

L'électronique biosourcé intégré dans des vêtements intelligents communicants



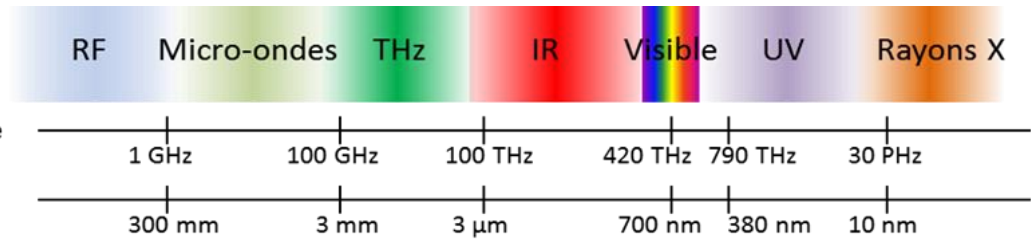
École Normale Supérieure de Rennes

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- 1. Télécommunications
- 2. Electronique biosourcé et eco-friendly
- 3. Vêtement intelligents
- 4. Conclusion

1. Télécommunications

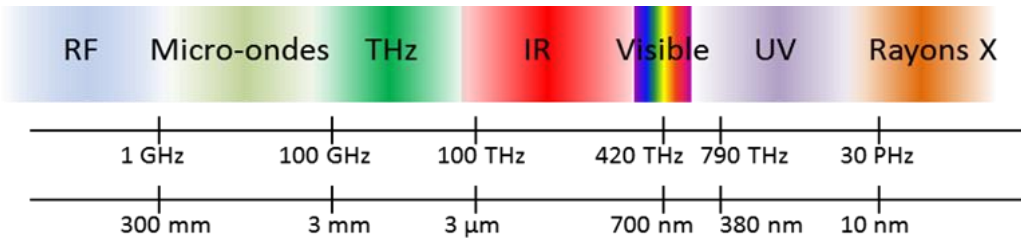
1.1. Les TeraHertz



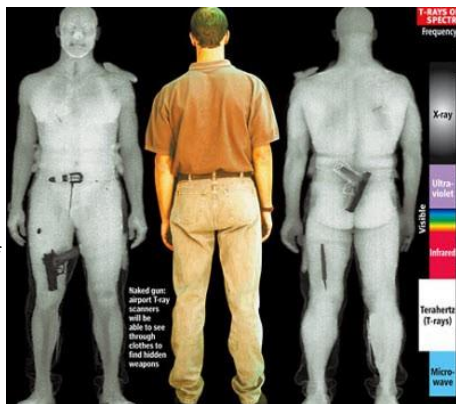
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1. Télécommunications

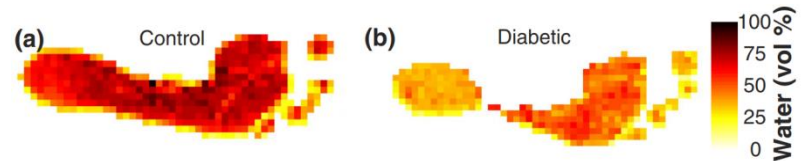
1.1. Les TeraHertz



Securité et défense



Médical



G. G. Hernandez-Cardoso, «Terahertz imaging for early screening of diabetic foot syndrome: A proof of concept», *Scientific Reports* volume 7, Article number: 42124 (2017).

Bâtiment

Photovoltaïque

Viticulture

Sport

Eolien

Alimentaire

Plastique

Automobile

Papeterie

Pharmacie

Naval

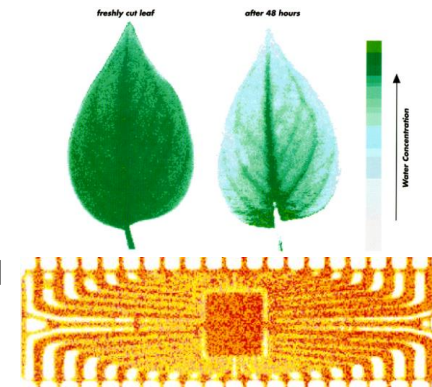
Semiconducteur

Spatial

Nucléaire

Armurerie

Industries



B. B. Hu et M. C. Nuss, « Imaging with terahertz waves », *Opt. Lett.*, *OL*, vol. 20, no 16, p. 1716-1718, août 1995.

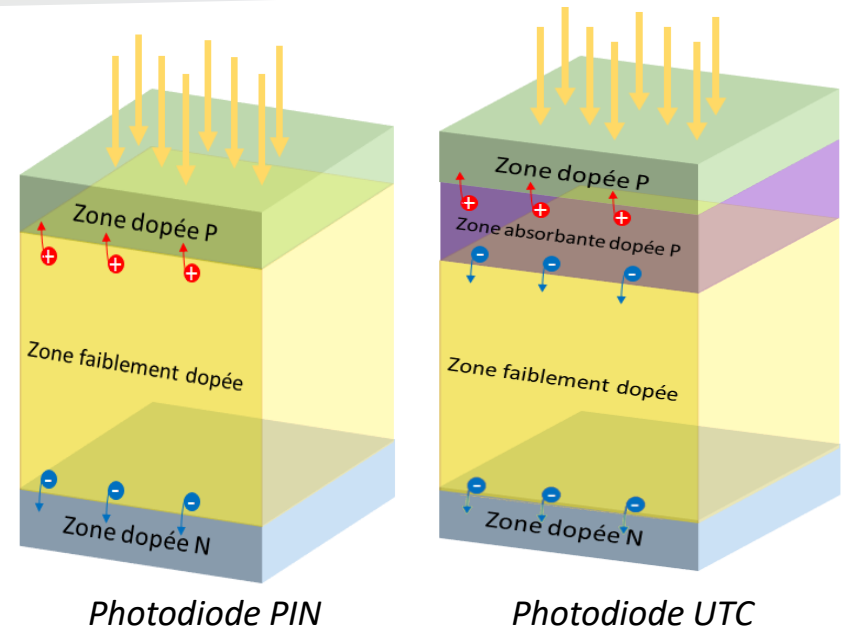
- 1. Télécommunications
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P. Chandrayan, «How TeraHertz Technology Will Change The World Of Wireless Communication ?», *Codeburst.io*, avril 2018.

1. Télécommunications

1.2. Les sources

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- 2. Electronique biosourcé et eco-friendly
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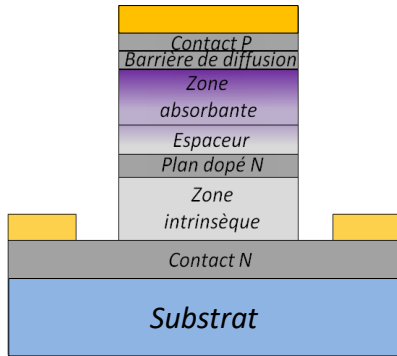
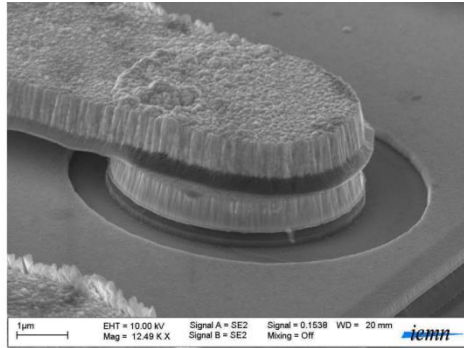
$$C = \epsilon \frac{S}{e}$$

$\epsilon = \epsilon_0 \epsilon_R$: permittivité absolue (F/m)
 S : surface des électrodes / armatures (m²)
 e : épaisseur de la zone faiblement dopée

1. Télécommunications

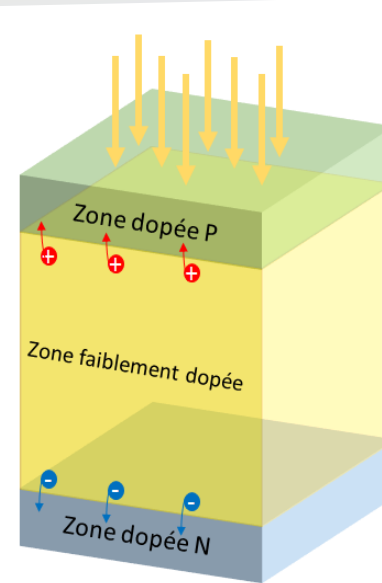
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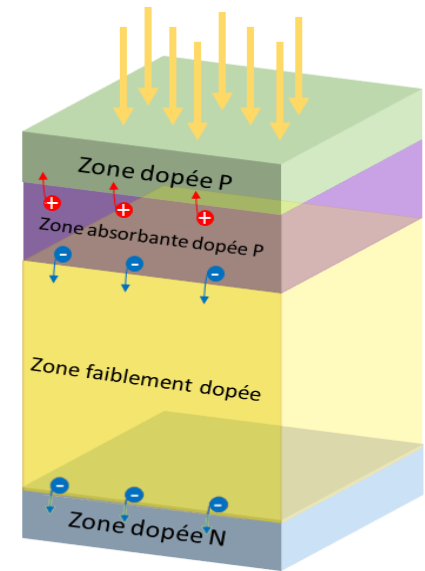


$\lambda = 1,55 \mu\text{m}$

0,3 μW @ 300 GHz ($P_{opt} = 43 \text{ mW}$)



Photodiode PIN



Photodiode UTC

$$C = \epsilon \frac{S}{e}$$

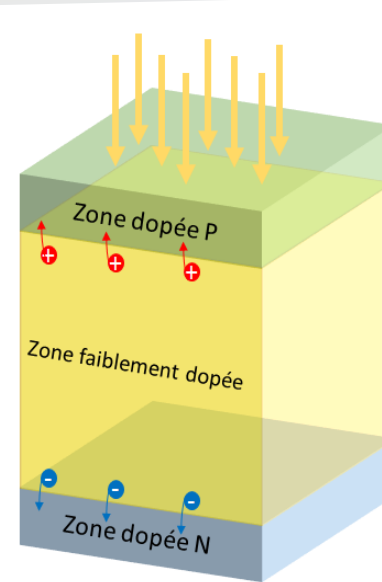
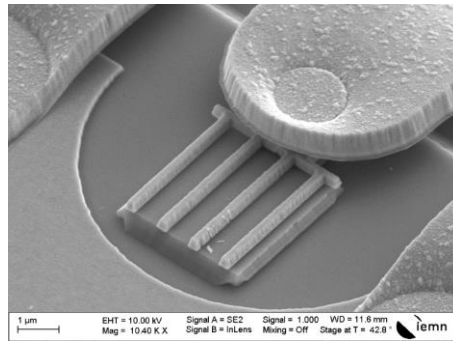
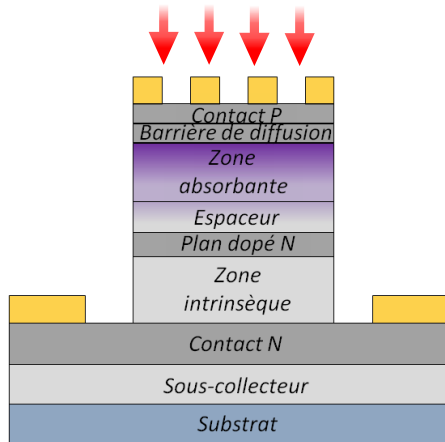
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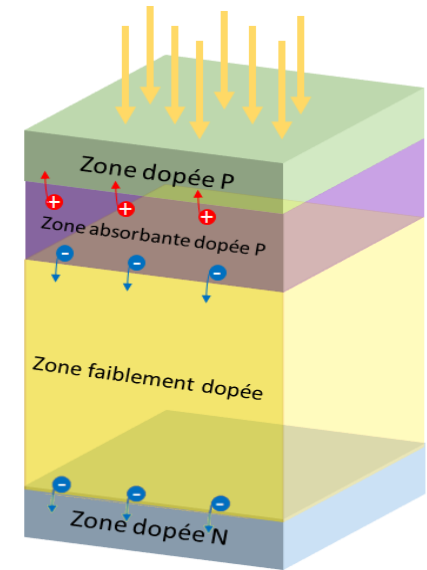
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$\lambda = 1,55 \mu\text{m}$



Photodiode PIN



Photodiode UTC

0,3 μW @ 300 GHz ($P_{\text{opt}} = 43 \text{ mW}$)

394 μW @ 300 GHz ($P_{\text{opt}} = 200 \text{ mW}$)

$$C = \epsilon \frac{S}{e}$$

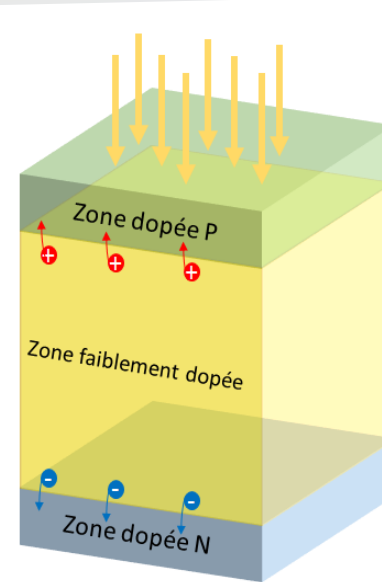
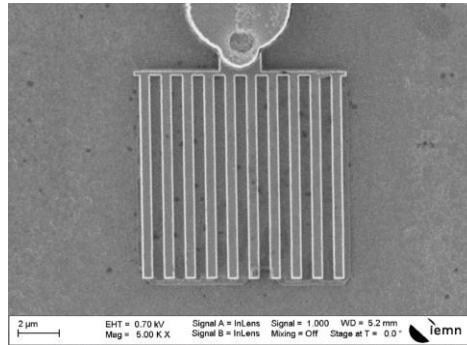
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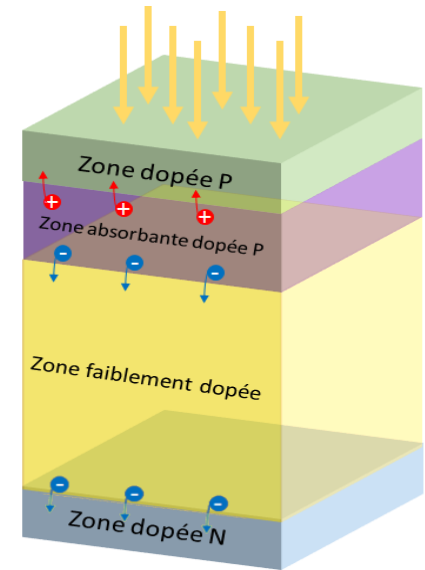
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$$\lambda = 1,55 \mu\text{m}$$



Photodiode PIN



Photodiode UTC

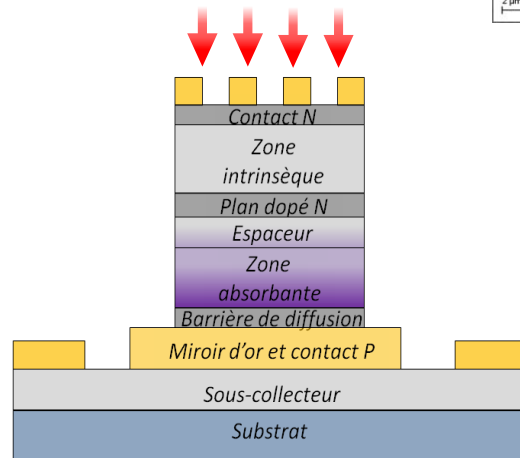
0,3 μW @ 300 GHz ($P_{\text{opt}} = 43 \text{ mW}$)

394 μW @ 300 GHz ($P_{\text{opt}} = 200 \text{ mW}$)

$\approx 1 \text{ mW}$ @ 300 GHz ($P_{\text{opt}} = 83 \text{ mW}$)

$$C = \epsilon \frac{S}{e}$$

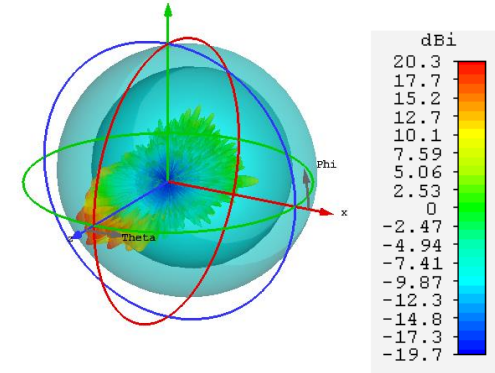
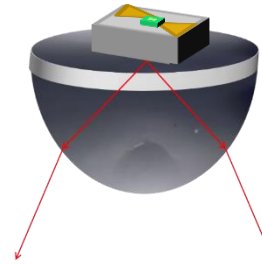
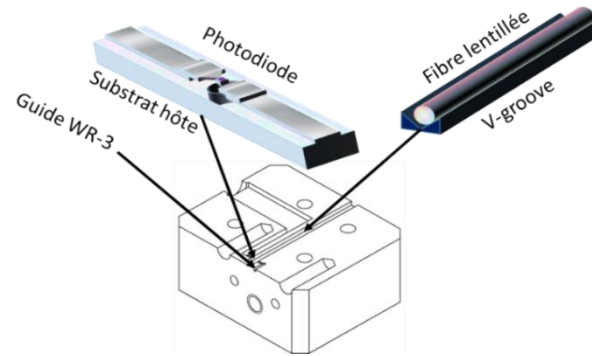
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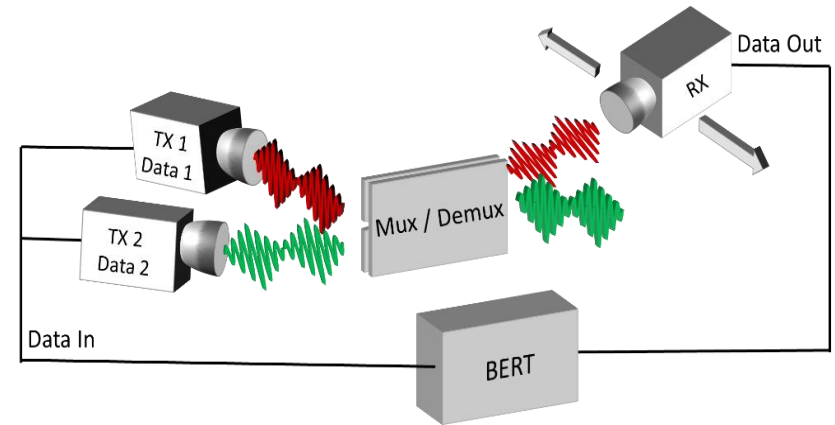
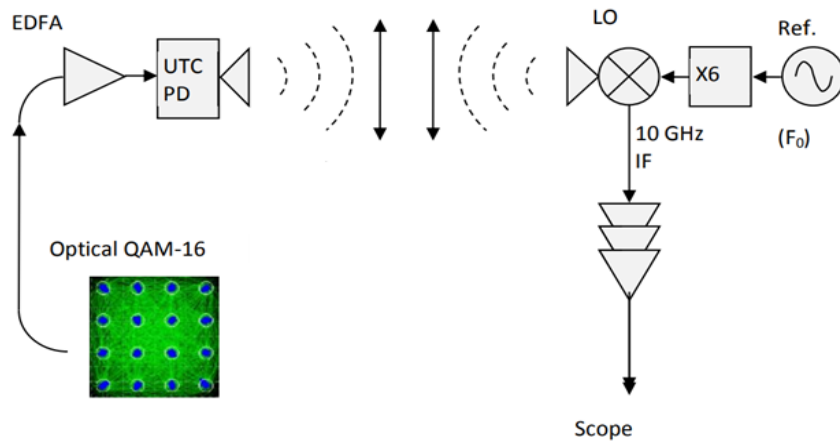
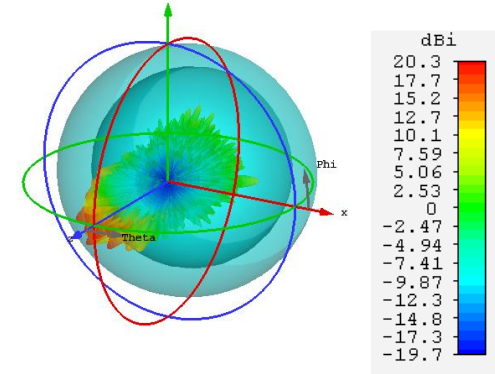
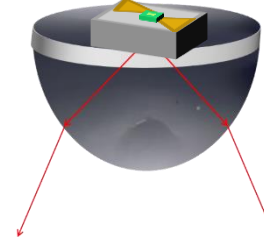
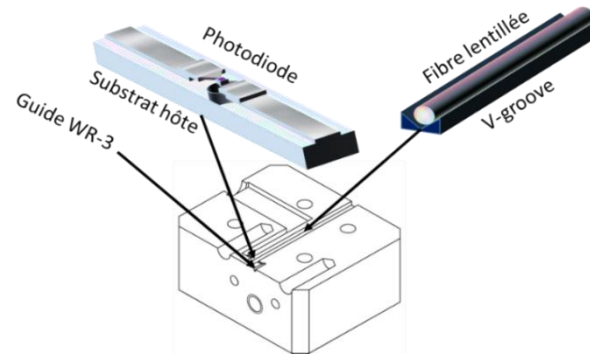
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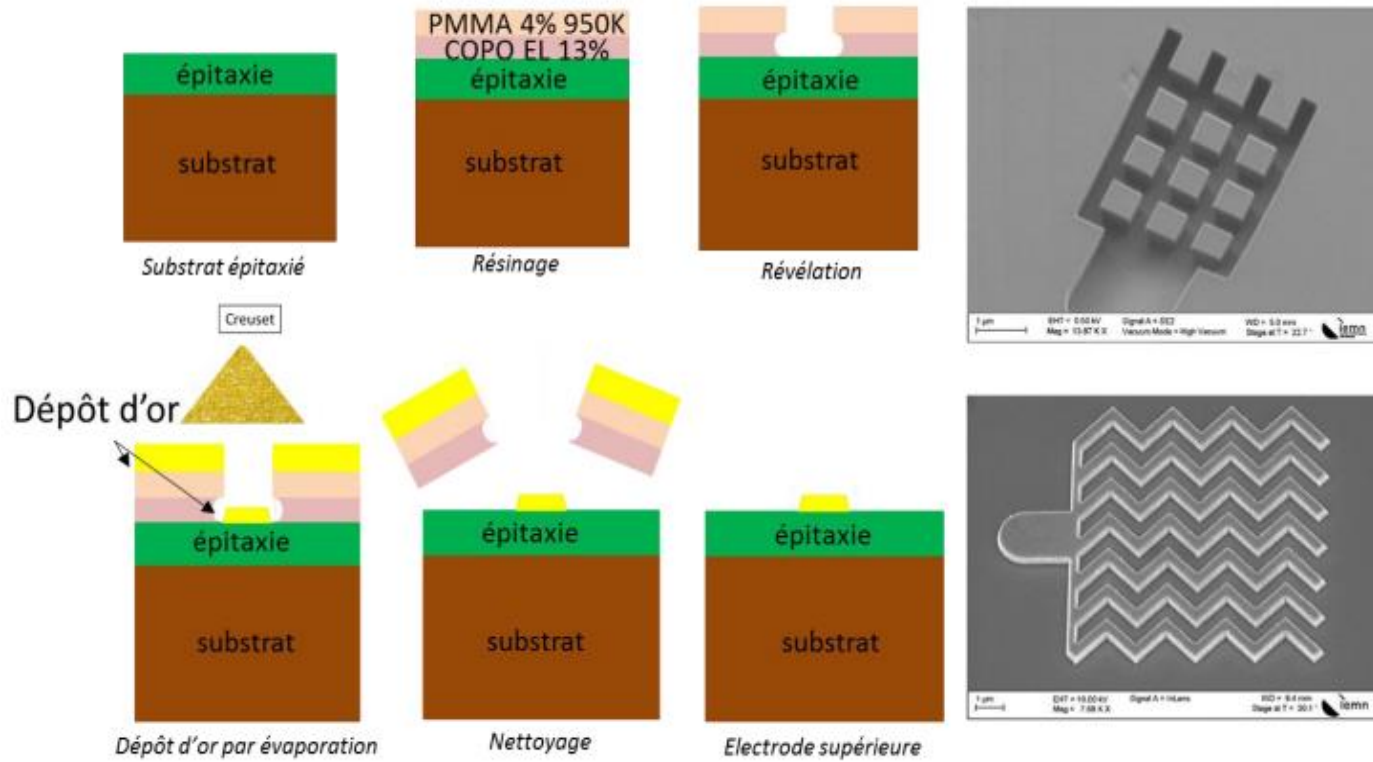
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1. Télécommunications

1.3. La microfabrication

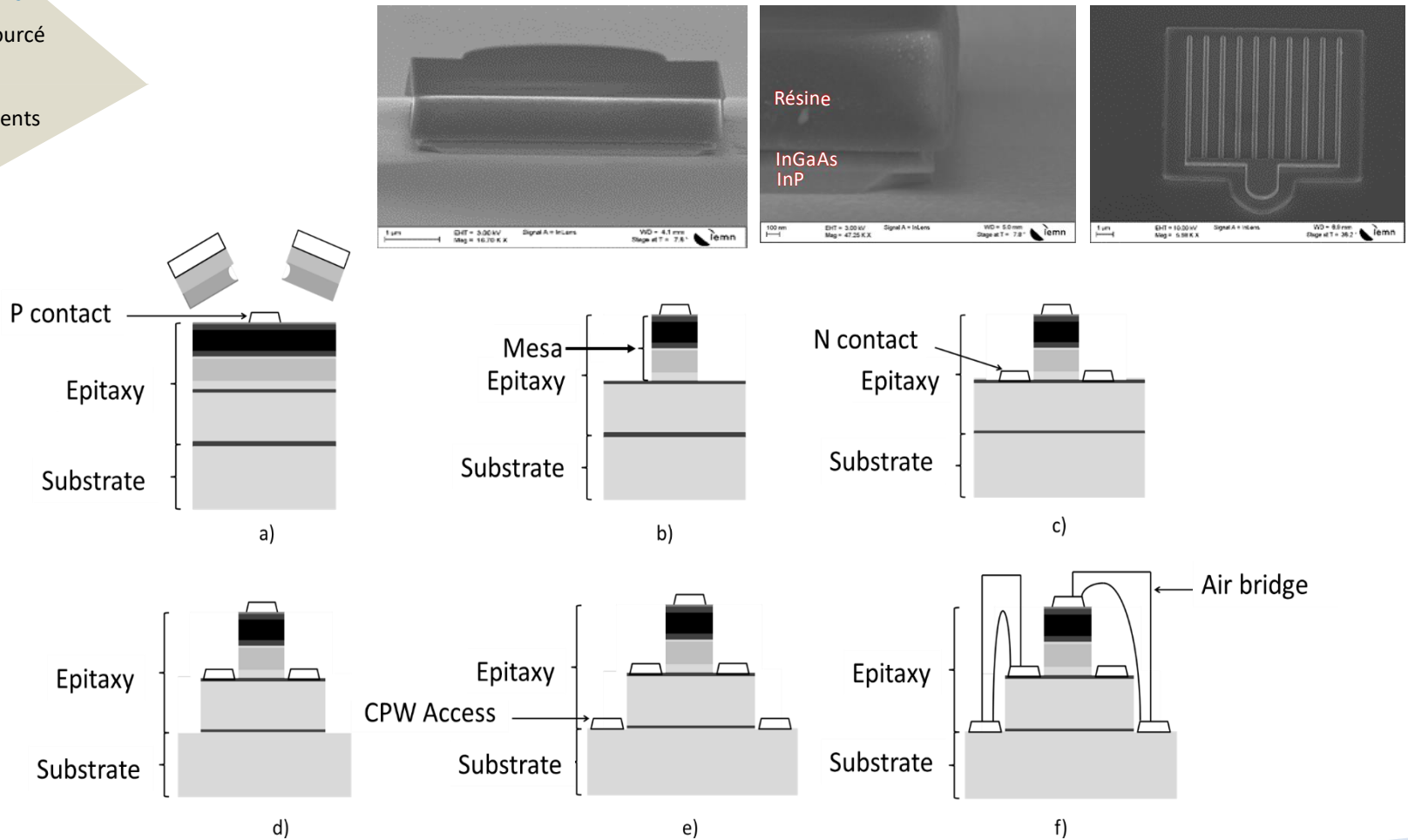
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1. Télécommunications

1.3. La microfabrication

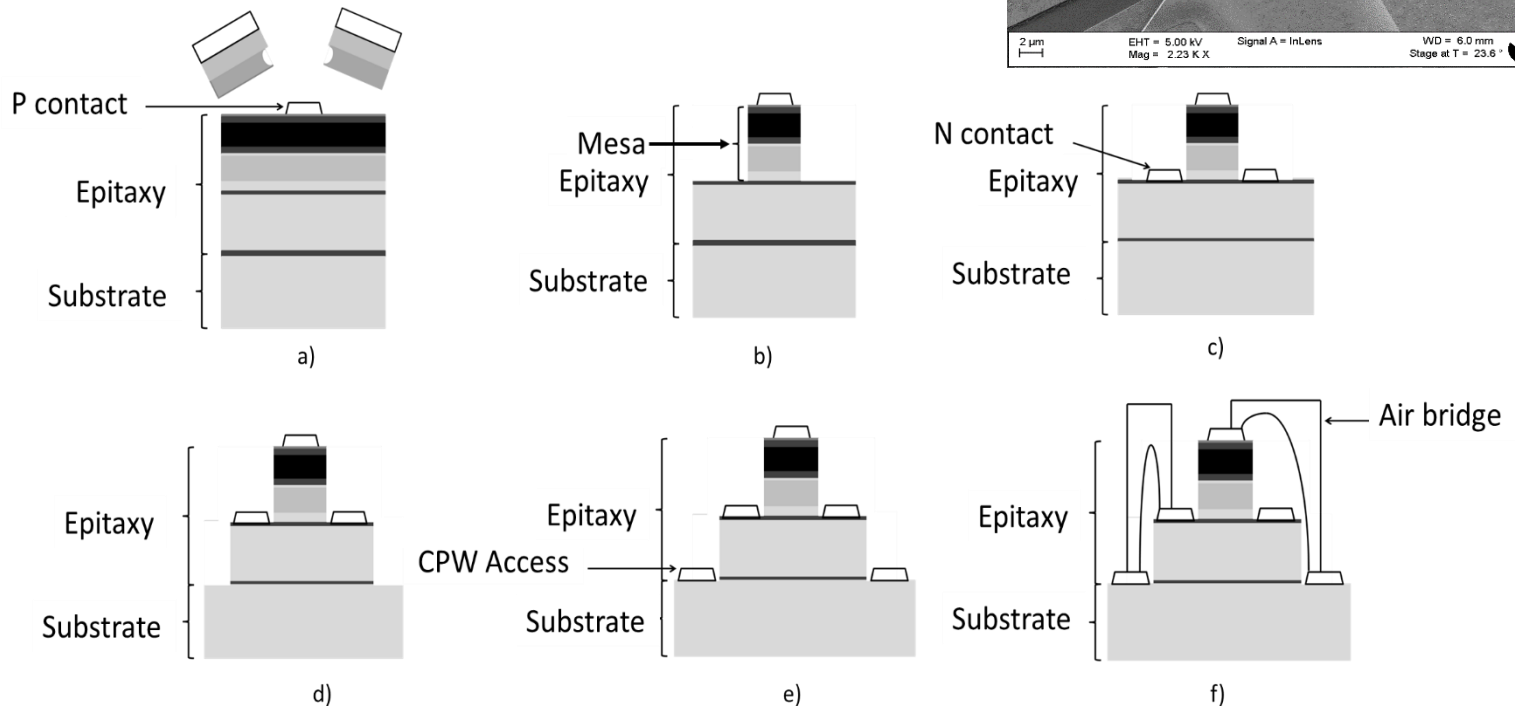
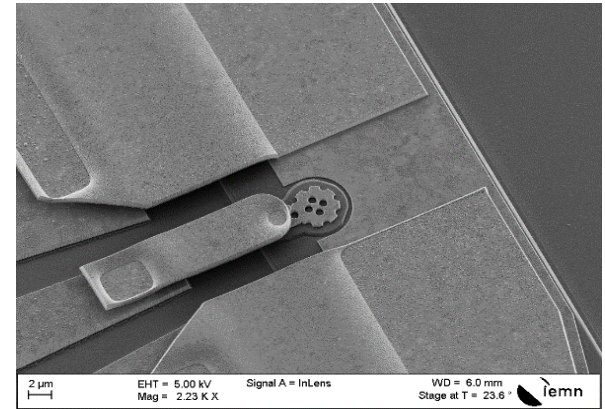
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1. Télécommunications

1.3. La microfabrication

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1. Télécommunications

1.3. La microfabrication

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Corrosif



Toxicité aiguë



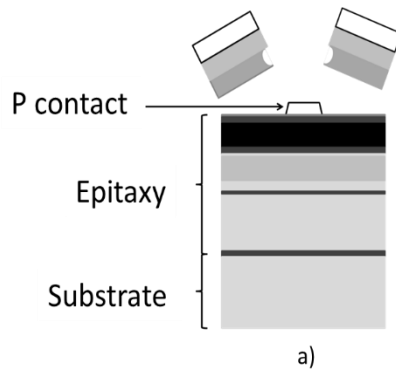
Nocif ou irritant



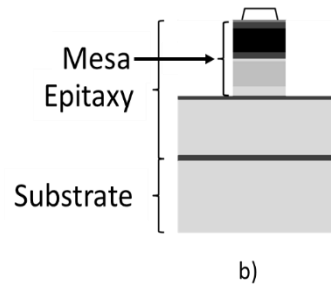
Danger pour la santé



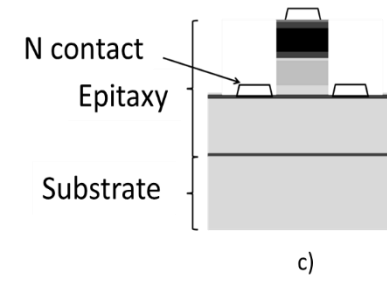
Danger pour l'environnement



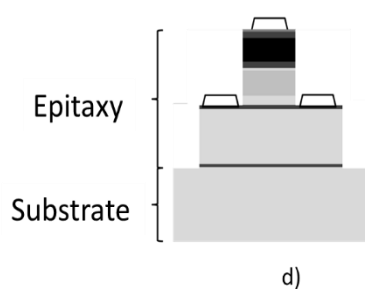
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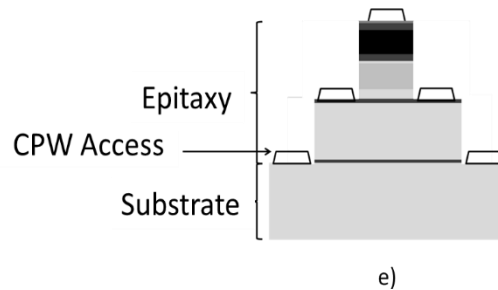
b)



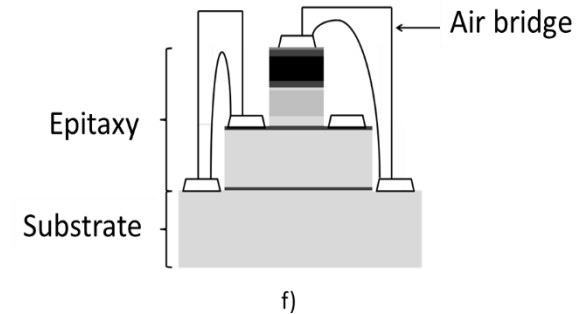
c)



d)



e)



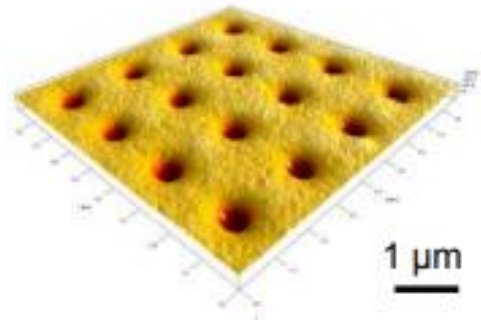
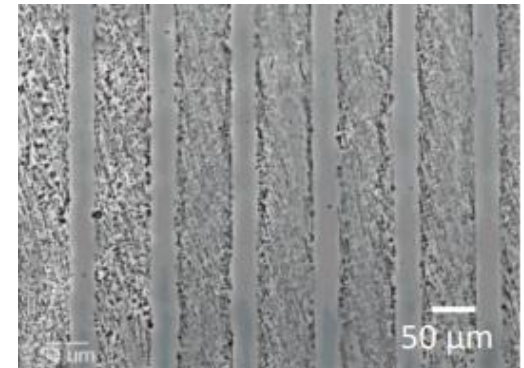
f)

2. Electronique Biosourcé et eco-friendly

2.1. Fabrication écoresponsable

Résines

Kumar G., et al., Spatially controlled cell engineering on biomaterials using polyelectrolytes. Langmuir 19, 10550–10556 (2003).



Voznesenskiy, et al., Y. Study of Biopolymer Chitosan as Resist for Submicron Electronic Lithography. Solid State Phenom. 213, 180–185 (2014).



Larisch, W. et al. Proton beam writing of microstructures in Agar gel for patterned cell growth. Nucl. Instruments Methods Phys. Res. Sect. B Beam Interact. with Mater. Atoms 269, 2444–2447 (2011).

- Révélateurs
- Solutions de gravure
- Substrats

2. Electronique Biosourcé et eco-friendly

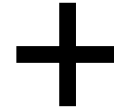
2.2. Matériaux bio-sourcés

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Photovoltaïque



P. Enciso, et al., « Photovoltaic cells based on the use of natural pigments: Phycoerythrin from red-antarctic algae as sensitizers for DSSC », MRS Advances, vol. 3, n° 61, p. 3557-3562, déc. 2018.



P. K. Sinha, et al., « Green Algae, Sunflower Seed and Reduced Graphene Oxide in Organic Photovoltaic Cell », in 2018 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS), févr. 2018, p. 136-138.

2. Electronique Biosourcé et eco-friendly

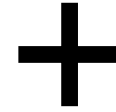
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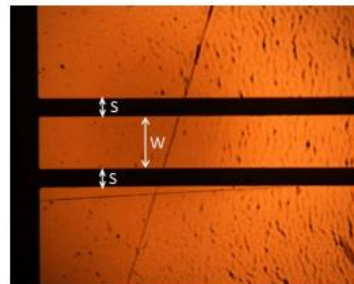
P. K. Sinha, et al., « Green Algae, Sunflower Seed and Reduced Graphene Oxide in Organic Photovoltaic Cell », in *2018 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS)*, févr. 2018, p. 136-138.

Encapsulation



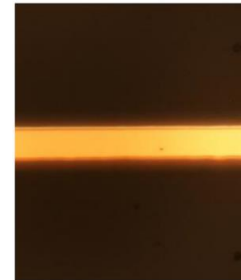
Résine 816 G - Axxon

Hyperfréquences



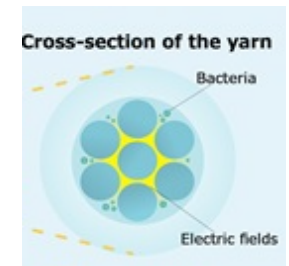
P.-Y. Cresson, et al., « Wideband (10–67 GHz) Dielectric Properties of Biosourced Cellulose Ester Flexible Films », *IEEE Transactions on Microwave Theory and Techniques*, vol. 68, n° 6, p. 2144-2150, juin 2020.

Thermique



G. Boussatour, et al., « Measurement of the thermal conductivity of flexible biosourced polymers using the 3-omega method », *Polymer Testing*, vol. 70, p. 503-510, sept. 2018.

Piézoélectrique



PIECLEX
UTILIZE YOUR ENERGY

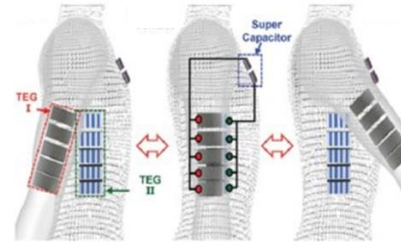
3. Des vêtements intelligents

3.1. Des vêtements autonomes

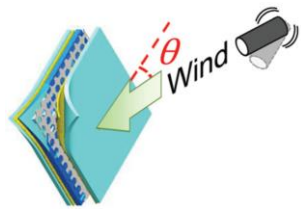
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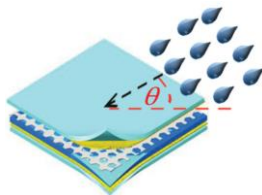
S. Dong, F. Xu, Y. Sheng et al., « Seamlessly knitted stretchable comfortable textile triboelectric nanogenerators for E-textile power sources », *Nano Energy*, vol. 78, p. 105327, déc. 2020.



M. Geisler, « Récupération d'énergie mécanique pour vêtements connectés autonomes », *phd thesis, Université Grenoble Alpes*, 2017.



Récupérateur de l'énergie du vent



Récupérateur de l'énergie de la pluie

Y.-C. Lai, et al., « Waterproof Fabric-Based Multifunctional Triboelectric Nanogenerator for Universally Harvesting Energy from Raindrops, Wind, and Human Motions and as Self-Powered Sensors », *Advanced Science*, vol. 6, n° 5, p. 1801883, 2019.

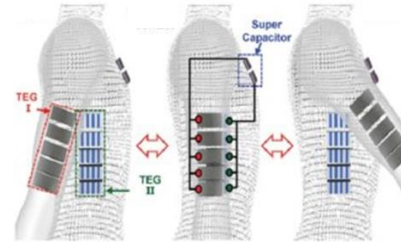
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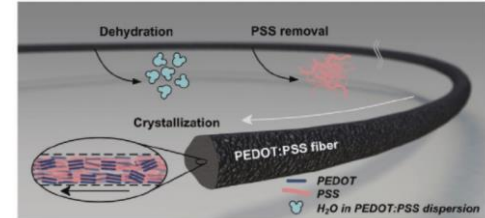
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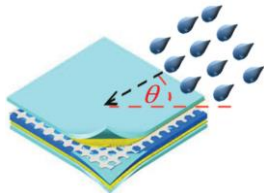
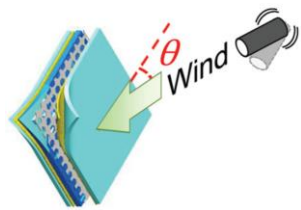
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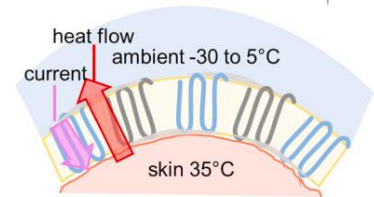


Y. Kim et al., « Robust PEDOT:PSS Wet-Spun Fibers for Thermoelectric Textiles », *Macromolecular Materials and Engineering*, vol. 305, n° 3, p. 1900749, 2020.



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A. Lund, Y. Tian, S. Darabi, et al., « A polymer-based textile thermoelectric generator for wearable energy harvesting », *Journal of Power Sources*, vol. 480, p. 228836, déc. 2020.

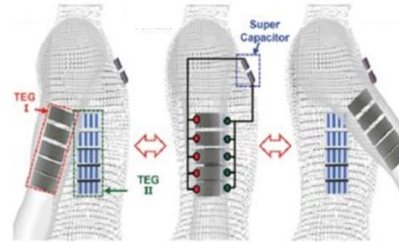
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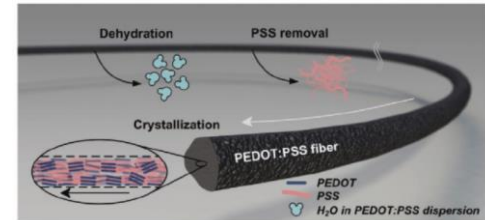
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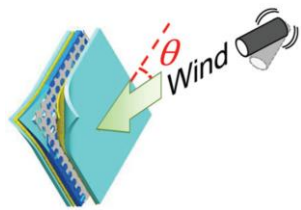
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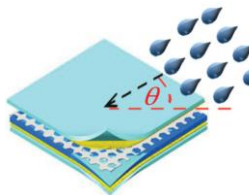


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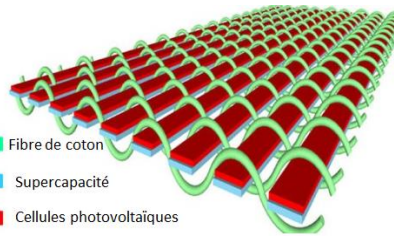


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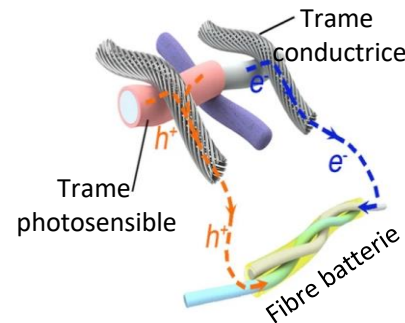


Récupérateur de l'énergie de la pluie

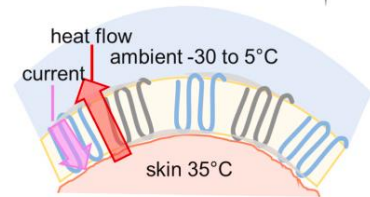


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3. Des vêtements intelligents

3.2. Des vêtements communicants

- 1. Télécommunications
- 2. Electronique biosourcé et eco-friendly
- 3. Vêtements intelligents
- 4. Conclusion



Y.-Q. Fan, F. Gao, M. Wang et al., « Recent Development of Wearable Microfluidics Applied in Body Fluid Testing and Drug Delivery », *Chinese Journal of Analytical Chemistry*, vol. 45, n° 3, p. 455-463, mars 2017.



TEXISOCKS™

- Correction de mauvaises postures
- Caractériser le mouvement.

Sport

Médecine

Industrie

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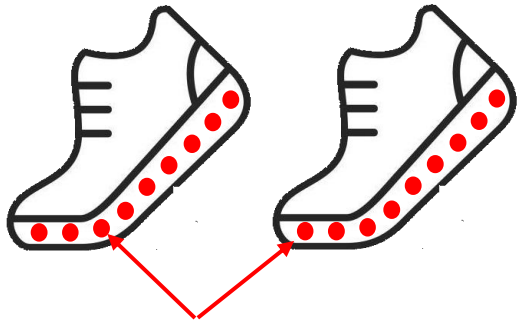
TEXISOCKS™

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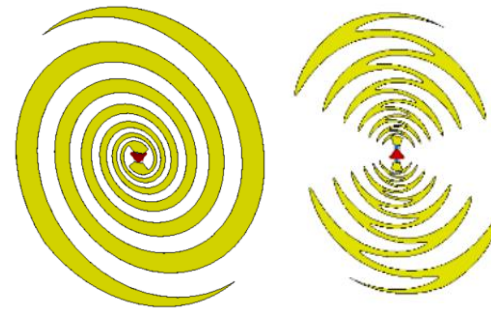
Sport

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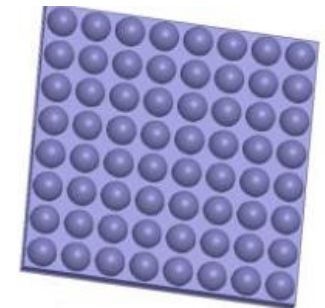
Industrie



Multiple systèmes communicants pour déterminer la distance parcourue.



Antennes



Réseau de lentilles

Merci de votre attention