

Swedish-Japanese Joint Symposium

Continuous health status monitoring of elderly people using flexible skin patch sensors

Japan

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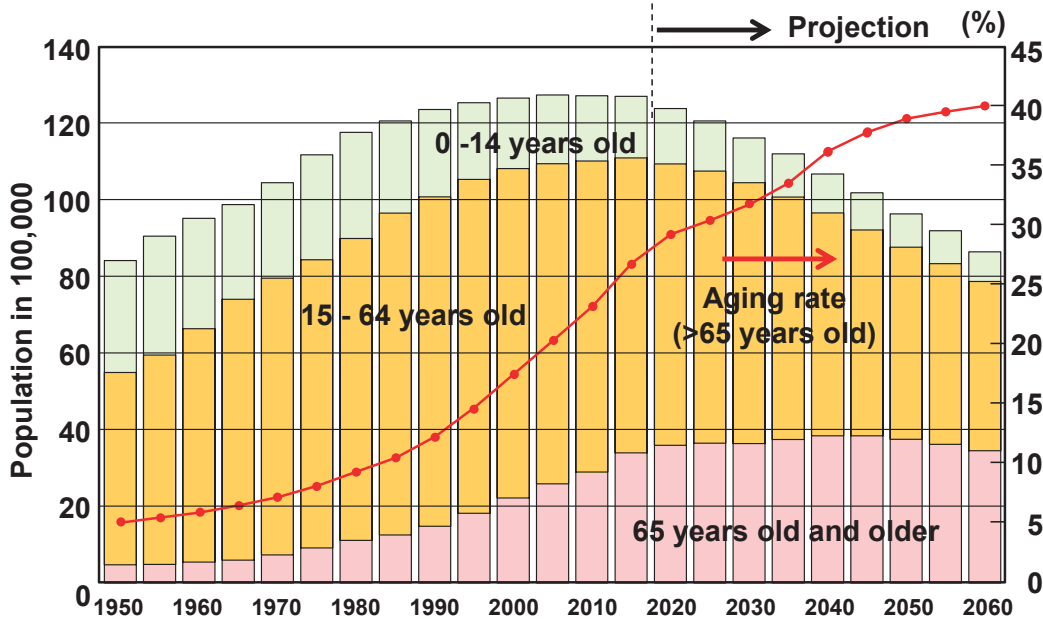
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The arrival of super aged society in Japan



Aging in Japan

Super-aged in 2007
Aging rate

27.3% in 2017
>30% in 2025

Super-aged, **Worldwide**
(Moody's)

13 countries by 2020
34 countries by 2030

Data: Cabinet Office, Government Of Japan, Ministry of Internal Affairs and Communications, National Institute of Population and Social Security Research, and Ministry of Health, Labor and Welfare, Japan.

Innovation for healthy longevity society and social system reform are urgently required.





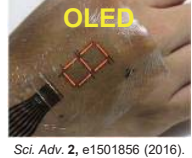






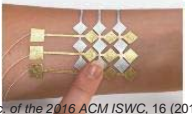


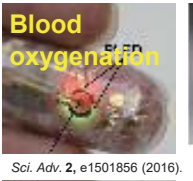
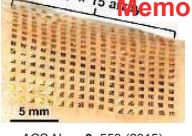


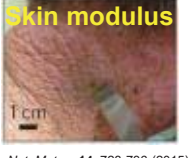


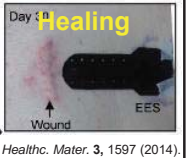
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Accessibility to information



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Skin electronics

Display	Sensor		Energy
<p>Inorganic LED</p>  <p><i>Science</i> 325, 21 (2009).</p>	<p>Physical sensor</p> <p>Epidermal electronics</p>  <p><i>Science</i> 333, 838 (2011).</p>	<p>Chemical sensor</p> <p>UV</p>  <p><i>Adv. Funct. Mater.</i> 27, 1604465 (2017).</p>	<p>Skin battery</p>  <p><i>Adv. Health Mater.</i> 4, 506 (2015).</p>
<p>OLED</p>  <p><i>Sci. Adv.</i> 2, e1501856 (2016).</p>	<p>Imperceptible electronics</p>  <p><i>Nature</i> 499, 458 (2013).</p>	<p>ECG</p>  <p><i>Sci. Rep.</i> 4, 6074 (2014).</p>	<p>Bio-fuel cell</p>  <p><i>Energy Environ. Sci.</i> 10, 1581 (2017).</p>
<p>QLED</p>  <p><i>Adv. Mater.</i> 29, 1 (2017).</p>	<p>EMG</p>  <p><i>Adv. Mater.</i> 25, 2773 (2013).</p>	<p>Microfluidic</p>  <p><i>Sci. Transl. Med.</i> 8, 366ra165 (2016).</p>	<p>System</p> <p>Human interface</p>  <p><i>Proc. of the 2016 ACM ISWC</i>, 16 (2016).</p>
<p>Micro LED</p>  <p><i>Adv. Mater.</i> 29, 1703817 (2017).</p>	<p>Pressure</p>  <p><i>Nat. Com.</i> 4, 1859 (2013).</p>	<p>Blood oxygenation</p>  <p><i>Sci. Adv.</i> 2, e1501856 (2016).</p>	<p>Memory</p>  <p><i>ACS Nano</i> 9, 558 (2015).</p>
	<p>Temperature</p>  <p><i>Nat. Mater.</i> 12, 938 (2013).</p>	<p>Hydration</p>  <p><i>IEEE Trans. Biomed. Eng.</i> 60, 2848 (2013).</p>	
	<p>Skin modulus</p>  <p><i>Nat. Mater.</i> 14, 728-736 (2015).</p>	<p>Sweat</p>  <p><i>Nature</i> 529, 509 (2016).</p>	
		<p>Strain</p>  <p><i>Nat. Mater.</i> 11, 795 (2012).</p>	<p>Healing</p>  <p><i>Adv. Healthc. Mater.</i> 3, 1597 (2014).</p>

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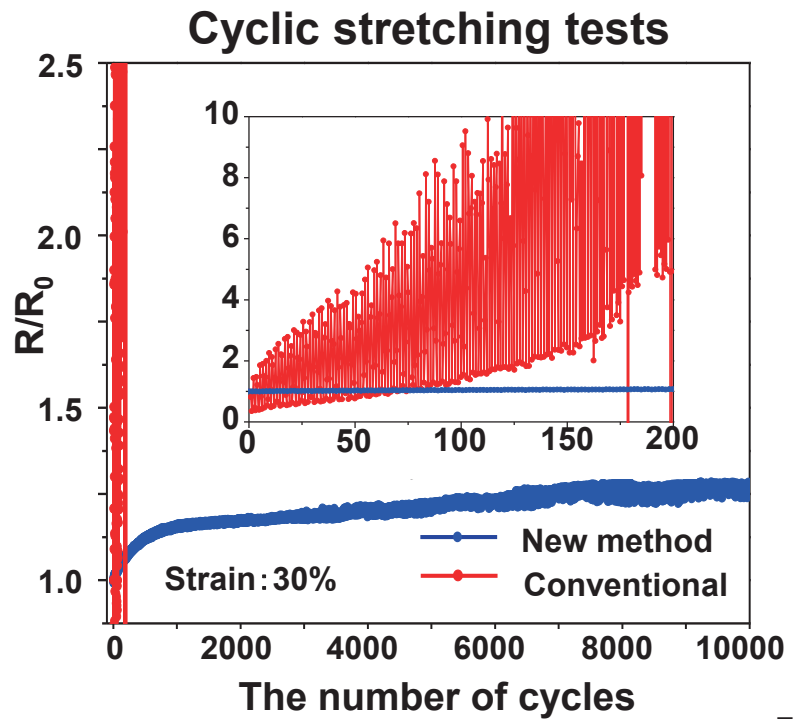
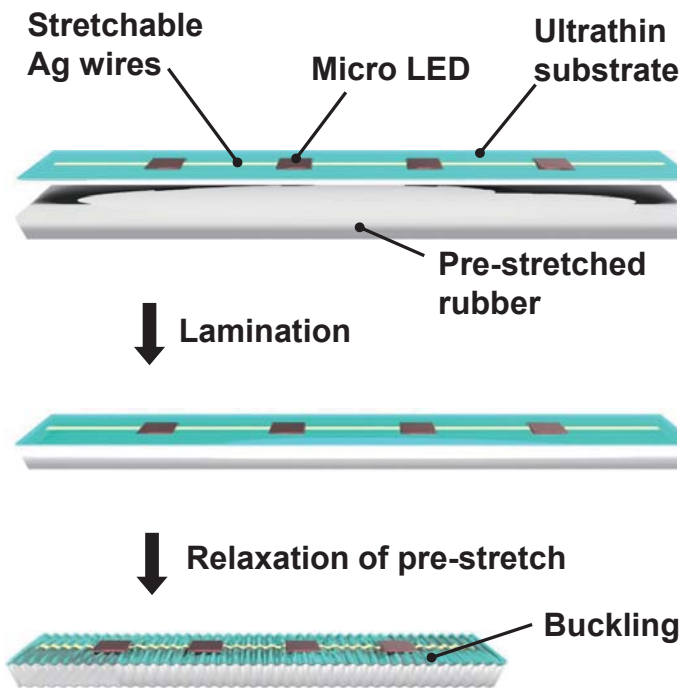
A skin display is an array of micro-LEDs embedded in a thin rubber sheet.



We have developed a skin display with stretchability of 45%.

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Fabrication process and mechanical durability



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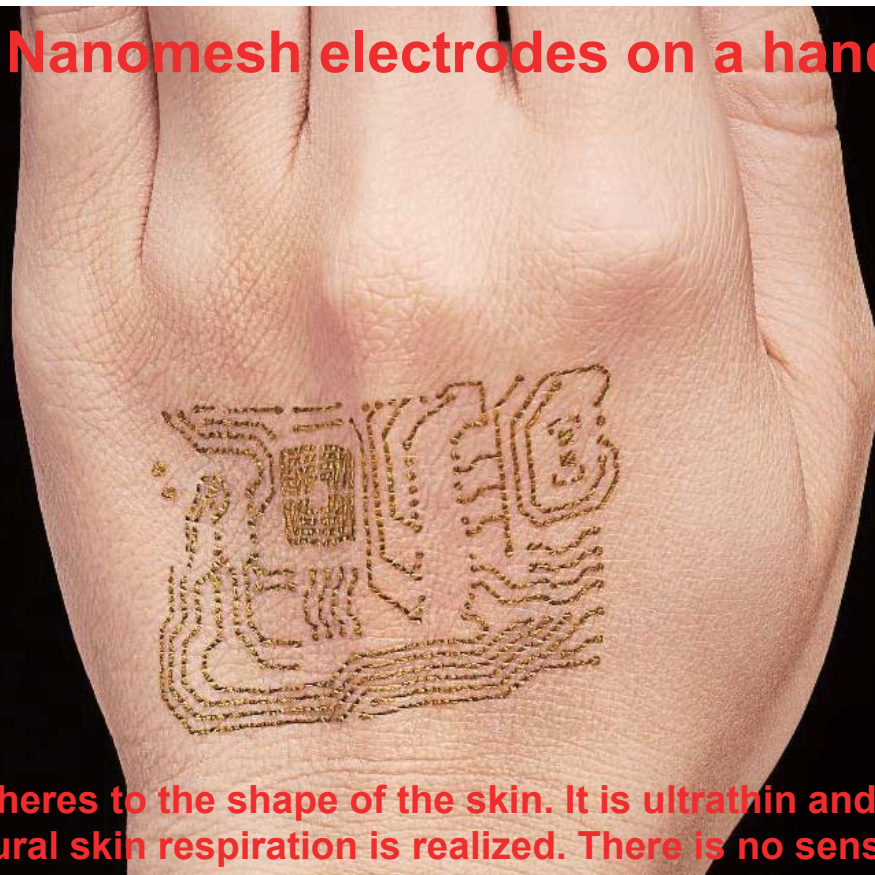
A skin display attached to the hand



- ✓ A skin display can be nicely fitted on the skin due to its stretchability.
- ✓ It exhibits simple graphics with motion including a electrocardiogram waveform measured with skin sensors.

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Nanomesh electrodes on a hand



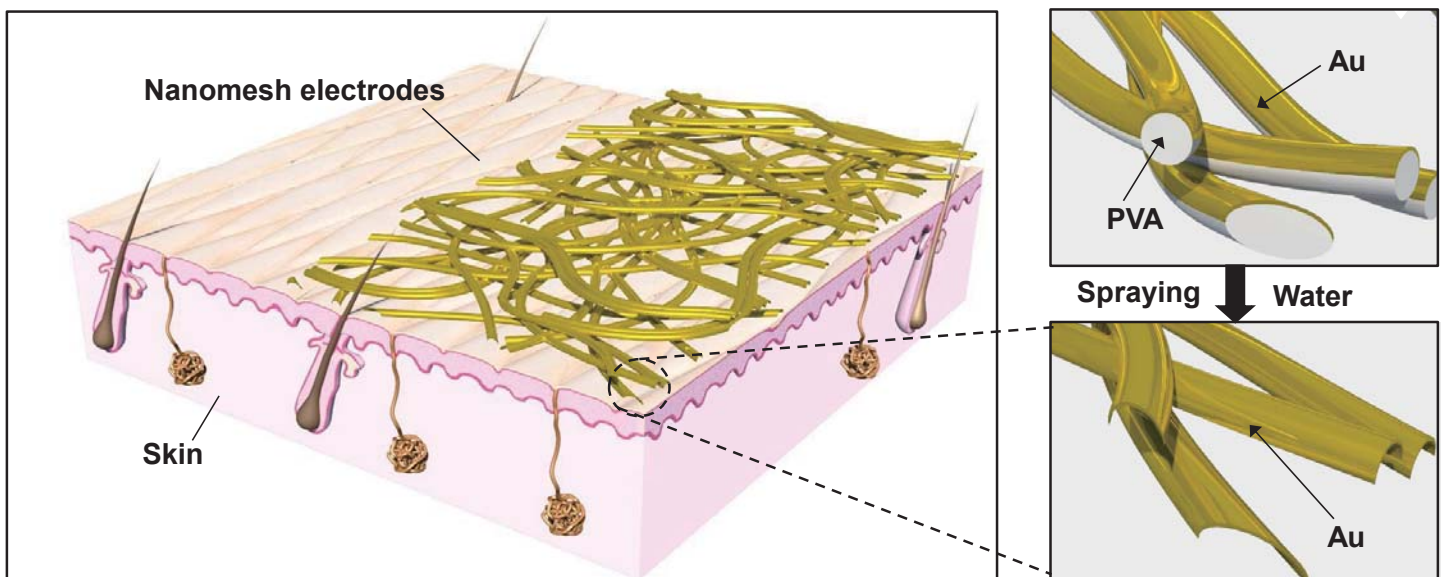
It firmly adheres to the shape of the skin. It is ultrathin and lightweight. A natural skin respiration is realized. There is no sense of fit.

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Nanomesh electrodes

Process flow

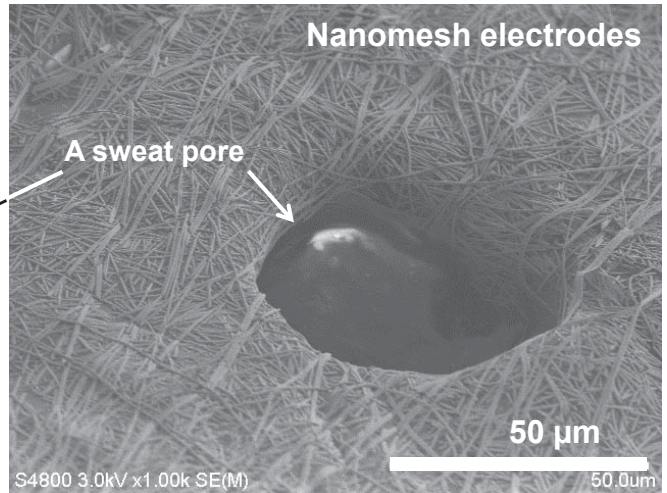
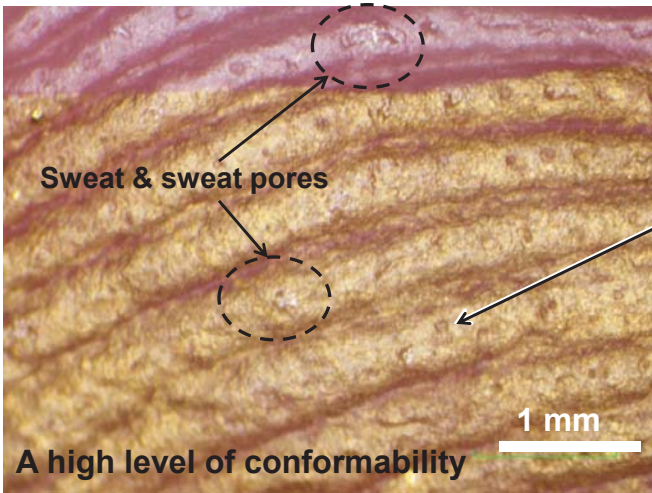
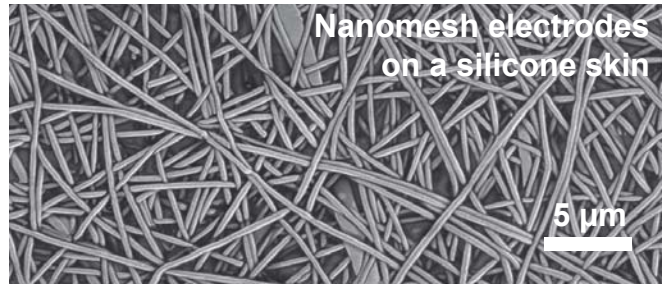
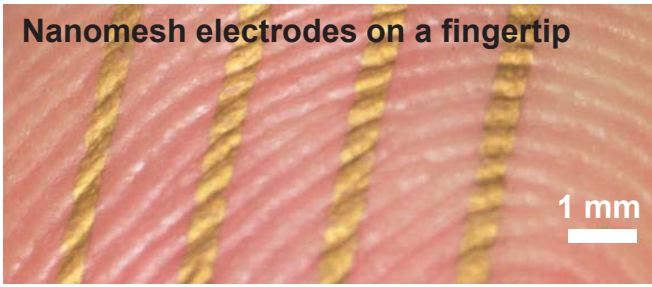
1. A nanomesh is made of polyvinyl-alcohol (PVA) by an electrospinning method.
2. Gold patterns are formed by vacuum evaporation through a shadow mask.
3. Nanomesh electrodes are laminated onto the skin with dissolving PVA by spraying water.



Nature Nanotechnology (2017). DOI: 10.1038/nnano.2017.125

A nanomesh adheres to the skin. 10

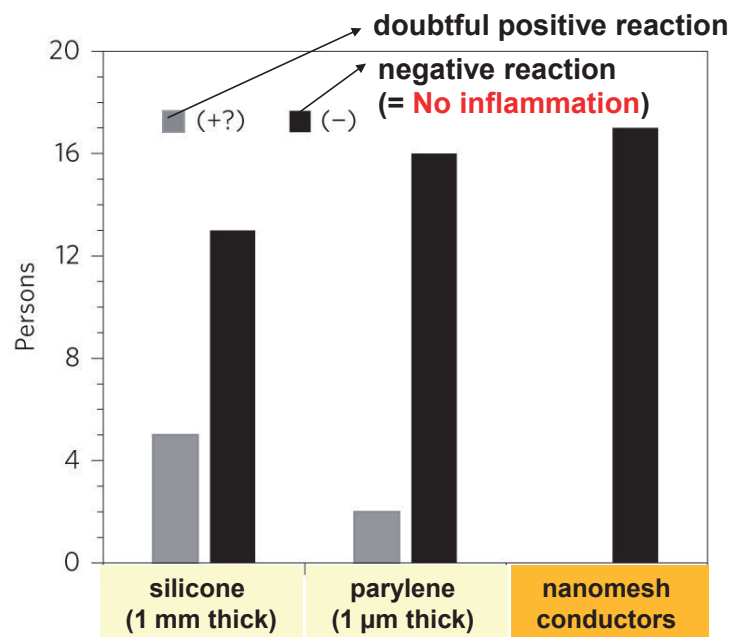
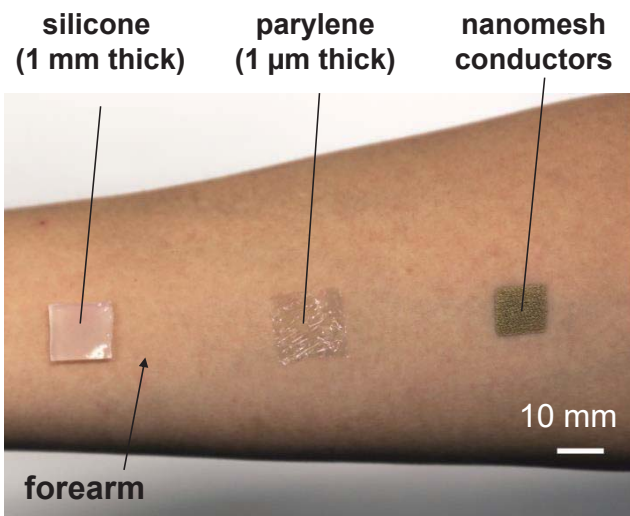
Skin sensors with nanomesh electrodes



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Biocompatibility test

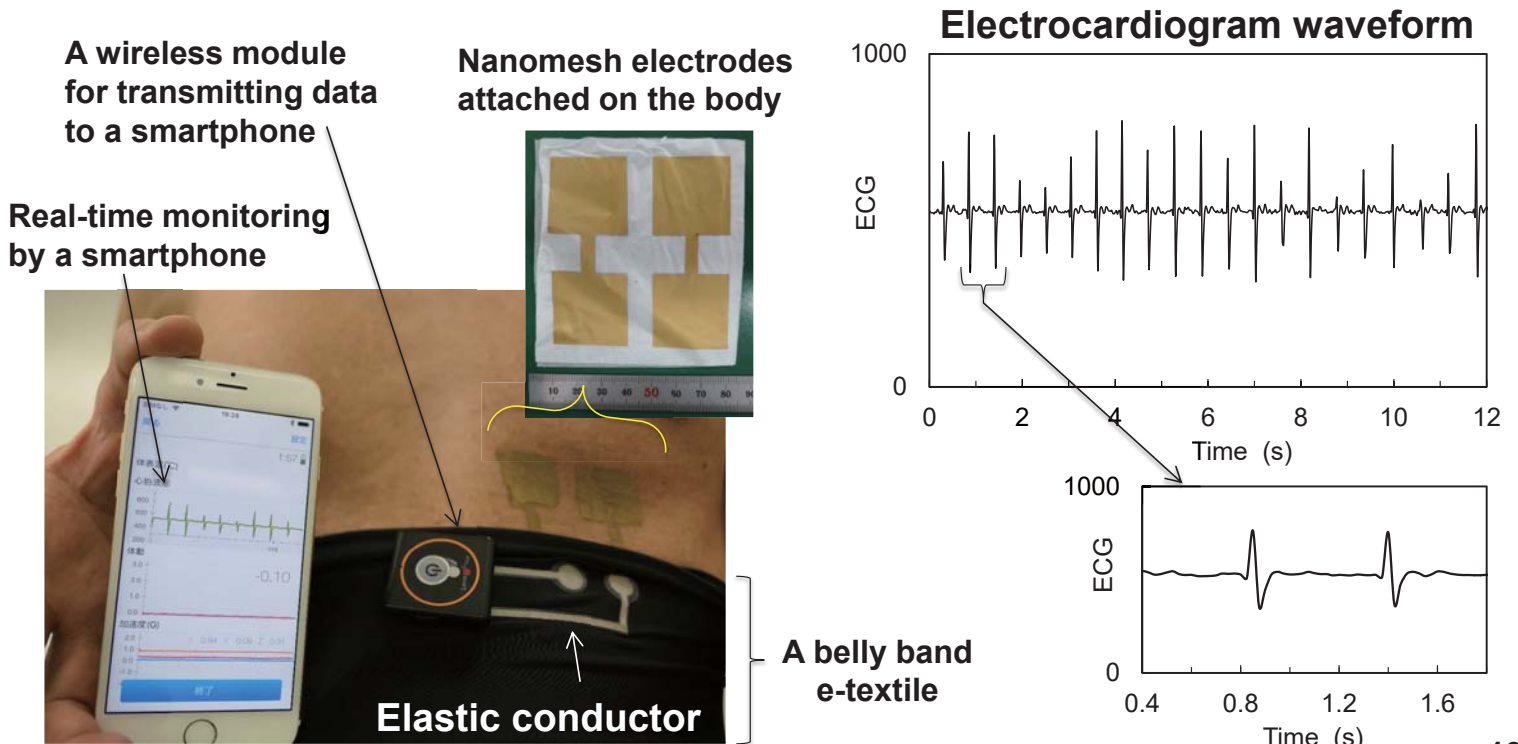
Three samples were attached to the forearm **for a week**.



Dermatitis evaluate different substrates according to the patch test criteria of the ICDRG*. * International Contact Dermatitis Research Group

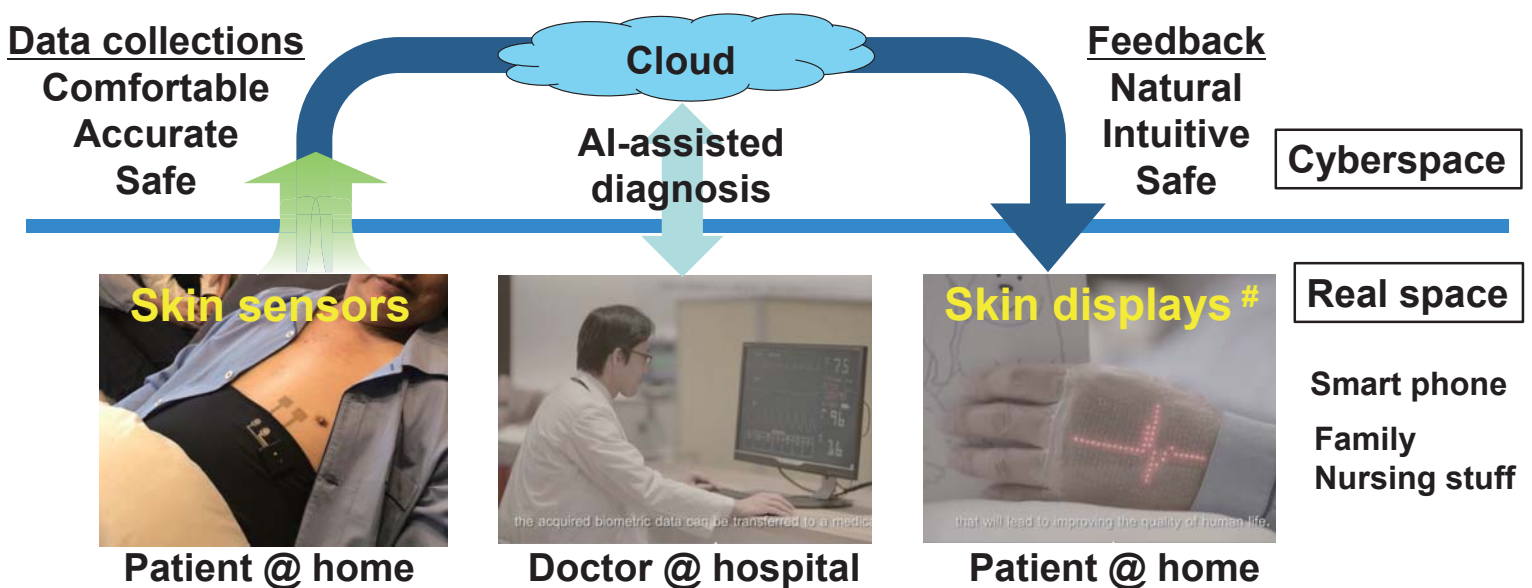
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Skin sensor to measure electrocardiogram



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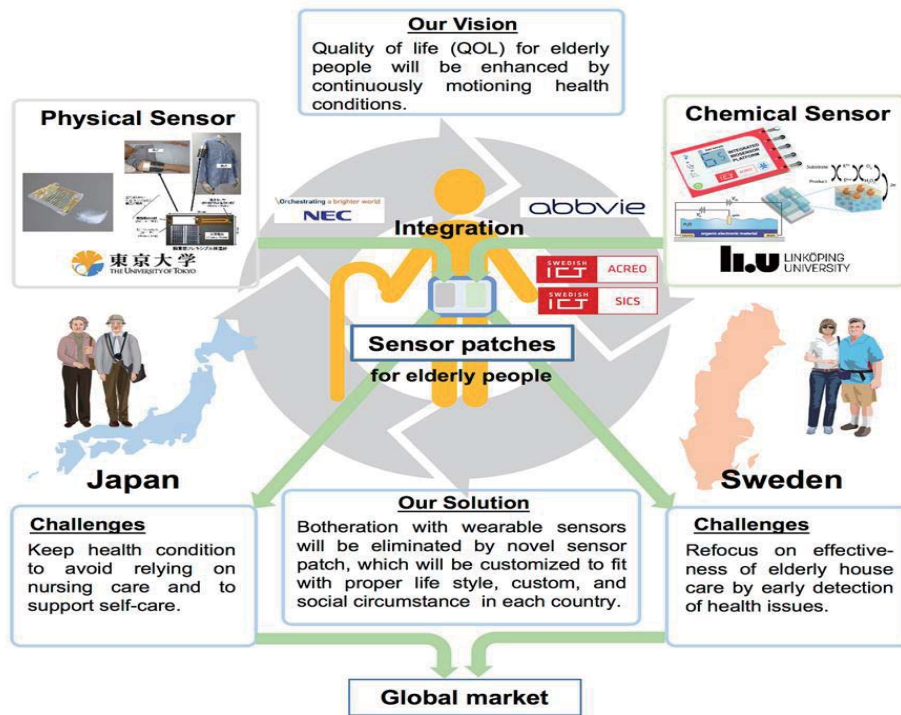
A health-monitoring system with skin electronics



A skin sensor system combined with skin display can realize a natural flow from measurement of biometric signals to display of information.

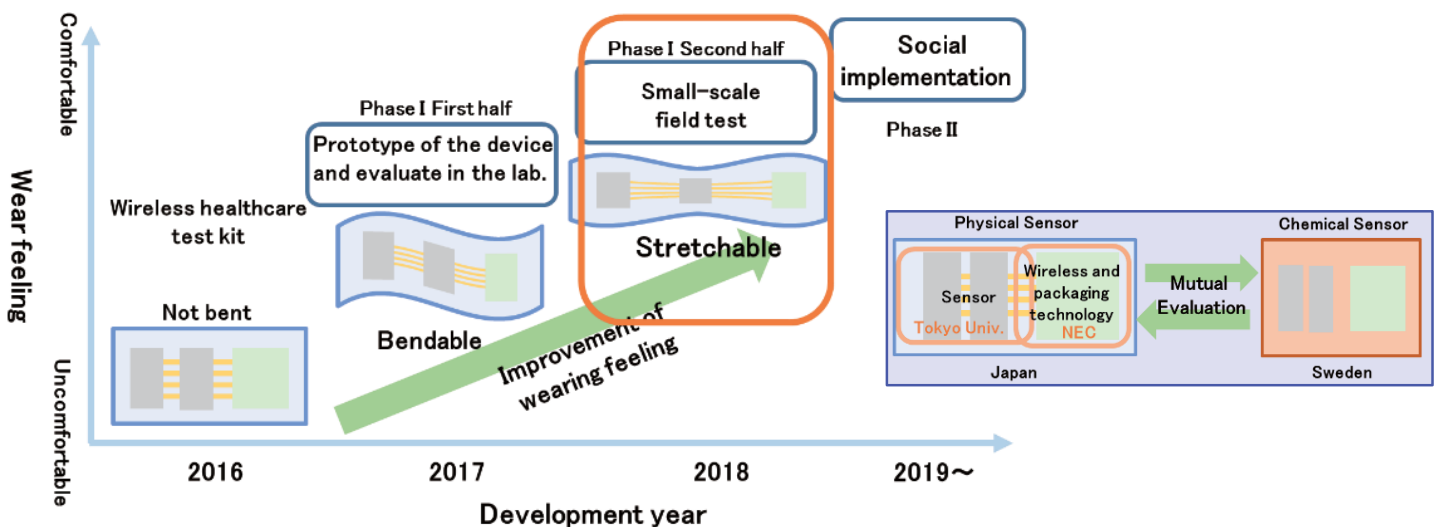
A waveform stored in memory was exhibited on a skin display in this work. 14

Overview of this project



Schedule of the project

- Promote social implementation by technologies to reduce discomfort in wearable devices and realize a healthy life for elderly people
- NEC would like to contribute to improving the practicality of physical sensors developed at the Univ. of Tokyo by providing wireless and packaging technologies.



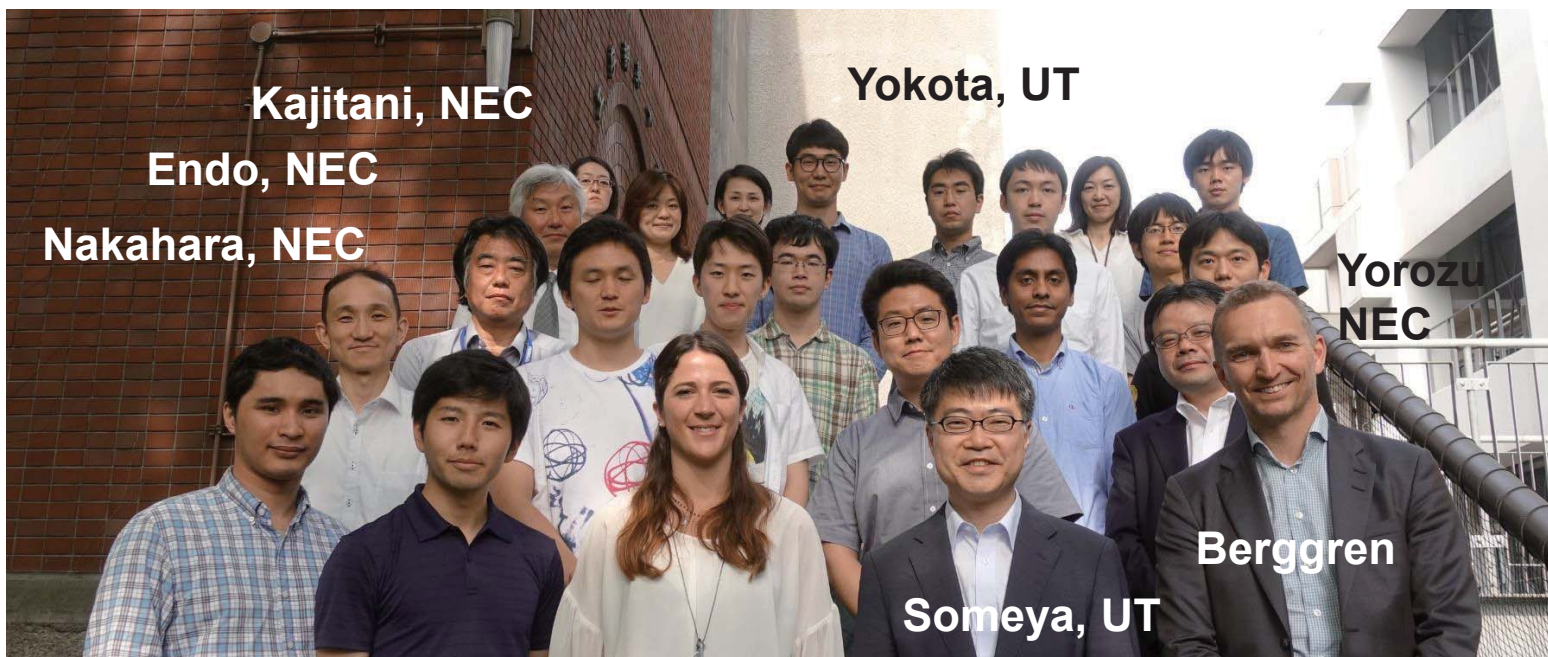
Summary

- The new-type wearable sensors with excellent wearing feeling have been developed by using skin electronics.
- A wireless module for skin sensors has been miniaturized and data collection platform has been developed.
- We will conduct a sensing test integrating with Swedish chemical sensors.

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Acknowledgements

This research is supported by JST and VINNOVA.



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