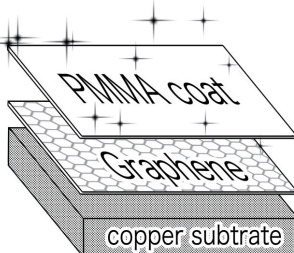
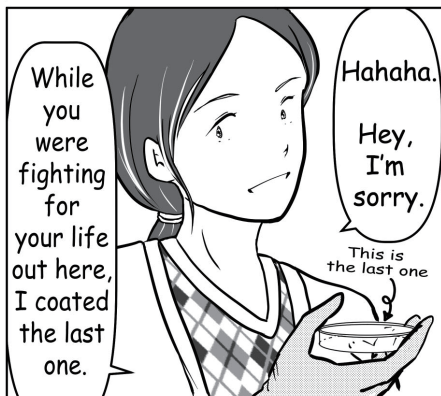


Chapter Three: The Unprecedented Nature of Terahertz-Waves

But normally we'd do a proper coating on the completed graphene, and melt the copper substrate with etchant.



We used a basic recipe this time, which is why you'd have to scoop it up with the silicon substrate on a spatula.



令和3(2021)年度学術変革領域研究(A)

2.5次元物質科学:
社会変革に向けた物質科学のパラダイムシフト

NEWS
LETTER

Welcome to the 2.5 D Laboratory

© もんでんひでこ

Previously in the series

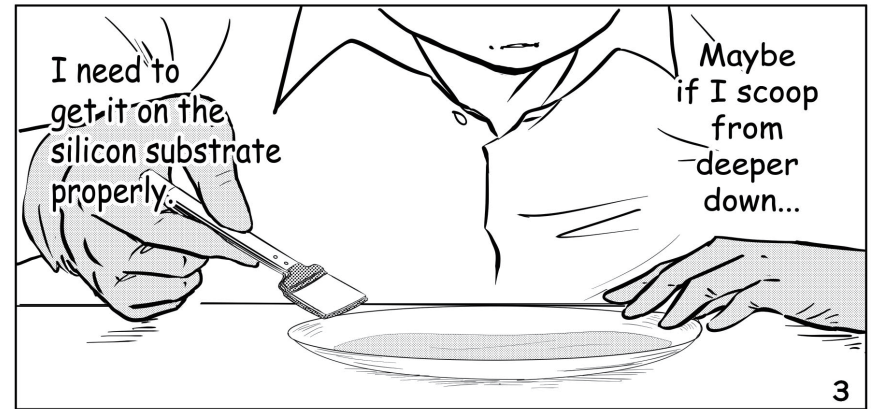
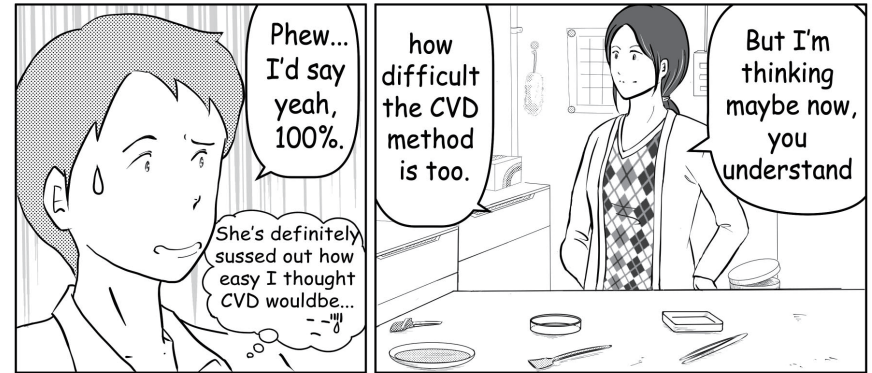
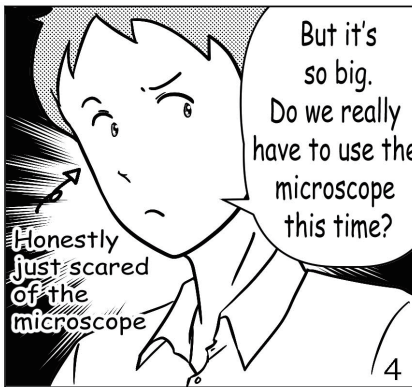
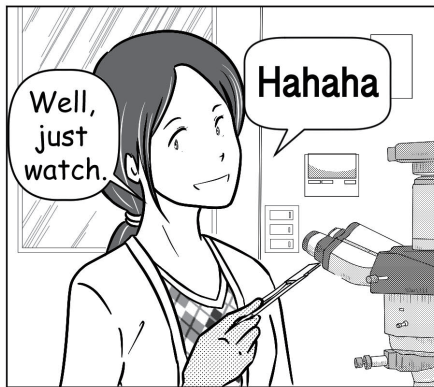
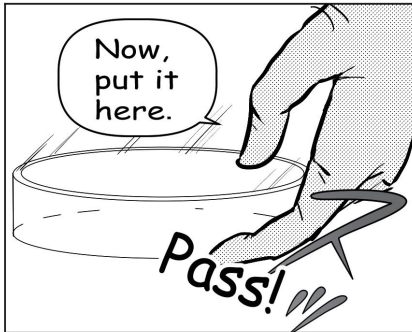
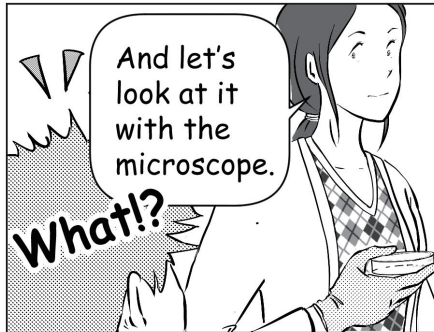
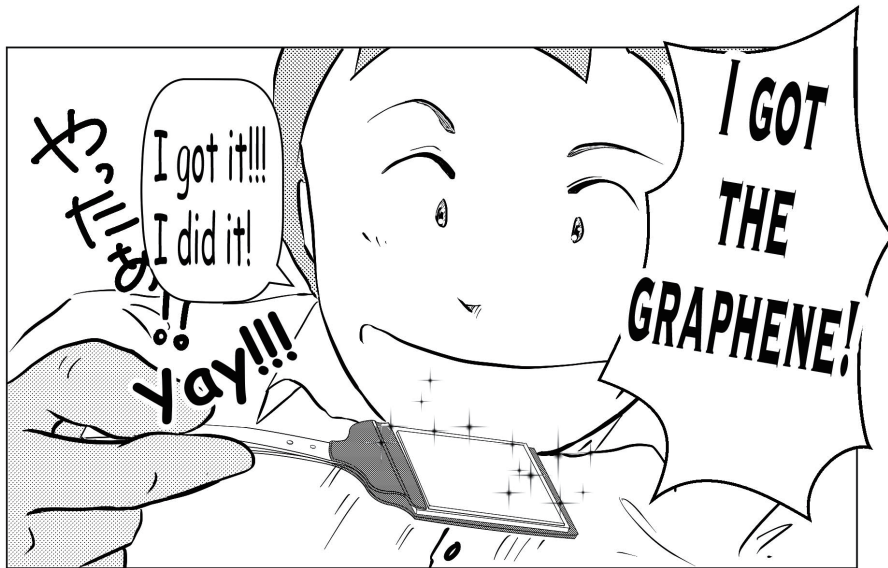
Koji Ota, a senior at university, takes on a graphene production entrance test to get into a cutting-edge science lab, but fails to get the results he needed with exfoliation.

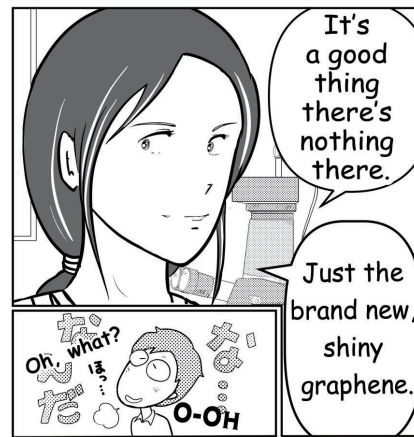
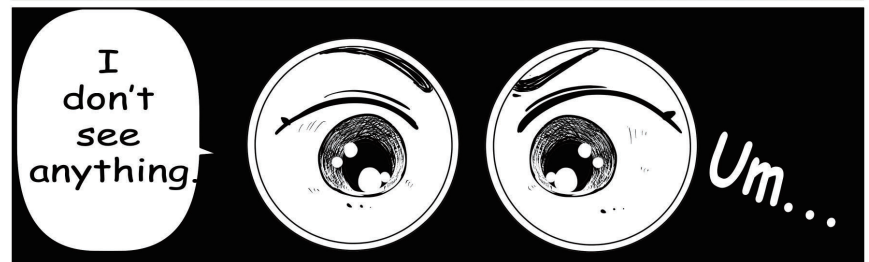
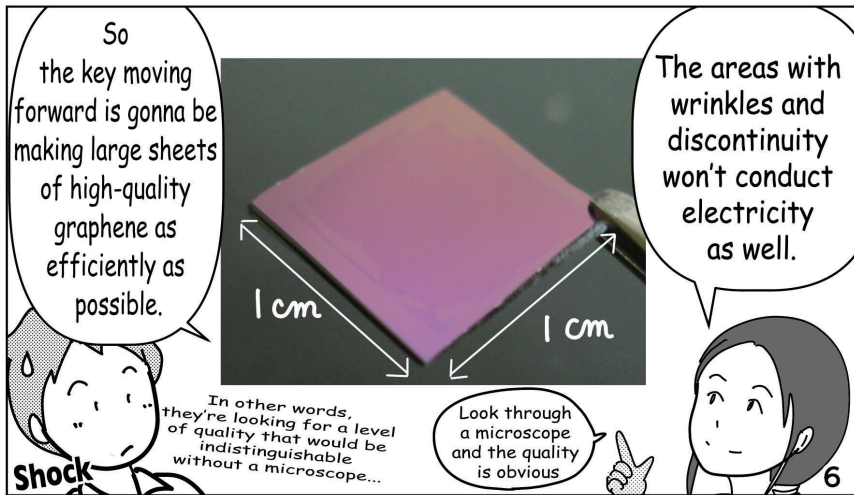
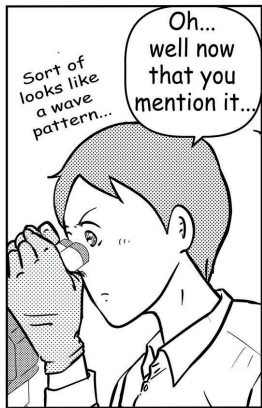
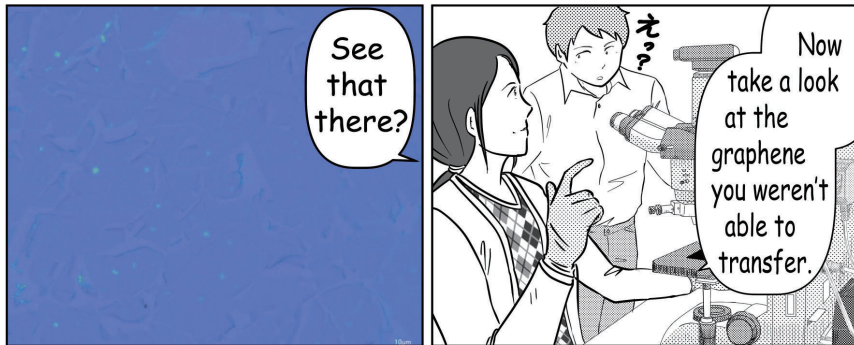
He returns to Kasuga University, confident that the CVD method, which produces large-sea graphene, would allow even him—in all his clumsiness—to pass the test.

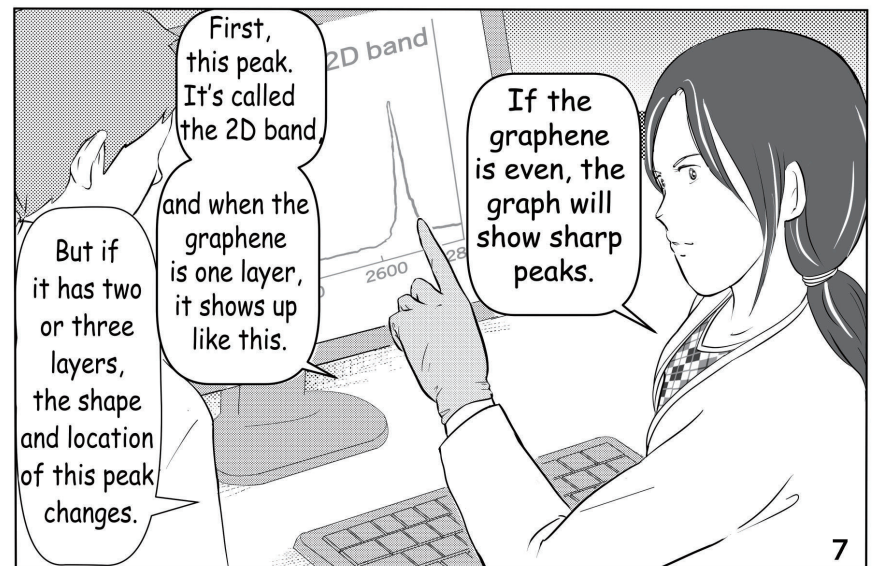
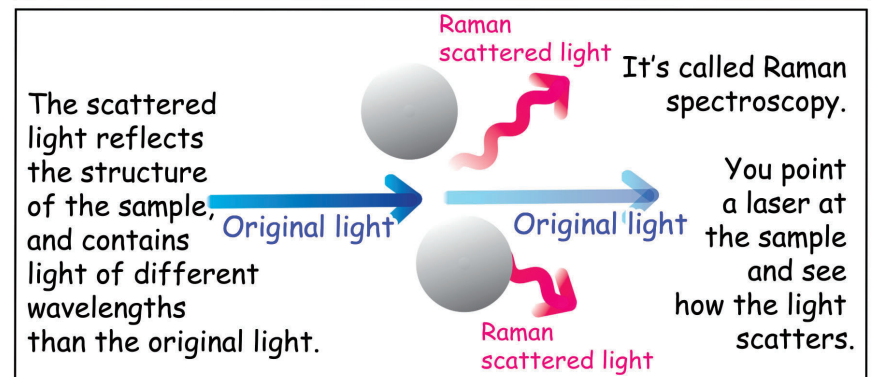
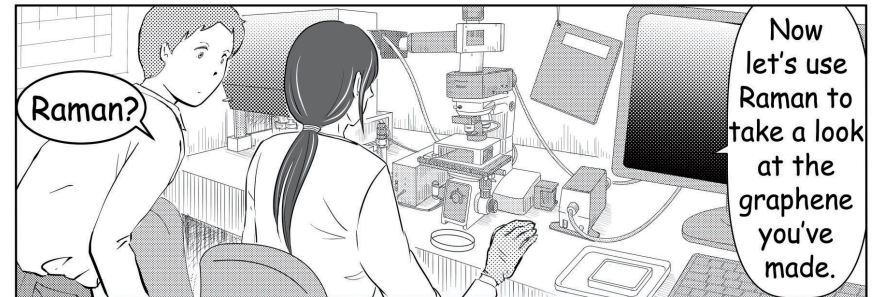
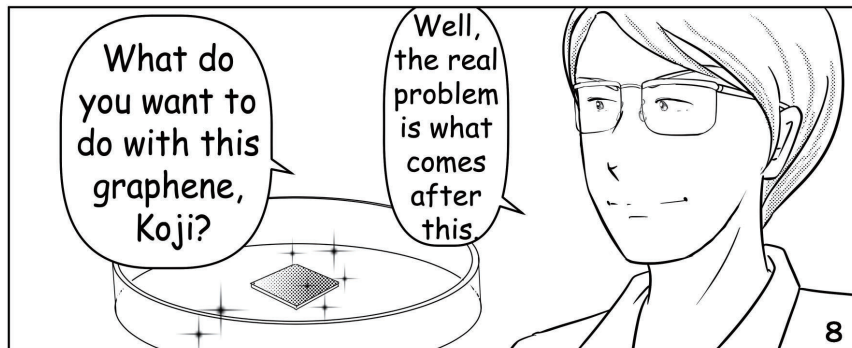
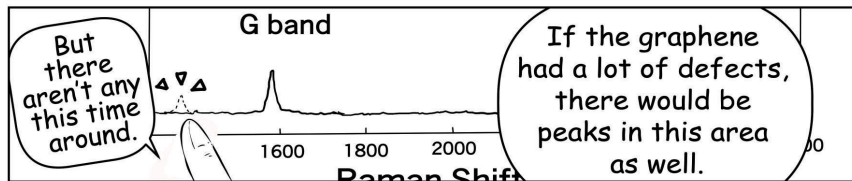
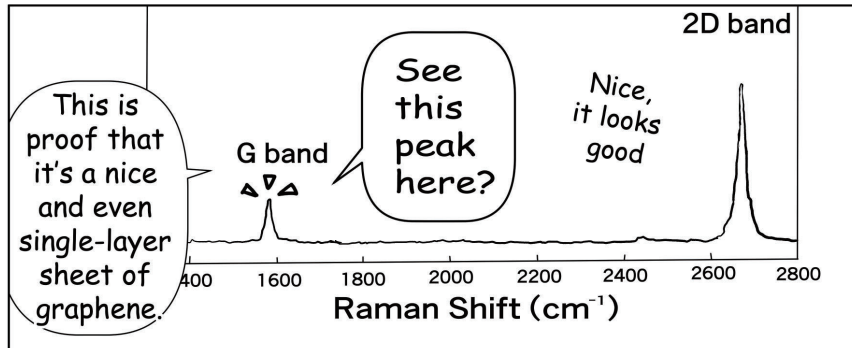
Again, however, he finds himself schooled in the meticulous expertise that goes into graphene production.

Having finally produced some graphene, he finds himself again at a loss, this time due to his inability to transfer the graphene to a substrate.







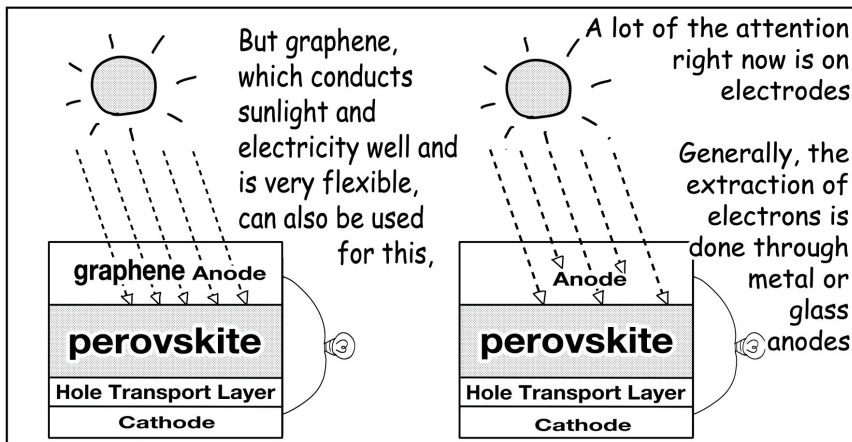


東京都
The technology that was introduced then was perovskite solar cells.

These solar cells are made primarily of a chemical compound called perovskite.

Do you remember at the end of last year, the Governor of Tokyo announced a policy for joint research with development companies to expand the use of renewable energy in Tokyo?

<https://www.metro.tokyo.lg.jp/tosei/governor/governor/kishakaken/2022/12/02.html>



Oh, and speaking of graphene.

There's a research lab nearby that's right in the middle of this sort of development race.

Lightweight!
Flexible!

which is why there's now a race to develop more efficient and lightweight solar cells.

Huh, seems completely different from the solar panels we've seen thus far

10

I just thought I'd be able to stay in the lab if I made as big a thing of graphene as possible.

Damn, I haven't thought about that yet.

What??

You can't do that, you'll have to join a different lab.

In any case, I'm gonna have you make graphene using the method that won the author the Nobel Prize.

Oh no!

Hey, I dodged that pretty good!

Uh... Well, what are the topics that are getting the most attention right now?

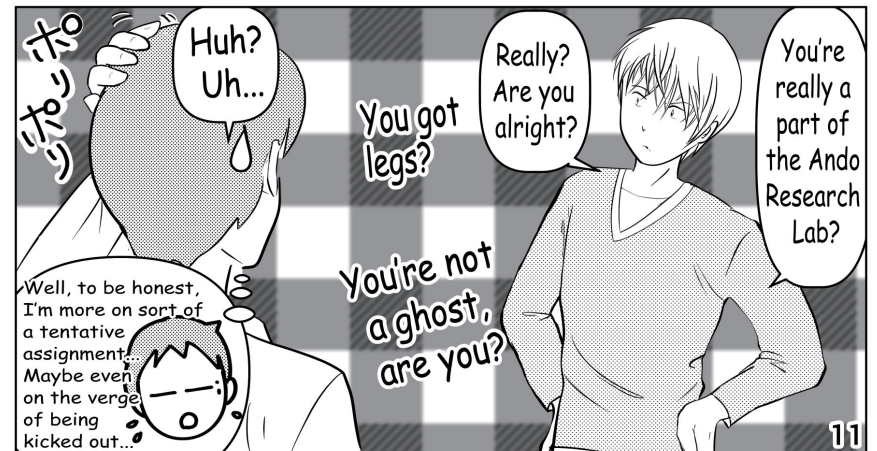
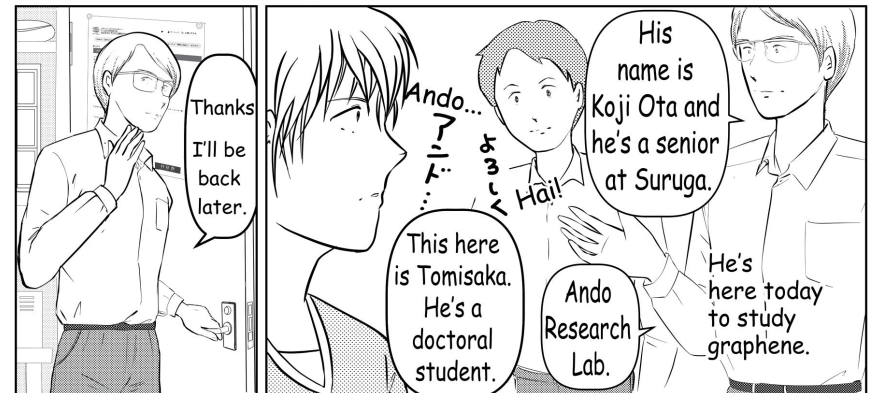
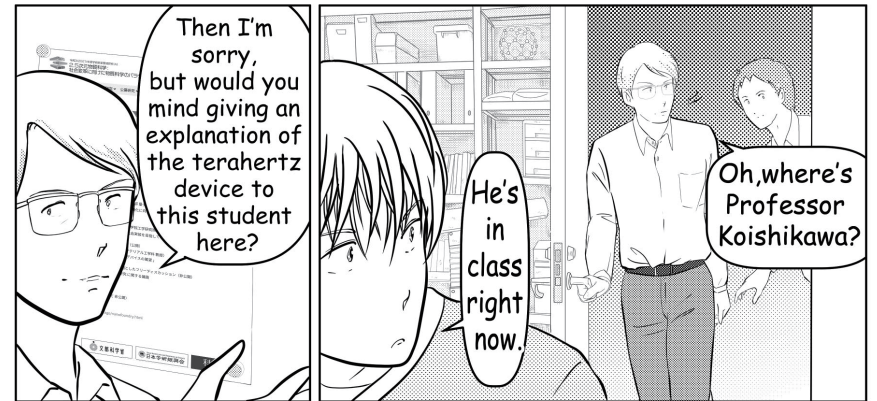
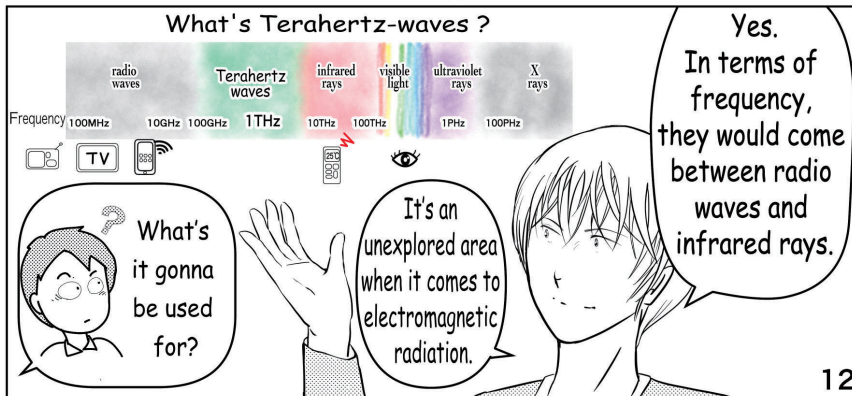
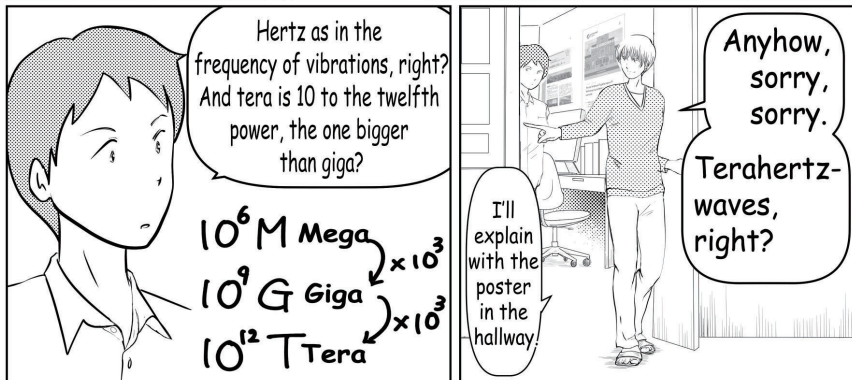
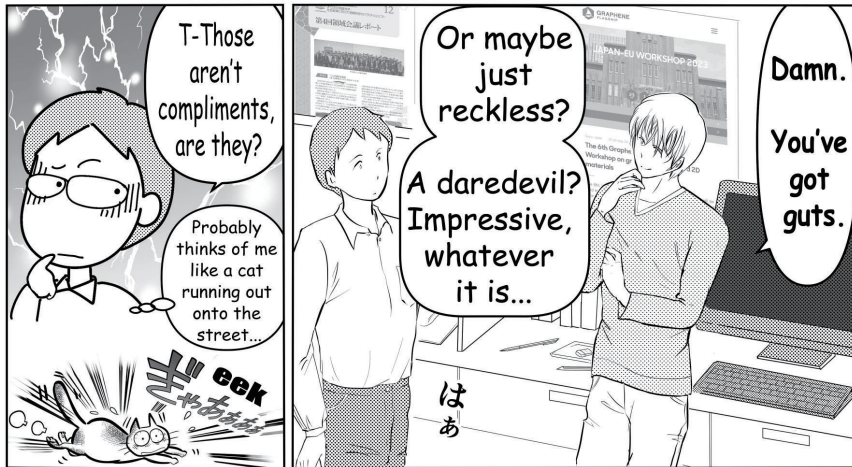
Playing it cool

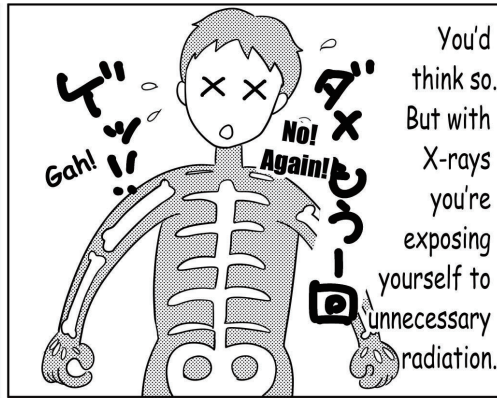
Graphene is a cutting-edge material that might end up being a game changer in the race for technological development.

Japan-EU Workshop on Graphene and Related Materials will be held in Tokyo from 20-22 May 2023. This conference aims at building a

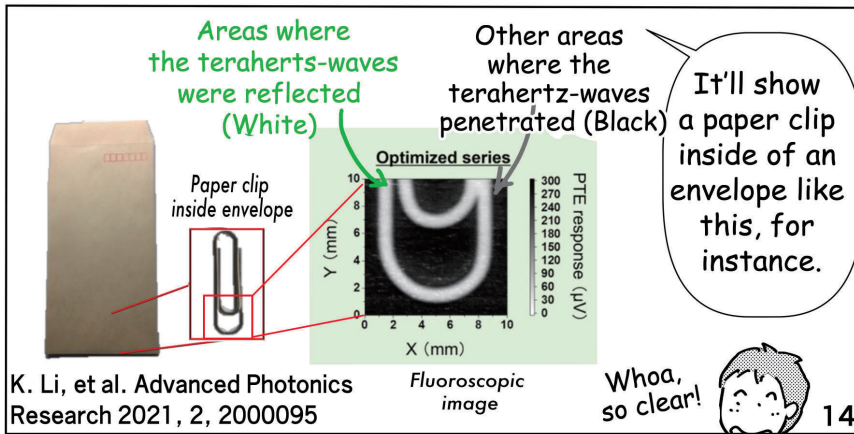
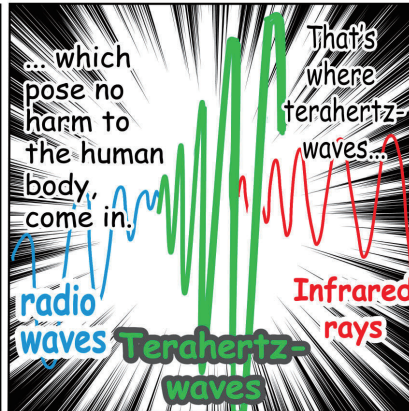
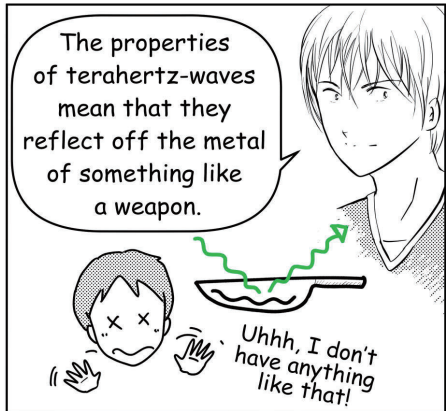
Graphene Flagship Japan-EU Workshop on Graphene and Related Materials

9

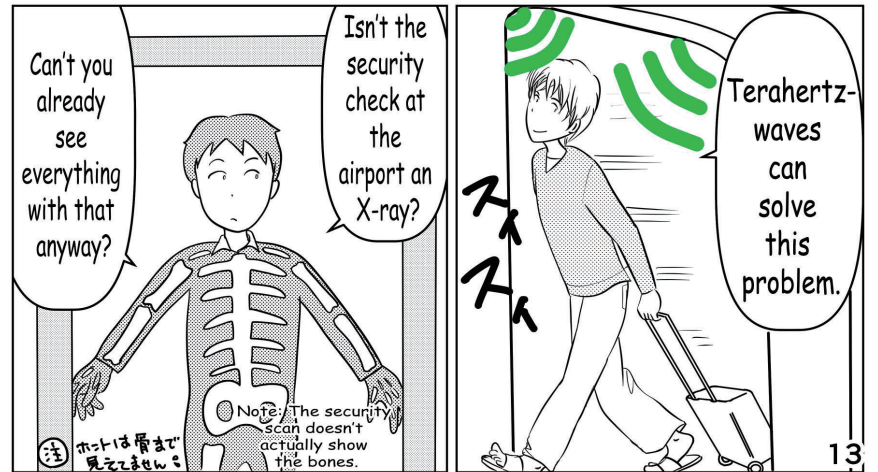
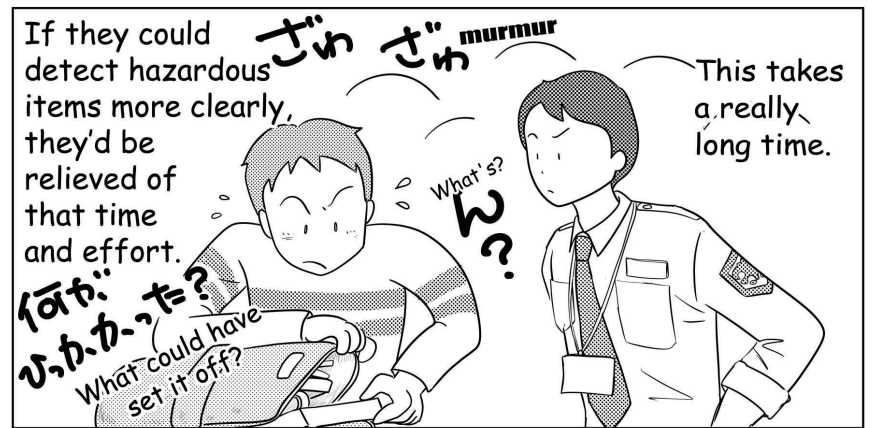
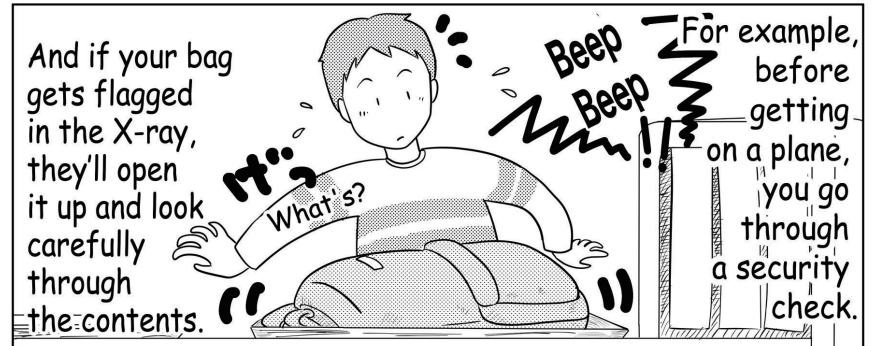




You'd think so. But with X-rays you're exposing yourself to unnecessary radiation.



Whoa, so clear! 14



13

We've found that if you shine terahertz-waves of various frequencies onto a molecule...

... only those of a frequency specific to that molecule are absorbed.

This molecule only absorbs 1 THz.

Let's say, for instance, that you shine 1, 2, 3, and 4 THz onto the molecule.

Yup, that's exactly right.

You can tell what the molecule is from the frequencies it absorbs.

Hey, that's a good analogy

So it's like a human fingerprint?

Let's say, for instance, that illegal drugs absorb electromagnetic waves of 1 THz.

and that explosives absorb electromagnetic waves of 2 THz.

Intensity of terahertz-waves applied

Intensity of terahertz-waves applied

Damn, they found it.

In other words, terahertz-waves have the penetration of X-rays, and gives a clear view of what's inside and are also harmless.

What's more, it's not like knives and other weapons are the only things they check for at airports.

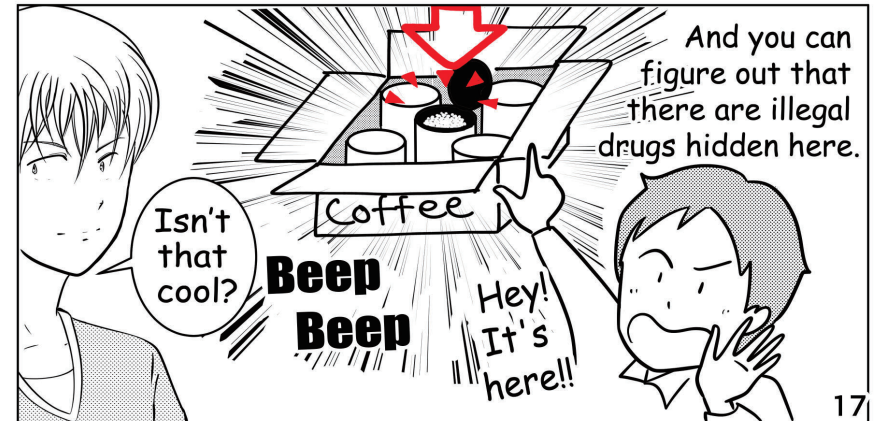
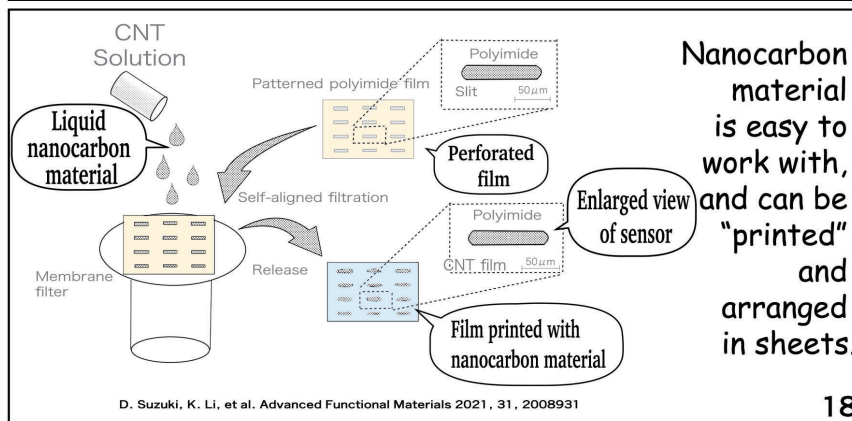
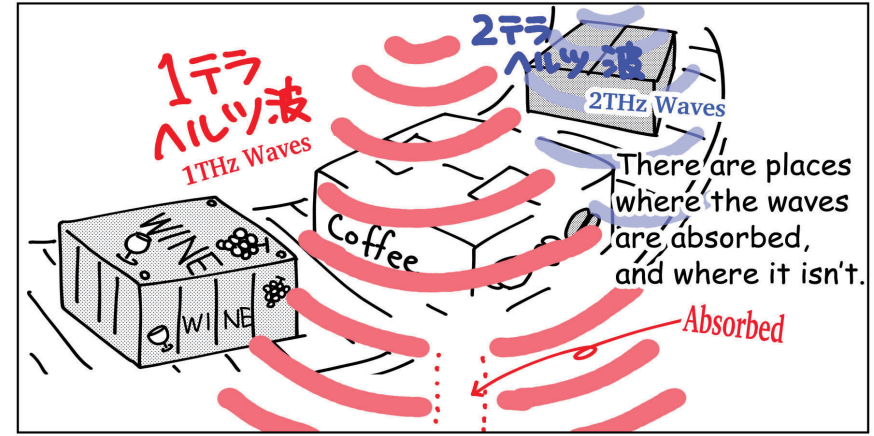
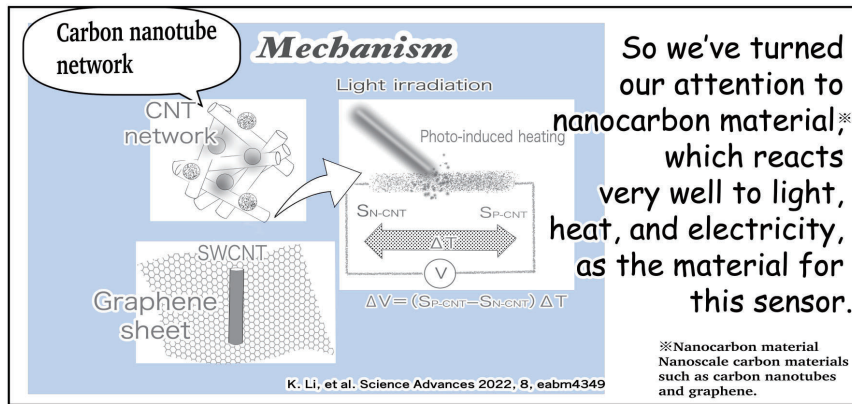
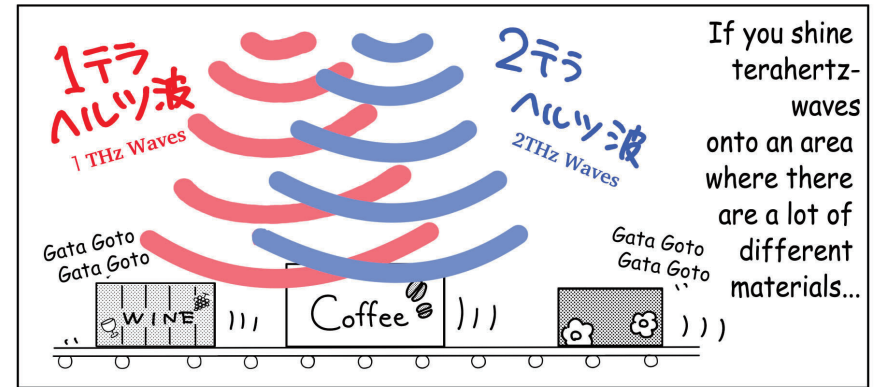
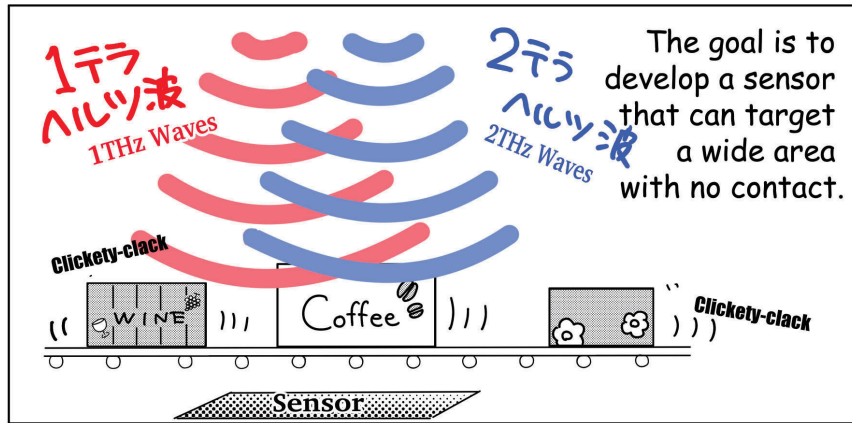
They also need to watch out for illegal drugs or plants that are import prohibited.

And it turns out, the frequency of these vibrations is just about the same as terahertz-waves.

Molecular vibrations can be used to check for these.

Buru Buru

radio waves Terahertz waves infrared rays visible light ultraviolet rays X rays



※https://www.mlit.go.jp/sogoseisaku/maintenance/02research/02_01.html

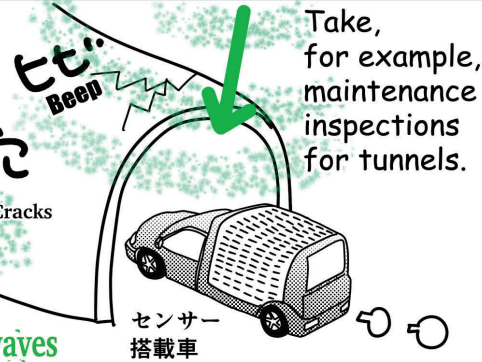
It's predicted that the social infrastructure that was developed intensively during Japan's period of rapid economic growth...

... will all deteriorate at once over the next 20 years.

The maintenance of this infrastructure is now an urgent social issue.

Driving a vehicle equipped with these sensors through the tunnel just once would be enough to inspect the entirety of the tunnel.

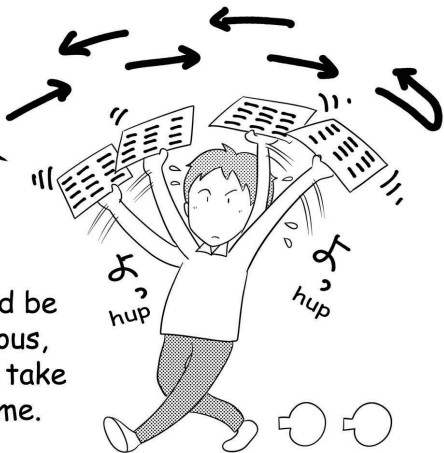
Terahertz-waves



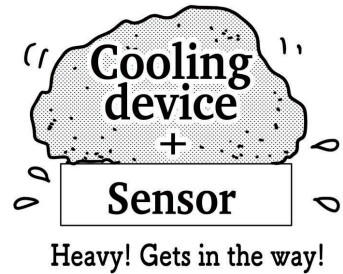
Take, for example, maintenance inspections for tunnels.

Inspections without blind spots are really hard.

That would be truly tedious, and would take a lot of time.



If this were a rigid, or more limited sensor, you'd have to change the direction of the sensor as you moved along.



There are some terahertz-wave sensors that need to be cooled to have this property...

... but it's of course better to be able to use it at temperatures you would find in everyday life.

NTT
NTTグループについて ニュース 事業案内 株主・投資家情報 研究開発 災害対策

Realizing Zero-Bias Operation of a Graphene Photodetector at 220 GHz and Elucidating the Optical-to-Electrical Conversion Process: Demonstrating the Promise of Graphene as a Broadband High-Speed Photodetector Material

世界最速、グラフェン光検出器のゼロバイアス動作220 GHzの実現と光-電気変換プロセスの解明
～広帯域高速光検出器材料としてのグラフェンの有望性を実証～

That's why nanocarbon material is getting all this attention right now as a material that can be used for these terahertz-waves.

日本電信電話株式会社（本社：東京都千代田区、代表取締役社長：島田 明、以下「NTT」）は、研究機構（以下「FIMS」）と共同で、グラフェン光検出器（※1）の世界最速ゼロバイアス動作（※2）（220 GHz）における光-電気変換プロセスを解明しました。グラフェンは、テラヘルツ（THz）波から可視光まで幅広い波長域で高感度に電気応答すると期待されており、光検出器として利用することにより、既存半導体領域でも高速の光-電気変換が可能になる有望な材料です。しかしながら、これまでゼロバイアス下にはスキャニング型顕微鏡の制限により70 GHzに限られていました。またこれらの期間により、グラフェン本質的な光検出器としての動作機構が解明されていませんでした。これに対し、本研究ではデバイス構造を、オンチップTHz分光技術を用いて電流を高速度で読み出すことにより、220 GHzの動作速度を実証した。動作速度と感度にはトレードオフの関係があることを示しました。さらに、これらの結果を解析できる光-電気変換プロセスを解明することに成功しました。得られた知見により、感度を優先した光-電気変換型検出器など、使用用途に合わせてグラフェン検出器の設計を最適化することが可能になる本研究は、2022年8月25日英国科学誌 Nature Photonics にオンラインで掲載されました。

東北大学
TOHOKU UNIVERSITY
Press Release
RIMEN
2022年12月15日
報道機関 各位
東北大学電気通信研究所
理化学研究所

新原理グラフェンランジスタによる高速・高感度テラヘルツ波の検出に成功
次世代6G&7G超高速無線通信の実現に明るい光

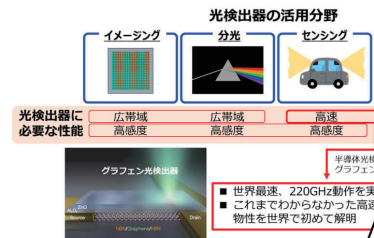
【発表のポイント】
・炭素原子の単層シートであるグラフェンを使い、室温下で高速応答かつ高感度なテラヘルツ波の検出に成功した。
・単一の金属材料で全ての電極を形成する最も単純なグラフェンランジスタ構造でも高速・高感度な検出が実現する材料として注目されています。
・6G、7Gクラスの次世代超高速無線通信の実現に貢献すると期待される。

【概要】
炭素原子の単原子層材料であるグラフェンは、電子の有効質量がゼロなどの特異な物性を有することから、従来の技術では困難な室温で動作する高速応答かつ高感度なテラヘルツ波検出素子を実現する材料として注目されています。東北大学電気通信研究所の佐藤昭雄教授らと理化学研究所量子工学研究センターの南出泰雄チームリーダーらの研究グループは、グラフェンを使って、室温で動作する高速応答かつ高感度なテラヘルツ波の検出に成功しました。テラヘルツ波の高速・高感度な検出素子として、電磁波吸収で発熱した電子・正孔の空間分布で生じる起電力効果を利用する「光熱起電力検出素子」が知られていますが、電子・正孔の両方が寄与する複雑なバイポーラ型^{※1}かつ検出素子の2つの電極に異種材料を用いなければ起電力が生じず、高性能化と量産化・低コスト化の両立が極めて困難でした。研究グループは、グラフェンをチャネルとする電子のみが関与するユニポーラ型^{※2}で、かつ全ての電極に同一種類の金属材料を用いる単純なランジスタ素子構造でも検出動作が可能で、新たな原理を思い出し、高速・高感度なテラヘルツ波検出に初めて成功しました。次世代6G&7G超高速無線通信実現のブレークスルーとなる画期的な成果です。

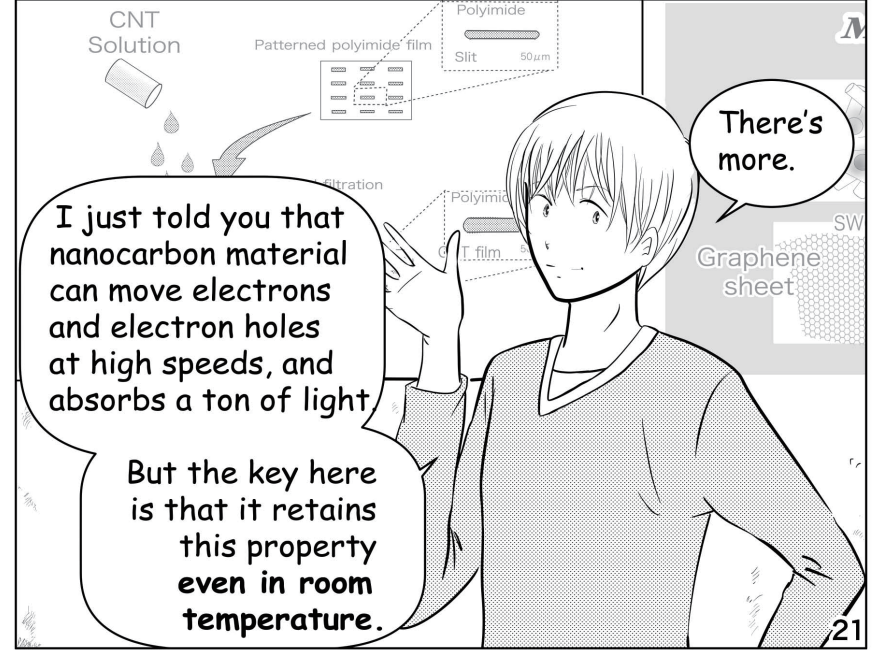
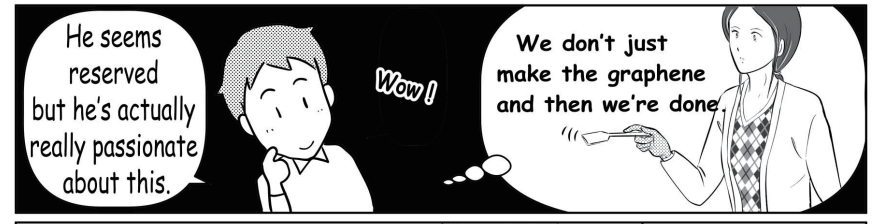
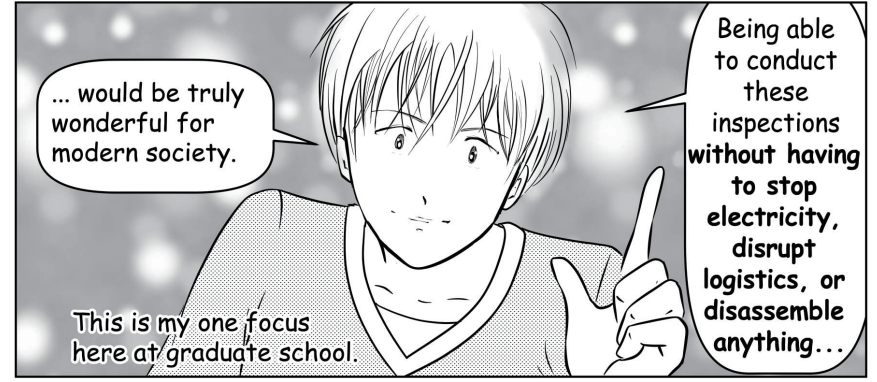
本成果は、米国物理学会誌 (American Institute of Physics) が発行するオンラインアクセス国際学術論文誌 APL Photonics に「Featured Article」として2022年12月15日オンライン掲載されました。

*編集委員会により特に学術的意義・インパクトが高いと評価された論文

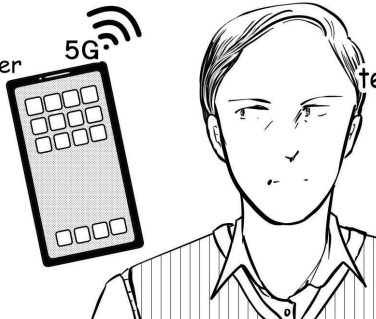
https://www.tohoku.ac.jp/japanese/newing/pressing/tohokuuniv-press20221215_02web_th.pdf



Success in High-Speed, High-Sensitivity Terahertz Detection Using a Graphene Transistor: A Bright Light of Hope Towards the Realization of Next-Generation 6G and 7G Ultra-High-Speed Wireless Communication



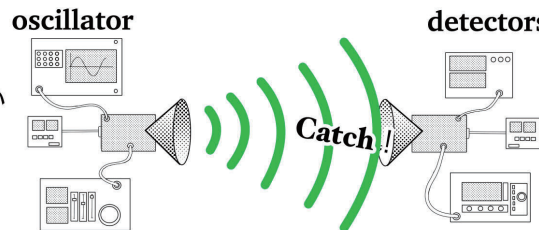
The use of terahertz-waves, which have a higher frequency than radio waves... would allow us to advance our telecommunication standards into the ultra-high-speed, high-capacity realm of 6G and 7G.



You've heard of the telecommunication technology 5G, right? It's been getting a lot of attention recently.

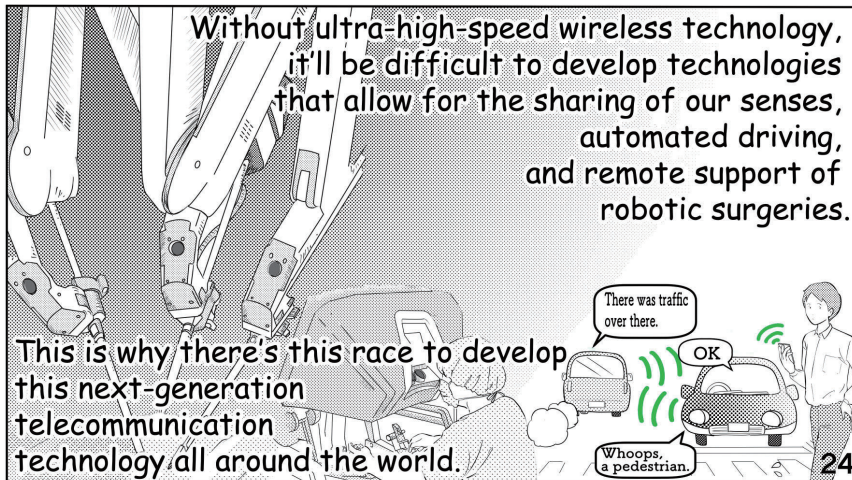
Feels so real...
Even smells real. *おぉ〜 Wow!*

But even then, we're still just developing oscillators and detectors that can handle these terahertz-waves.



oscillator detectors

Without ultra-high-speed wireless technology, it'll be difficult to develop technologies that allow for the sharing of our senses, automated driving, and remote support of robotic surgeries.



This is why there's this race to develop this next-generation telecommunication technology all around the world.

There was traffic over there.
Whoops, a pedestrian.
OK

Oh, and it's trade secrets from here on out. You might be an undergrad student, but you've gotta keep this a secret.

shh

KEEP OUT 立入禁止

And so... we too are taking advantage of the exceptional properties of nanocarbon material... ... to compete in the development of a device that can handle these terahertz-waves.

Ah, please, I'm a total beginner so...
Geez, that's amazing.
... you've got nothing to worry about.
Don't be absurd

※K. Li, et.al. Micromachines 2023,14,16

Yes, I heard from Professor Chikushi earlier.

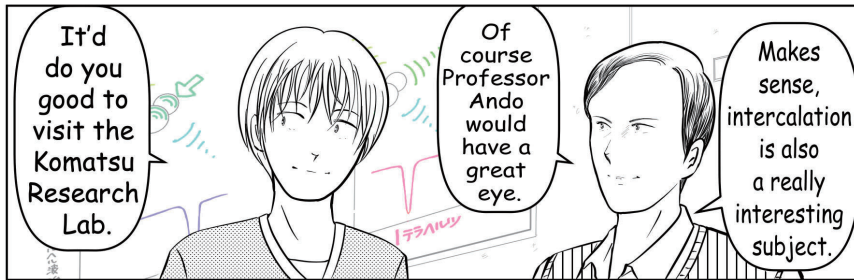
Oh, professor.

An impromptu poster session?

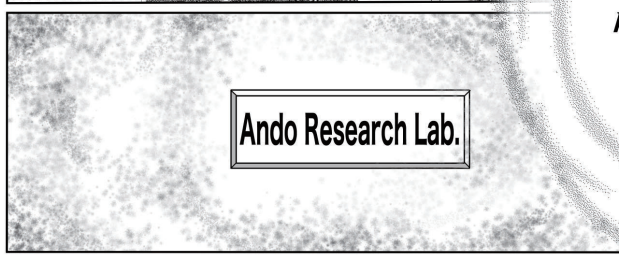
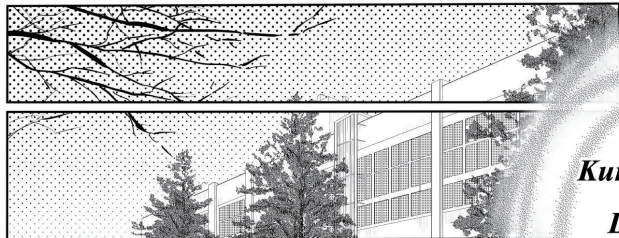
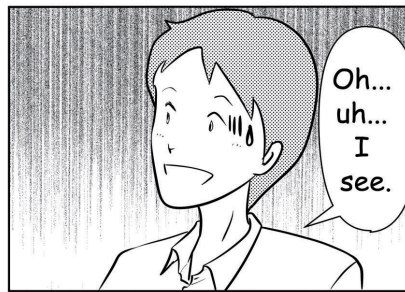
Oh, hello.

I just finished explaining it to him, and...

Hmm... In terms of what's not written on the poster...



**Huh?
What's
happening?**



*Kunoshiro-san..
Let's have
him work
with us
on our
mission.*

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