Wearable device/smart watch

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Outline

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1. Introduction

1.1. Product

Which AirPods are right for you? There are four AirPods models on the website, AirPods(2nd generation), AirPods(3nd generation), AirPods Pro(2nd generation), and AirPods Max. Each AirPods model has pros and cons, and we will compare all AirPods models. We can have a quick look. (Fig 1)

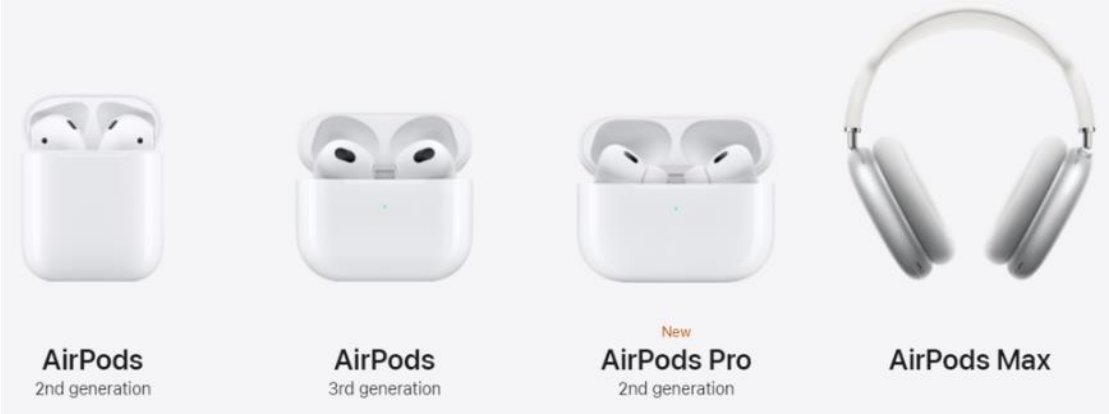

Fig 1. Quick look

1.2. Compare

We can focus on the properties of AirPods model, such as function, chip, Siri, listening time, and so on. We can compare the difference (Table 1).

	AirPods (2nd generation)	AirPods (3rd generation)	AirPods Pro (2nd generation)
Active Noise Cancellation			✓
Adaptive Transparency			✓
	Double-tap	Force sensor	Touch control
Personalized Spatial Audio with dynamic head tracking		✓	✓
Sweat and water resistant		✓	✓
chip	H1	H1	H2
Hey Siri	✓	✓	✓
listening time	5 hrs	6 hrs	6 hrs

Table 1. All AirPods model Comparison

1.3. AirPods Pro (2nd generation)

AirPods Pro (Fig 2) rebuilt from the sound up. It has been reengineered for even richer audio experiences. Next-level Active Noise Cancellation and Adaptive Transparency reduce more external noise. Spatial Audio takes immersion to a remarkably personal level. Touch control now lets you adjust volume with a swipe. And a leap in power delivers 6 hours of battery life from a single charge.

Fig 2. AirPods Pro

About audio performance, H2 chip (Fig 3) provides more immersive by every measure. The new Apple-designed H2 chip is the force behind AirPods Pro and its advanced audio performance. It works in concert with a custom-built driver and amplifier to deliver crisp, clear high notes and deep, rich bass in stunning definition, so every sound is more vivid than ever.

Fig 3. H2 chip

The brand-new H2 chip carries out more functions than ever, using computational algorithms to deliver even smarter noise cancellation, superior three-dimensional sound, and more efficient battery life all at once.

The chip uses powerful new adaptation algorithms to process sound more quickly, tuning audio at the precise moment you hear it. Every detail is rendered for your specific ear shape, immersing you in higher-fidelity sound. A redesigned inward-facing microphone works with voice enhancement algorithms to better recognize and articulate your voice, so it sounds more natural when you're on phone and video calls. A custom-built driver and amplifier work with the H2 chip to provide lower distortion during playback, so you'll hear deeper bass and crisper highs across all volume levels.

About noise cancellation, it is a marvel of modern silence. Featuring up to two times more noise cancellation than their predecessor, the H2-powered AirPods Pro are built to let you listen in peace. With control over what you hear and don't hear, you'll be immersed in songs and podcasts like never before. AirPods Pro has more Active noise cancellation. Noise-cancelling microphones (Fig 4) and a rear vent are optimally placed to quickly detect sound coming in, working together to counter noise before it

reaches your ear. A new driver and improved acoustic algorithms help Active Noise Cancellation reduce more unwanted noise, so nothing interrupts listening during your commute and when you need to focus.

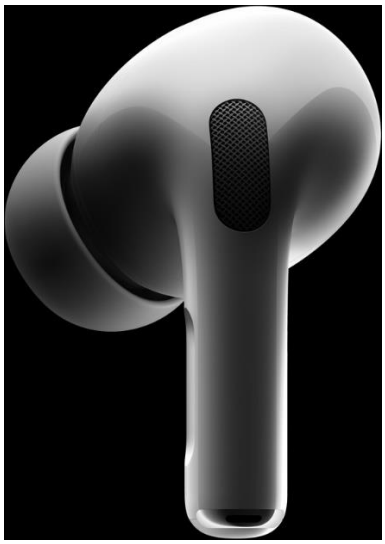

Fig 4. Noise-cancelling microphones

Adaptive Transparency is an interesting function. It harnesses the power of H2 to minimize the intensity of loud noises like sirens or power tools, so you can comfortably hear the world around you.

AirPods Pro has a higher level of control, Touch control. It lets you easily manage playback functions from the stem. Swipe up or down to adjust volume, press to play and pause music or answer and end calls, or hold to switch between Active Noise Cancellation and Adaptive Transparency.

1.3.1. Touch control

Control audio with your AirPods Pro (2nd generation). Touch control has four mode (Fig 5). First, to play and pause audio, press the Touch control on the stem of an AirPod. To resume playback, press again. Second, to skip forward, double-press the Touch control. Third, to skip back, triple-press the Touch control. Last, To turn the volume up or down, place your thumb on the stem of either AirPod, and use your index

finger to swipe up or down on the Touch control.

Fig 5. Four mode

1.3.2. Personalized listening

About personalized listening, AirPods Pro take the listening experience to a new level of individuality. Personalized Spatial Audio with dynamic head tracking works with all your devices to immerse you deeper in all-around-you sound.2 And Adaptive EQ accounts for the fit of AirPods Pro, so you hear every frequency just as it was intended. To play sound that better suits your unique ear shape, Personalized Spatial Audio works with the TrueDepth camera on your iPhone to create a custom profile based on your head's geometry. The profile syncs across your devices, delivering phenomenal sound every way you listen. Dynamic head tracking now brings three-dimensional audio to Group FaceTime calls, so conversations feel like you're in the same room with your friends and family. Adaptive EQ tunes music to your ears in real time, based on the fit of AirPods Pro. Inward-facing microphones measure what you're hearing, then adjust the low to high frequencies of a song, so you get consistently detailed playback, every time.

1.3.3. Charging Case

A new U1 chip enables **Find My with Precision Finding** for your case, so you can exactly locate it. You can also use Find My with proximity view if you lose track of your AirPods Pro. A lanyard loop allows you to attach the case to a backpack or handbag, so immersive sound is always within reach. The case's built-in speaker plays sound to help you easily locate it, and all-new tones alert you when the battery is low or pairing is complete. (Fig 6)

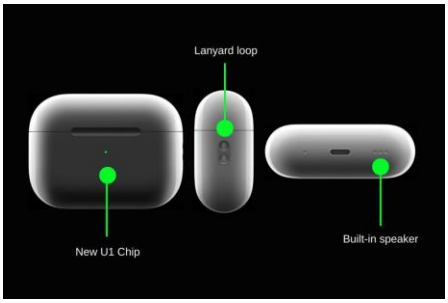

Fig 6. Charging Case

2. Spec

2.1. AirPods (1 Generation)

Fig 7. AirPods (a)

Fig 8. AirPods (b)

2.2. AirPods Pro Teardown (H1 chip)

Fig 9. AirPods Pro(a)

Fig 10. AirPods Pro(b)

2.3. AirPods Pro2 Teardown (H2 chip)

Fig 11. H2 chip

3. Technology Analysis

3.1. Biometric

Biometric technology have gained much interest recently.. There are many biometric traits, such as Face, Fingerprint, Voiceprint, Iris, ECG, Ear Canal, and so on. Biometrics could include Touch and Face ID but also new biometric measures such as identifying the user's inner ear construction or even in the gait of a user's walk.

3.2. Ear Canal

AirPods could identify you based on the shape of your Ear Canal. The principle is the shape of each person's ear is different, so the sound waves are input into the ear, the waveform of the rebound will be different. Currently, Apple and NEC do their best on studying this technique.

3.3. Patently Apple

In the Future, AirPods will require User Authentication with Touch or Face ID and other unique Biometric Measures to fully Operate. Determine whether user is an authorize user in accordance with determination that similarity score satisfies a similarity criterion. However, conventional systems are generally lacking with respect to user identification using headphones. In particular, traditional systems are not well equipped to determine whether a user wearing a respective set of headphones is an authorized user of a corresponding device, such as a mobile phone. For example, conventional systems will typically allow any user (e.g., an unauthorized user) to place headphones in their ear, even if such headphones are communicatively coupled to the

device of another user. As a result, conventional systems may risk releasing personal information from an associated device to unauthorized wearers of corresponding headphones. (Fig 12)

Fig 12. Patently Apple

We look Apple's patent sketch (Fig 13). FIGS. 8A-8C illustrate a system for user identification using headphones; FIG. 9 illustrates a system for user identification using headphones; FIG. 11B illustrates a partial process for user identification using headphones.

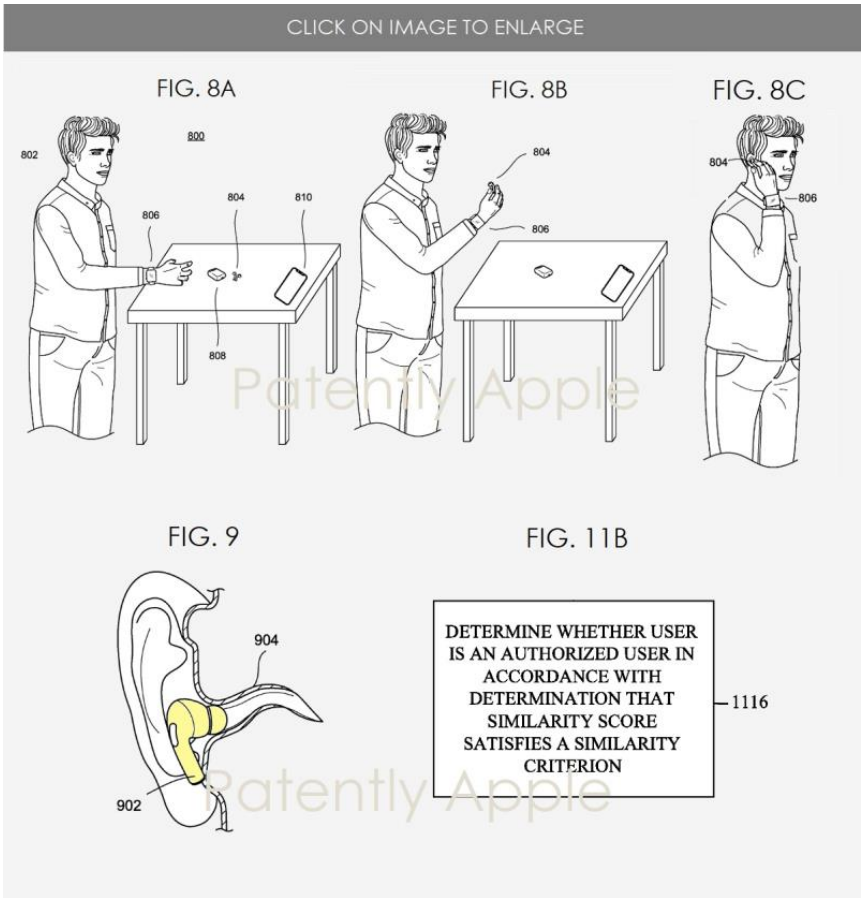

Fig 13. Apple's patent sketch

Considering that this is a patent application, the timing of such a product to market is unknown at this time. However, AirPods aren't specifically mentioned in the patent, suggesting the product could come under a different name.

4. Industry Analysis

4.1. AirPods Pro V.S. Sony WF-1000XM4

AirPods Pro's competitor is Sony WF-1000XM4 (Fig 14 and Fig 15). In this section, we compare the difference between AirPods Pro and Sony WF-1000XM4 (Table 2).

Fig 14. AirPods Pro (2nd generation)

Fig 15. Sony WF-1000XM4

	AirPods Pro (2nd generation)	Sony WF-1000XM4
Chip	H2	V1
Bluetooth	5.3	5.2
Audio Coding	AAC	AAC、LDAC
Bit rate	320Kbps	990Kbps

Table 2. Comparison

From Table 4.1.1, about the audio coding, Sony WF-1000XM4 is better than AirPods Pro, because the bit rate of Sony WF-1000XM4 is more high. As a result, if you very care about the sound quality, Sony WF-1000XM4 is the best choice. If you don't really care about the sound quality, on the whole, I think AirPods Pro is good, because Apple ecosystem is very convenient.

4.2. SWOT

We make a SWOT analysis in this part (Table 3). First is the Strength, Apple ecosystem is very famous and convenient. Lanyard loop design is so unique that help you easily locate it, and it has built-in speaker that all-new tones alert you when the battery is low or pairing is complete. Adaptive Transparency can make you comfortably hear the world around you. Most import of all, the patent is exclusive Apple. The second is Opportunities, Apple can use the patent to make a product, which can bring more profits. The third is Weakness, sound quality is not very good, thus, Apple should improve their technique. The last is Threats, Sony WF-1000XM4 is very competitive, which is famous for their sound quality and it has continuous improvement.

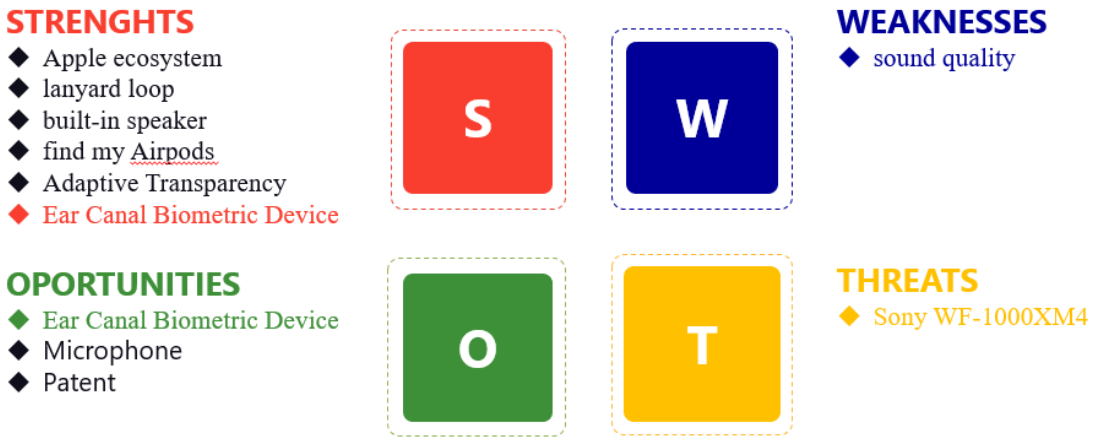

Table 3. SWOT analysis

5. Conclusion

Biometric technology have gained much interest recently. The identities of individuals are recognized by directly utilizing their physiological or behavioral characteristics. Apple has filed a patent for an in-ear biometric device. The new patent, granted by the US Patent and Trademark Office and listed (USPTO) on January 27, 2022. AirPods could not only identify you based on the shape of your EAR CANAL but also prevent lost AirPods from being used by anyone other than the owner if they get misplaced or stolen. This is a patent application, the timing of such a product to market is unknown at this time, and I think it will be soon.

6. Reference

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