Concours de
VULGARISATION SCIENTIFIQUE
2024

NOUVELLE GAGNANTE

CATÉGORIE : SCIENCES NATURELLES ET GÉNIE

Germanium Membranes: A New Twist on an Old Material

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Phones, computers, and other gadgets play a big part in our daily lives, and they all need special materials called semiconductors to work. There are many different semiconductors, each having their specific use and application varying from colored LEDs (light-emitting diodes) to computer processors, but today we will focus on one specific semiconductor called Germanium (Ge).

What's Germanium and Why Should We Care?

You might not have heard of Ge, but it has been a part of our electronics for many years. However, finding Ge is a bit like looking for a needle in a haystack. It's very rare, making up only a tiny fraction of the Earth's crust (less than 0.00015 %)[1], and it's tough to extract without harming the environment. This may for example involve burning tons of Ge-rich coal to obtain just a few grams of this rare material. Nonetheless, Ge has played a pivotal role in technology for over 70 years, contributing to create everything from the first transistors for modern computers in the late 40's to today's high-tech gadgets in satellites and autonomous cars, or high-performance solar panels.

Now here's where it gets interesting. Usually, Ge is used in thick pieces, but only a super-thin (ten times thinner than a hair) part of it is necessary for our devices to function properly. The rest ends up as dead weight and wasted material. So, scientists at 3IT (Institut interdisciplinaire d'innovation technologique) got creative and made incredibly thin Ge membranes[2], but still able to perform their function in electronics as intended. It's like using just the right amount of icing on a cake – not too much, not too little.

How are Germanium Membranes Made?

Creating these membranes involves intricate processes, but we can simplify all the science to its essentials. We start with a block of Germanium and turn its surface into a porous structure that looks like a sponge, using chemicals and electricity. This spongy structure then serves as tiny scaffolding for the deposition of the Ge membrane at just the right thickness, necessary for our devices to work[2]. We then gently move this membrane onto a plastic sheet or any other substrate, just like transferring a delicate sticker (Fig. 1a). The best part? We can clean up and reuse the original block of Ge to produce more membranes, making the most of this rare resource (Fig. 1b).

Bright future filled with membrane applications

Beyond material efficiency and cost reductions, these super-thin membranes offer groundbreaking advantages in other aspects. Their lightweight nature proves invaluable for applications in satellites where every gram matters. The flexibility of these membranes opens new horizons for electronics that you can easily bend or roll up. This also revolutionizes how we design and fabricate electronics, paving the way for entirely new types of exciting gadgets and devices that we can think of. As an increasing number of materials can be fashioned into membrane form, scientists are tirelessly exploring novel applications and implementations for these ultra-thin foils. Overall, these thin membranes enable us to use significantly less of precious materials, like Ge, in our electronics, thereby reducing our environmental impact on the planet. Moreover, the gadgets of tomorrow could surpass our wildest expectations – all thanks to these membranes.

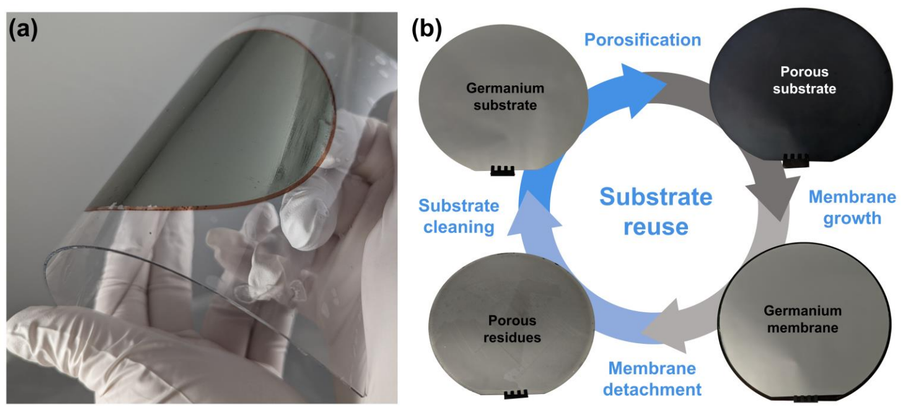

Figure 1. (a) Thin Ge membrane transferred on a flexible plastic substrate (b) Illustration of substrate reuse cycle for the production of multiple membranes from a single Ge substrate.

Références:

[1] United States Geological Survey - Germanium - Giving Microelectronics an Efficiency Boost. Available online: https://pubs.usgs.gov/fs/2015/3011/fs20153011.pdf

[2] Hanuš, T.; Ilahi, B.; Chapotot, A.; Pelletier, H.; Cho, J.; Dessein, K.; Boucherif, A. Wafer-Scale Ge Freestanding Membranes for Lightweight and Flexible Optoelectronics. Materials Today Advances 2023, 18, 100373, doi:10.1016/j.mtadv.2023.100373.

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