including the wrist, arm, abdomen, and shirt over the chest. **b.** Measured resonance frequency of the hierarchically structured microstrip antenna with a double-arched patch placed at different locations

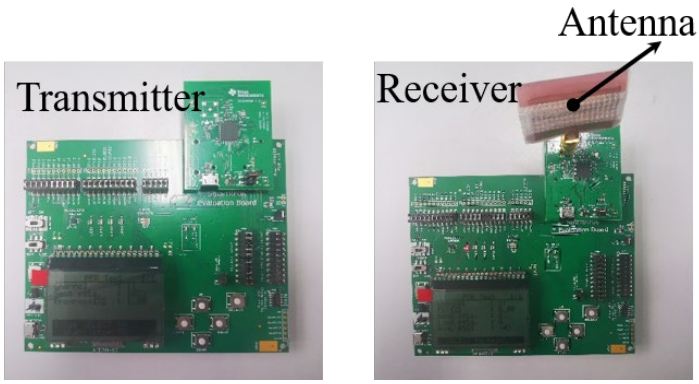

Fig. S7 RF transmitter and receiver used to evaluate the wireless communication performance of the hierarchically structured microstrip antenna.

Movie S1 (separate file). Demonstration of the strain sensing capability from the meshed microstrip antenna.

Movie S2 (separate file). "Ordered unraveling" in the hierarchically structured microstrip antenna with a single-arched patch upon stretching.