Supporting Information

for

Omnidirectionally Stretchable Organic Transistors for Use in Wearable Electronics: Ensure Overall Stretchability by Applying Non-Stretchable Wrinkled Components

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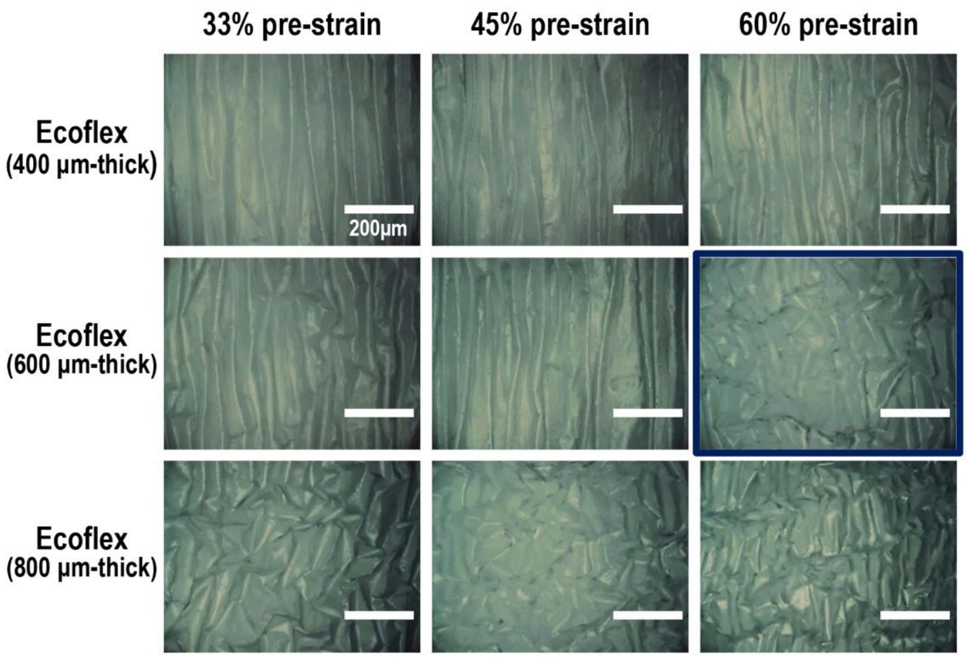

Figure S1. OM images of the wrinkle structures of the Ecoflex template under a controlled degree of pre-strain and for a given Ecoflex thickness, after releasing the biaxially pre-strained Ecoflex template. All scale bars are 200 µm.

As the pre-strain degree applied to the Ecoflex template increases, the frequency of wrinkles increases, which could be a result of the increase in compressive strain caused by the difference in Young's moduli between the elastic Ecoflex and the hard Parylene layers. What is unexpected in the results in Figure S1 is that the wrinkled structure was formed in uniaxial direction for the relatively thin 400 µm-template case, despite biaxial stretching to produce an omnidirectionally stretchable OFET device or template. Honestly, we cannot provide an exact reason for the results, but it is assumed that one of the main reasons is the reduced compressive stress and the structurally easy deformation due to the thin thickness of the elastomeric body to easily relieve the stress. In other words, when the Ecoflex template is stretched and released again, the compression stress increases as the its thickness increases, resulting in an increase in the frequency of wrinkled structure and the complexity of the shape. Although it is difficult to show clearly with OM images because of the transparent property of the Ecoflex template, the most complicated omnidirectional wrinkled structures were formed in the thick 800 µm-template case at 60 % pre-strain. However, this case was not used due to experimental difficulties in the fabrication and characterization of OFET devices, which caused the excessive wrinkles. Therefore, we used the wrinkled Ecoflex template prepared under conditions of 60 % strain and 600 µm thickness due to the formation of omnidirectionally uniform wrinkle structures under these preparation conditions.

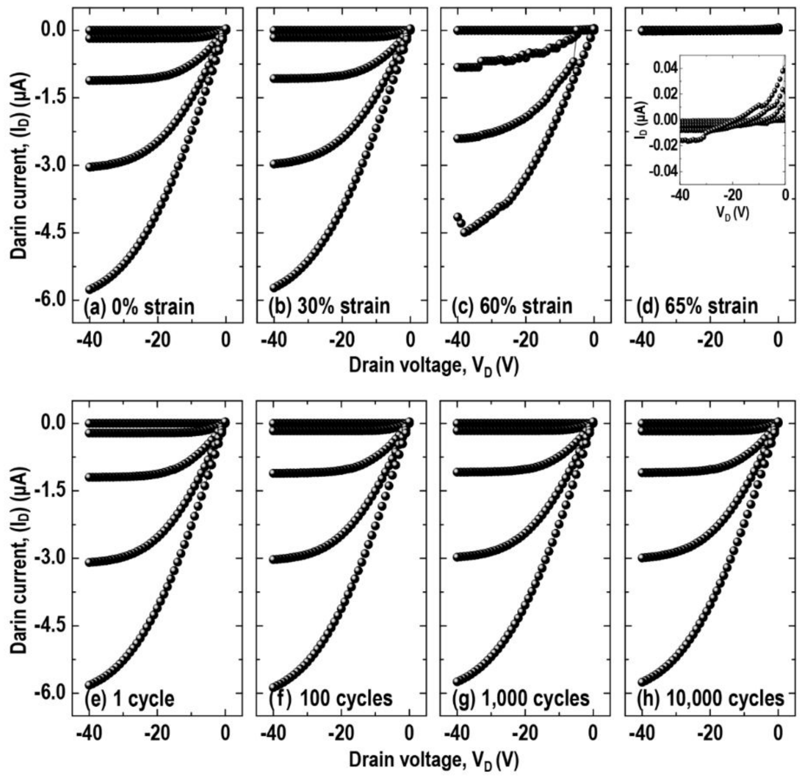

Figure S2. Output characteristics (the I_D–V_D relationship) for a representative C10-DNTT OFET having an omnidirectional wrinkle structure **(a–d)** under select tensile strain degrees or **(e–h)** under select cycle numbers, such that a stretching/releasing motion comprised one cycle. I_D is the source–drain current, and V_D is the drain voltage. These results were obtained from the C10-DNTT OFET devices that provided the transfer characteristics reported in Figure 3.

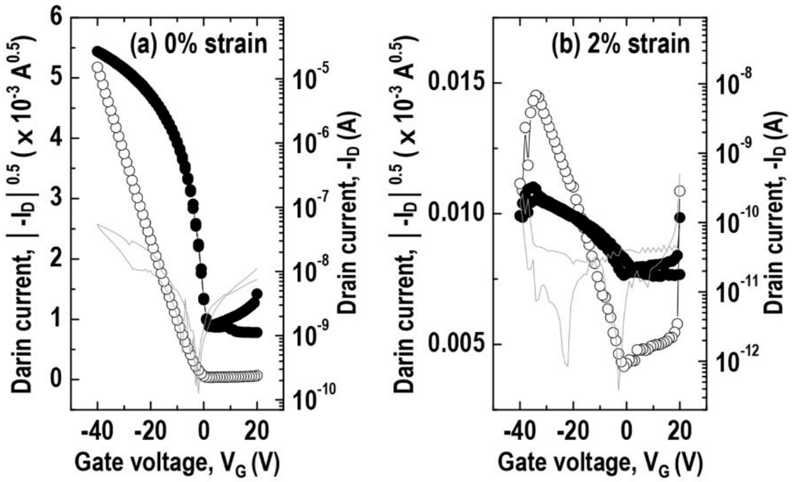

Figure S3. Transfer characteristics of the C10-DNTT OFET device prepared on non-wrinkled Ecoflex template under **(a)** 0 and **(b)** 2 % tensile strains.

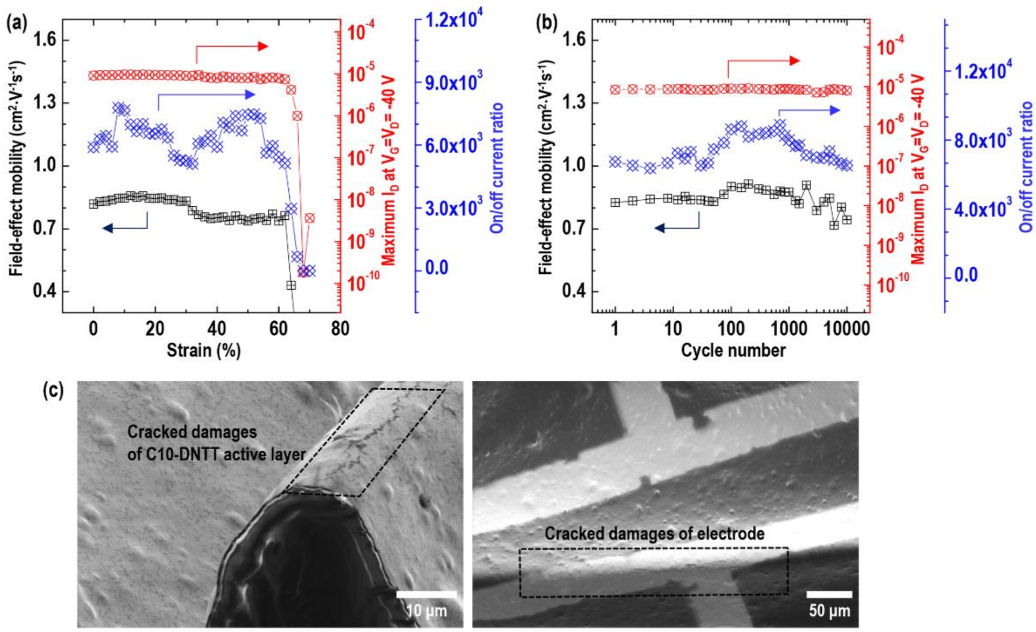

Figure S4. Variations in the field-effect mobility (μ_{FET}, black), maximum current ($I_{D,max}$, red), and on/off current ratio (blue) of the omnidirectional wrinkled C10-DNTT OFET devices **(a)** under tensile strains ranging from 0 to 70 %, and **(b)** over 10,000 cycles, wherein a stretching/releasing motion comprised one cycle. The results shown in Figure 4 present values re-calculated from the data presented in Figure S4. **(c)** SEM images of C10-DNTT active layer and electrode damaged at a strain degree of 64 %.

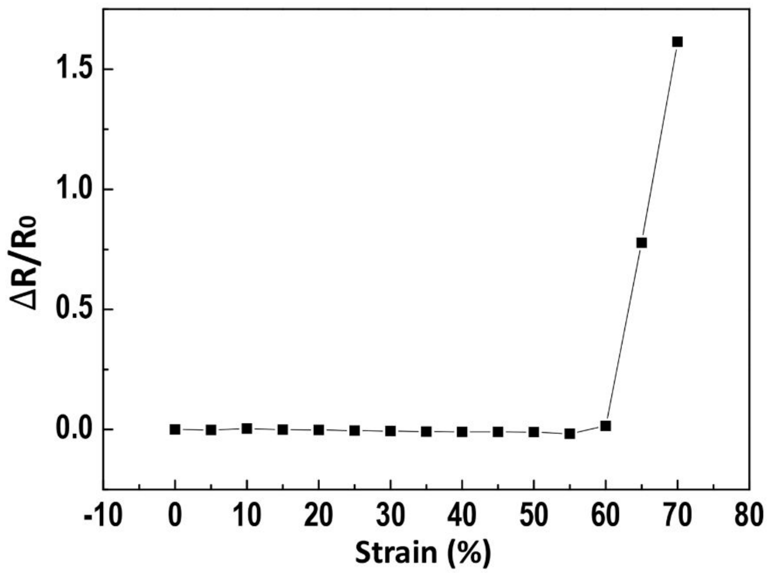

Figure S5. Variations of relative resistance ($\Delta R/R_0$) of Au electrode as a function of strain degree.

Au electrode with the wrinkle structure in the omnidirectionally stretchable OFET device showed little resistance change up to 60 % strain degree, and the resistance rapidly increased from the strain degree of 60 % or more. Considering about this result in relation to μ_{FET} variations with increasing the strain degree shown in Figure 4(a), we can find important information. The electrode with a wrinkle structure has sufficient resistance value to act as an electrode even at the strain degree of 62 %, which is the limit of stretchability of our device, whereas the μ_{FET} decreases dramatically from the strain of 62 %. The result indicates that the main reason for the decrease in the OFET performance above the strain limit could be not caused by the damaged electrode, but by damage to the C10-DNTT semiconducting layer.

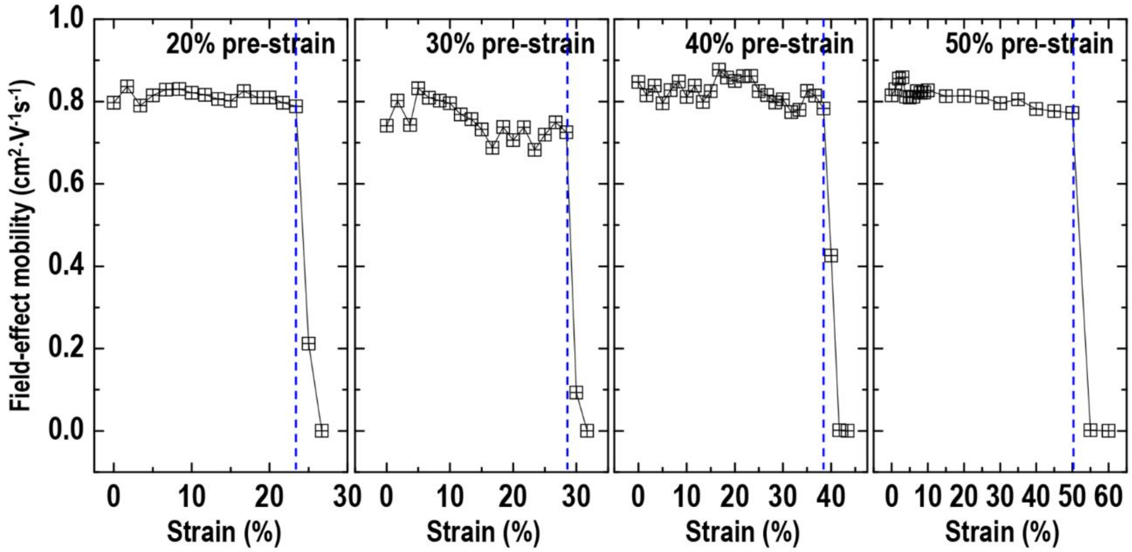

Figure S6. Variations in the field-effect mobilities (μ_{FET}s) as a function of applied strain degrees of the omnidirectional wrinkled C10-DNTT OFET devices prepared with variously pre-strained templates.

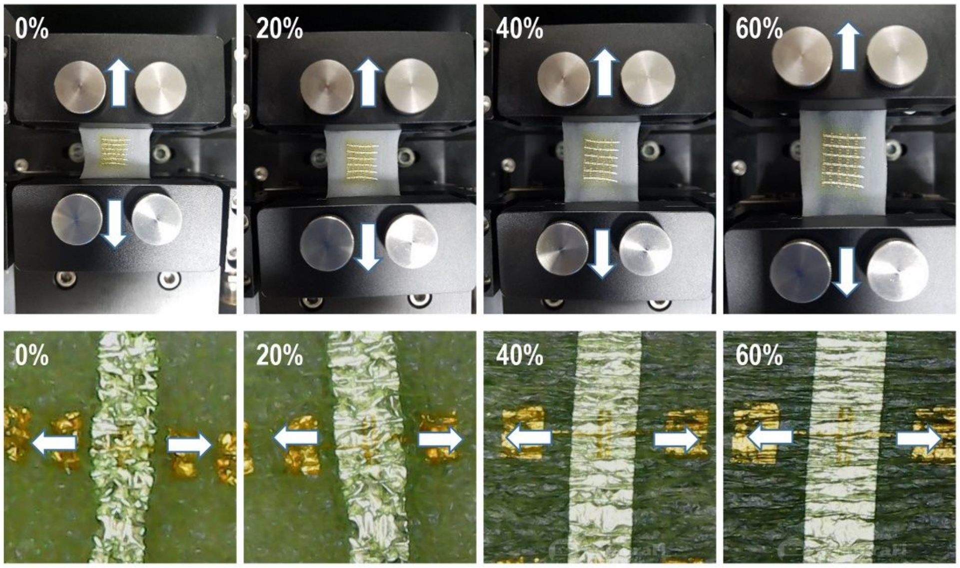

Figure S7. The upper and lower images show the home-built stretching/releasing system used in our experiments and the stretched channel region of the C10-DNTT OFET device under various tensile strains, respectively.