VIVIDQ

Rokid
Pioneer of AR.

BOE

## THREE KEY COMPANIES

# A NEW FRONTIER
# OF NON-INVASIVE SCG
# HUMAN-MACHINE INTERFACE

Imagine a world where your digital content & reality don't have to be separated by a screen…

Computer-generated holography (CGH) is the only 3D display technology capable of unlocking a new era of immersive experiences that are integrated into the fabric of the world around us.

Spatial Computing Glasses' first holographic experiences will be projected using some form of combiner, AI/AR/XR lenses. The holograph industry often can't talk about the progress they are making because of confidentiality and patent applications, but what is planned will change the way that humans see and interact with the digital world in some spectacular, paradigm-shifting ways. Twenty years from now, people will wear glasses, or even contacts, to consume AR and XR content.

Even the more mundane forms of digital content, like messages, can be seamlessly integrated with the world around you. You can chat with friends, read the news and emails, or catch up on social feeds without having to take a phone out.

Spatial Computing Glasses displays will serve multiple purposes. It won't be long until the quickest route to meet friends will be integrated into the sidewalk and buildings around you.

Science fiction films, especially cultural icons like Star Wars and Star Trek, present visions of the future without any real need to follow the constraints of reality. As such, SCG Technology will deliver something that, for many product creators and great storytellers, was seen as magical and beyond the reach of human ingenuity.

Since spinning out of the University of Cambridge in 2017, the company VIVIDQ has developed the world's leading intellectual property portfolio for the generation of true, 3D holograms. By tackling barriers to adoption, including computer overheads & image quality, they offer the only viable route to scalable holographic visuals.

# VIVIDQ is the Pioneer of Computer-Generated Holography

## Real-Time Computing

VIVIDQ's proprietary algorithms represent the greatest step forward in holographic computing, enabling high-quality hologram generation in real time at 100 FPS.

## Retina-Resolution Image Quality

VIVIDQ has achieved consumer-grade image quality on our holographic projectors, allowing for genuine per-pixel-depth 3D visuals with equal or better quality to current 2D displays.

## World-First Hardware Breakthroughs

VIVIDQ is the only solution to use existing components, and they have leveraged a world-class team of optical experts to make huge strides in hardware optimization, including patenting the world's first 3D waveguide to break established constraints on Field of View and Eyebox.

# INTRODUCING CO-REALITY CUTTING-EDGE RESEARCH

VIVIDQ's technology contains all the fundamentals necessary to develop and power holographic lenses or a one-piece heads-up goggle display, for SCG GLASSES, in conjunction with BOE film technology.

## High Speed Compute Algorithms

The essential routines, methods, and libraries for generating and displaying holographic images in real time, as well as auxiliary functions such as the ability to compensate for a viewer's eyes and eyesight in software,..

## Content Plug-Ins

To support a wide range of device types and manufacturing preferences, we've developed display driver solutions that support a broad range of hologram-ready displays, such as LCoS, DMD, and other spatial light modulators (SLMs). In addition, our technology can accommodate a range of light sources from lasers to LEDs, and enables full brightness control across the hologram and light sources, ensuring viewing consistency and fidelity to the input, with a high dynamic range.

## Software API & Render Pipeline

Includes detailed architectural documentation, enabling manufacturers to explore further miniaturization and cost reduction for mass production. Also includes a range of tools that help our customers and content developers to navigate the unique challenges presented by holographic image generation, from interfacing with 3D sources (game engines, depth cameras/sensors, etc) to transferring holograms onto display elements.

## Optical Module Design & Build

Includes designs for compact optical engines, pupil expansion methods for greater image coverage, and our revolutionary 3D waveguide combiner. Our waveguide design is an elegant solution for manufacturers looking to design stylish, ergonomic headsets while also reducing the cost of manufacturing, as no complicated mechanics are required for IPD adjustments.

# HOW DOES OUR HOLOGRAPHIC TECHNOLOGY WORK?

# Stage 1: Compute

Our software generates complex interference patterns - called holograms - based on input data from games engines and other 3D content sources. These engineer light waves to create fully 3D images and scenes. The hologram interference pattern that we calculate is a complete representation of the scene, containing all colour, texture and 3D cues needed by the human visual system.

# Stage 2: Display

The hologram interference pattern is rendered to a display, also known as a Spatial Light Modulator (SLM). Unlike standard 2D display, we are not showing an image. Instead, the displayed hologram is used to modulate reflected light to create a 3D image that appears behind or in front of the SLM. Our technology supports commonly used display types, such as Digital

Micromirror Display (DMD), Phase Light Modulators (PLM) and Liquid Crystal on Silicon (LCoS).

## Stage 3: Illumination

The hologram interference pattern is then illuminated with a coherent or partially coherent light source, such as lasers or LEDs. The reflected interference pattern forms holographic, full colour images in front of the SLM, which appear 3D to the viewer or viewers. And this all happens in real-time.

**BOE Technology Group Co., Ltd**

is a leading-edge company in the global semiconductor display industry and has a strong focus on innovative display solutions.

# BOE Flexible AMOLED Display

Flexible display refers to the display technology designed for ultra-thin, ultra-light, and flexible products on the basis of a flexible substrate. A mobile phone can be worn on the wrist, a tablet computer can be folded into a small pocket, and a TV can also be rolled up like a scroll.

Active-Matrix Organic Light-Emitting Diode (AMOLED) is an organic light-emitting display device mainly consisting of a substrate, a TFT-driven array, and an OLED light-emitting device (metal cathode + organic light-emitting layer + anode). It is an ultra-thin device with fast response time, wide view angle, and high contrast, which is suitable for flexible display technology. AMOLED, with polymer plastic or metal foil as its flexible substrate material, has a strong anti-bending capability and can realize dynamic bending display or even folding display.

It has broad application prospects in smartphones, wearable devices, and automotive devices. Through persistent technical innovation, BOE has made great breakthroughs in several key technologies, such as flexible AMOLED displays.

BOE has now successfully developed foldable displays, wrist displays, flexible displays with double fixed edges, and other flexible AMOLED products, presenting the unlimited potential of the innovation of smart display devices.

As one of the first companies mastering flexible display technology, BOE has been actively building flexible AMOLED production lines in many regions, which will further enhance the global competitive power of the display industry.

# SCG GLASSES TECHNOLOGY

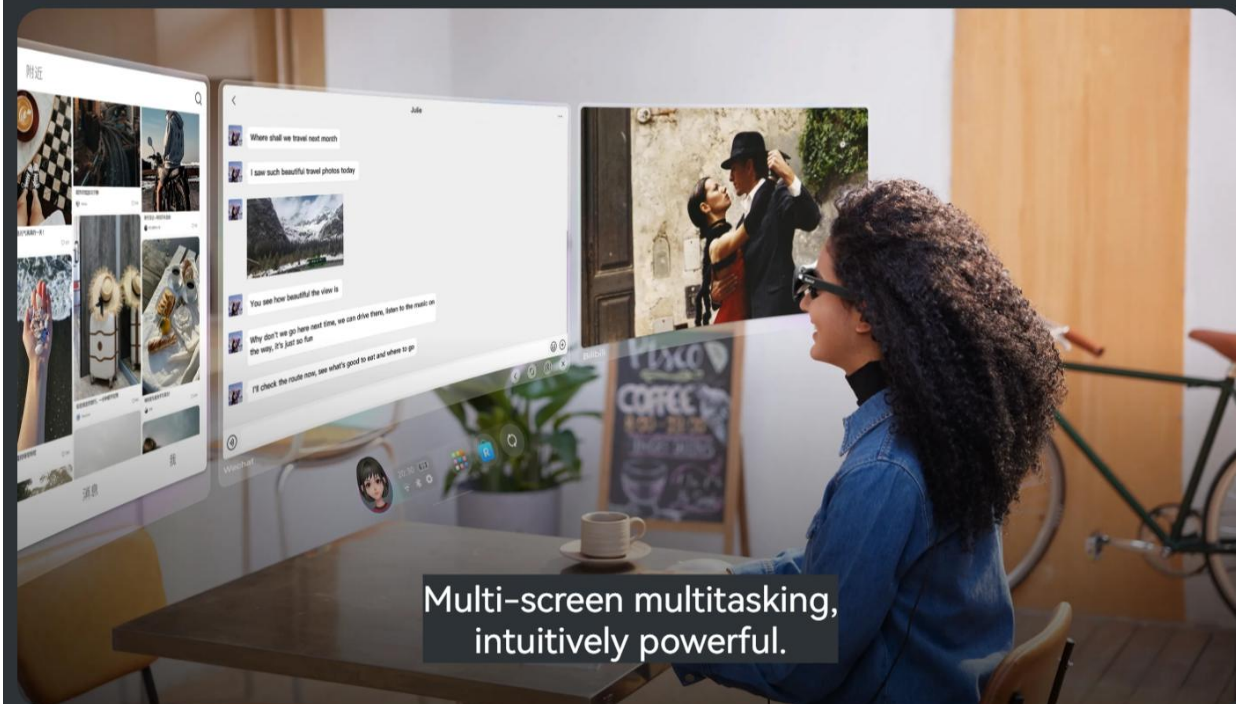
The upper left and right corners of the holographic wave guide lenses could be programmed to inform the wearer of the time in any time zone they preferred, the weather forecast, and acceptable UV and other radiation levels. Micro-cameras and earpiece pick-ups in the frame of the glasses, along with flexible, polymer-coated micro-screen adhesive throat-mike patches, all integrated into a cache before being distributed to either a user’s portable or Q-net storage.

LCD is a liquid-crystal display, and uses thin-film nano-liquid crystal display (TFT-LCD) technology, which consists of a layer of liquid crystal sandwiched between two glass substrates; the upper glass substrate is a color filter. The lower glass layer is inlaid with electro-crystals. The electric field created by the electric current passing through the crystal makes the original rotational arrangement of the liquid crystal molecules twist, thus changing the rotational amplitude of the light passing through and shining on the color filter in different proportions, thus producing different colors. The nano-transparent screen film material (NTS) is as thin as a human hair and capable of showing detailed images with a high degree of color and light clarity. It is light and flexible, and its transparency can be adjusted, with the screen capable of showing the most detail at its most opaque.

NTS is made in a roll-to-roll process in which a sheet of film is treated with tiny particles of titanium dioxide. These nanoparticles give the NTS its durability and improve the optical quality of the film, meaning images projected onto it remain clear. The film is layered with crystal polymer, a polymer-dispersed liquid crystal (PDLC) film. By applying an electrical field to the crystals, the PDLC can be made more or less transparent, allowing the screen to become more opaque when users want to see more detail.

The manufacturing process is easy to replicate due to its relative simplicity. It is highly resistant to extreme heat and cold, meaning it can be used indoors and outdoors. The technology for manufacturing NTS is created through a combination of nanomaterials and nanomanufacturing technology.

# Rokid’s new AR glasses are basically a laptop you wear on your face




Rokid's AR Spatial glasses create a massive 300-inch virtual screen for immersive entertainment and work.

## What you need to know

- Rokid’s AR Spatial glasses ditch the traditional desk and toss a massive 300-inch virtual screen right in your face.
- At just 75 grams and made with aerospace-grade materials, the Max 2 glasses are built for long hauls, and they play nice with prescription eyewear.
- Powered by Rokid’s own YodaOS Master, the system handles multiple windows and apps without the lag or bugginess you’d expect from typical AR gear.

Rokid today released the AR Spatial glasses that aim to blend AR into your everyday life, ditching the usual desk setup and changing how (and where) you get things done.

AR Spatial's setup pairs the Max 2 AR glasses with the new Station 2 hub, and together they whip up a giant 300-inch virtual screen that hangs in your line of sight.

Rokid's announcement says it's built with the always-on-the-go crowd in mind, so it might just be useful for remote workers juggling apps or anyone tired of squinting at a cramped laptop screen in busy spots.

## Light, tough, and prescription glasses-friendly

The Max 2 AR glasses are lightweight at just 75 grams and tough enough thanks to aerospace-grade materials. They're comfy enough to wear for hours, and if you've got prescription glasses, they'll fit right over them without a hitch.

These AR glasses also have built-in diopter adjustment from 0.00D to -6.00D for nearsighted users, plus customizable pupillary distance so everything lines up just right.

AR Spatial skips the usual AR headache and just works with what you already have, like your phone, tablet, or laptop. If you want the full desktop experience, just hook up a Bluetooth keyboard and mouse, and you've got a portable setup that actually feels familiar.

Rokid's AR Spatial runs on its own custom OS, YodaOS Master. You can juggle multiple virtual windows, jump between apps without lag, and skip the usual slowdowns that drag other AR glasses down.


# Reading Mode

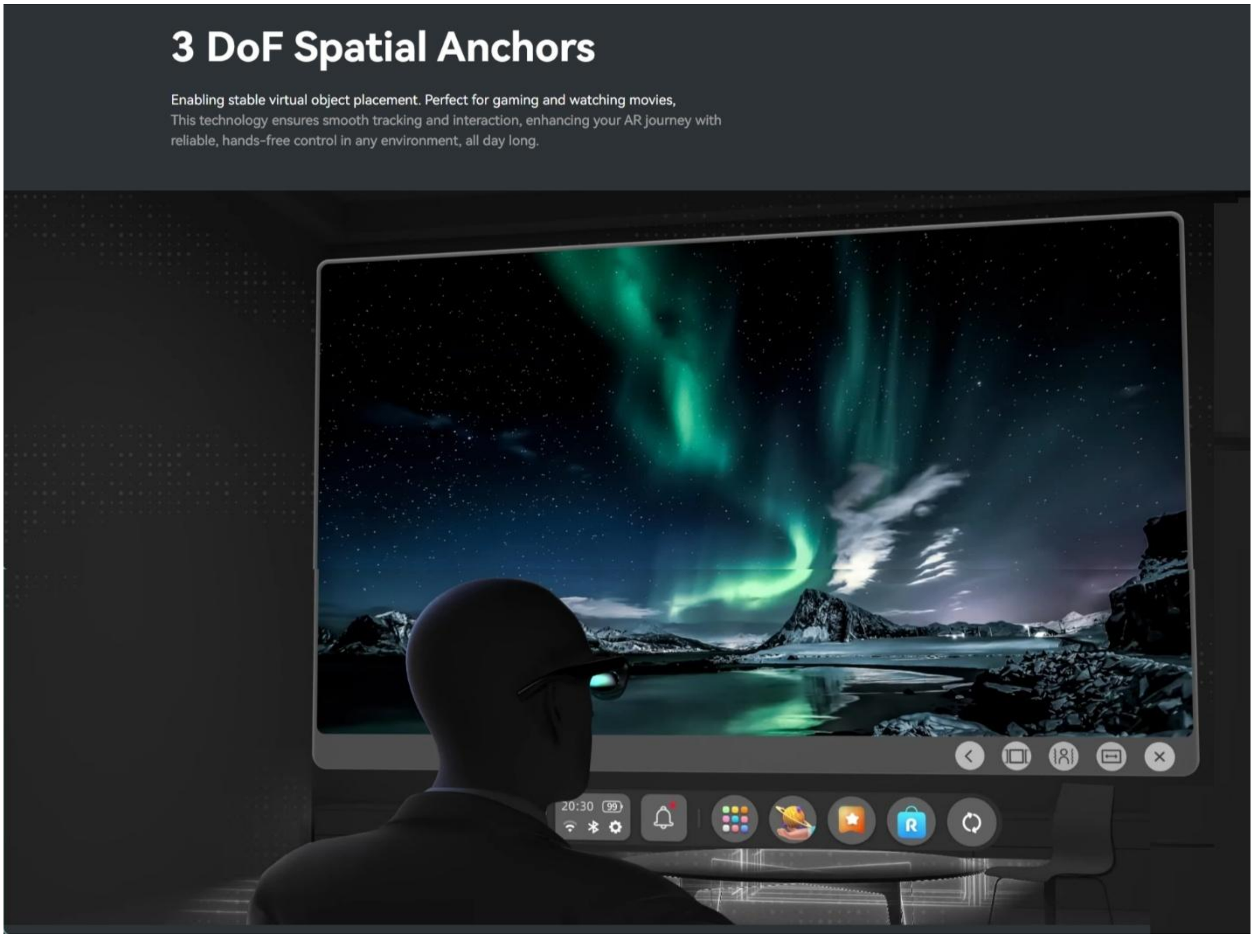
Enjoy Rokid AR Spatial's Reading Mode, optimized for e-books with glare-free, eye-friendly visuals.

Pulls the screen closer for clear e-book reading.


# Motion Mode

Stay steady on the move with Rokid AR Spatial's Motlon Mode.

Activate motion stabilization during travel to maintain screen stability, reducing dizziness and ensuring a smooth,immersive viewing experience anywhere.


3 DoF Spatial Anchors
Enabling stable virtual object placement. Perfect for gaming and watching movies,
This technology ensures smooth tracking and interaction, enhancing your AR journey with
reliable, hands-free control in any environment, all day long.
20:30

# Rokid NEW AI Glasses at WAIC 2025: Display-Enabled AI Glasses Redefine How We See and Interact with the World


**SHANGHAI, CN / ACCESS Newswire / July 29, 2025 /** At the 2025 World Artificial Intelligence Conference (WAIC), Rokid showcased its latest AI+AR wearable, Rokid Glasses in the Shanghai World Expo Exhibition Center. Rokid is driving a new era of AI interaction by harnessing the power of display-enabled visual experiences to transform how people engage with technology. The product transformed futuristic human-machine interaction into intuitive, everyday experiences with a lightweight, voice-controlled, visually immersive smart glasses platform.

During the event, Rokid highlighted the practical applications of the glasses through on-site demos, including a simulated multilingual café experience and hands-free payment via visual confirmation. Visitors were able to engage in cross-language conversations through real-time translation and complete basic transactions using only the glasses and voice commands.

Another highlight was the "AI-Powered Tech Concert". Performers wore Rokid Glasses to view live lyrics via teleprompter functionality.

At the same time, an officer used brainwave-controlled bionic limbs to play instruments, accompanied by robotic dog dancers, creating a futuristic symphony of AI, AR, and robotics.

Rokid Glasses also demonstrated potential in media and content production. On-site journalists used the device for first-person video capture and to display prompts during interviews, eliminating the need for printed notes or teleprompters.

The device's stealthy appearance, enabled by core structural components from strategic partner Lens Technology, mimics traditional eyewear while housing powerful internal hardware. Its diffraction waveguide display projects high-resolution overlays directly onto the transparent lens, enabling data display without obstructing the wearer's view.

The glasses are equipped with a Qualcomm AR1 chip and support integration with major large language models such as DeepSeek. Key features include multi-language translation, object recognition, AR overlays, and voice-based search. A 12MP camera enables photo and video recording, accompanied by a privacy indicator light for added transparency.

Having sold over 300,000 units to date in China, Rokid Glasses is now a production-ready, consumer-grade product redefining what smart glasses can be. Its compact design, intuitive interface, and deeply integrated AI capabilities make it a desirable intelligent companion for work, travel, and daily life.

**About Rokid**

Rokid is a product-oriented platform company with a focus on human-computer interaction for over ten years. As AR pioneers, Rokid researches and develops hardware and software for AR headsets and their ecology. The magic of AR leaves nobody behind. Rokid has been named a "High-tech Enterprise of Zhejiang" and a "National High-tech Enterprise," with its products recognized as top wearable devices. It has won the Las Vegas CES Innovation Award for three consecutive years and the German IF Design Award five times.

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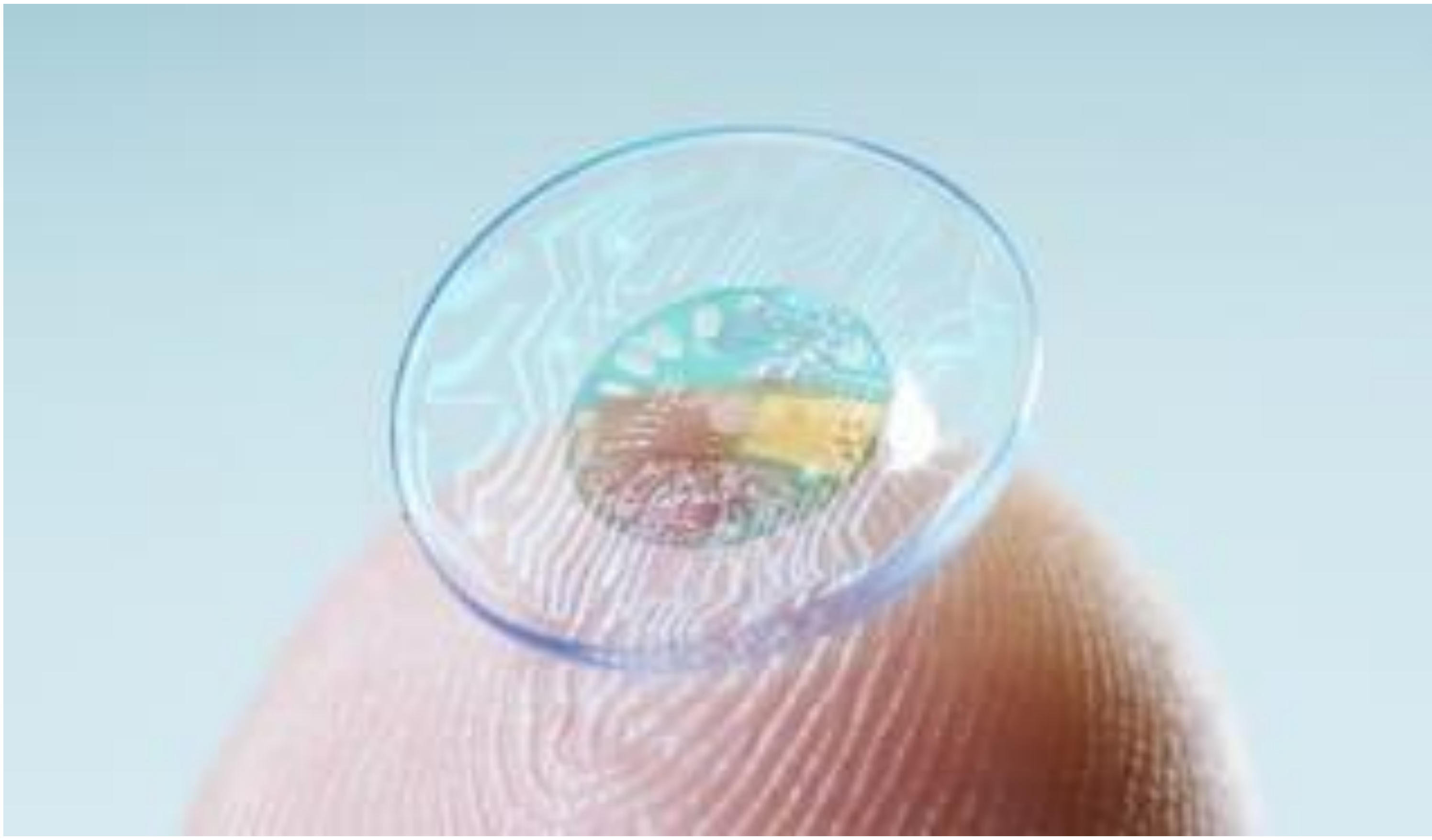
# What Are Augmented Reality (AR) Contact Lenses?

AR contact lenses are smart contact lenses embedded with microelectronics that overlay digital information onto a user's real-world view.



Does looking through a screen, rather than at one, still count as screen time?

AR contact lenses promise the immersiveness of augmented reality without having to wear a bulky headset or use your smartphone. These thin, curved lenses display digital information on top of your real-world view — and they're placed directly on the surface of your eye.

### What Are Augmented Reality (AR) Contact Lenses?

Augmented reality contact lenses are wearable devices that overlay digital information onto a user's real-world view while applied directly to the eye. Like regular contact lenses, they're made out of hydrogels or silicone, but embedded with flexible microbatteries, tiny LED displays, microprocessors, sensors and wireless communication components.

Offering hands-free access to digital content in real-time, the idea is to project images, data or interactive elements directly onto a user's natural line of vision without obstructing it or disrupting social interaction. A user can control its interface with the flick of an eye or holding a prolonged glance thanks to built in eye-tracking technology.

Unlike bulky headsets and glasses that may have awkward and limited angles, smart contact lenses would provide a highly discreet and seamless AR experience with a natural field of view, including peripheral vision. Without the barriers posed by traditional AR devices, this innovation could revolutionize how users interact with digital information, impacting daily activities such as navigation and gaming while transforming workflows across a wide array of sectors, from medical and education to industrial and professional sports.

## Do Augmented Reality Contact Lenses Exist?

Technically, yes. Prototypes of AR contact lenses exist, but none of them have made it out of the research lab.

The first prototype was developed by California-based startup Mojo Vision, which debuted the Mojo Lens in 2020. The project broke ground on smart lens technology, including preclinical testing and a live on-eye demonstration in 2022, but was indefinitely canceled the following year due to "significant challenges in raising capital."

Other AR contact lens and smart lens projects have emerged in its wake, many of which are geared toward medical applications. And while each new prototype brings AR contact lenses closer to consumer availability, reaching the mass market will require developers to successfully miniaturize electronics with sufficient battery life and display quality, in addition to undergoing rigorous clinical trials for regulatory clearance that ensures the product is biocompatible and ready for everyday use.

## Examples of AR Contact Lenses

As augmented reality and virtual reality software, headsets and smart glasses establish a $40 billion market, stakeholders are eager to take part in the expanding space. So far, tech giants Sony, Google and Samsung have all filed for smart contact lens patents. But it's deep-tech startups that are leading the charge in AR-enabled and smart contact lens innovation.

Consider the following projects that are establishing a proof of concept.

**Mojo Vision's Mojo Lens**

Mojo Vision's smart contacts, the Mojo Lens, was the first AR contact lens prototype. Now defunct, the device featured a 14,000 pixel-per-inch MicroLED display, eye-tracking and computer-vision image sensors and a micro-battery system. Measuring less than 0.5 millimeters in diameter, the smart contacts also included built-in, wireless radio communication antenna and a data-sorting ARM processor worn in a companion neck band device.

Innovega's eMacula system combines smart contact lenses with spectacles. | Video: eMacula

**Innovega's eMacula System**

Innovega is a smart AR/VR eyewear company developing a dual system that pairs disposable, daily smart contact lenses with high-tech glasses for those with moderate to severe visual impairments. In tandem, the "lens within a lens" picks up the images and media from the sunglasses display and projects them directly onto the eye, allowing a user to simultaneously view digital content transposed over the natural world. Innovega has filed over 80 patents, and is entering Phase III FDA clinical trials for its eMacula smart eyewear system.

InWith Corporation has made the first electronic soft contact lens capable of accessing AR.

## InWith Corporation’s Soft Smart Lenses

InWith Corporation has the first claim to creating AR-enabled contact lenses of the soft variety. These lenses feature electronic circuits built directly into the hydrogel that are designed to work with a smartphone. The idea is that anything you can access on your smartphone would be cast directly into a user’s line of vision, whether it be augmented or virtual reality. For those with a prescription to enhance sight, this feature would also be able to “tune” a user’s vision for a sharper image.

## XPANCEO’s Smart Contact Lens Series

Dubai-based deep-tech company XPANCEO has developed a series of AR smart contact lenses, showcasing five different prototypes for various use cases. One uses its on-eye display to adjust lighting, contrast and enhance color perception for colorblind users. Another comes with optical verification tools that allows users to tackle digital tasks, such as making payments, transferring funds and gaining access to restricted areas, with intuitive gaze commands. Other features include night vision and zoom capabilities as well as app control.

Blink Energy tests their smart lens-powering eyelid patch.

## Blink Energy’s BlinkIT Patch

Blink Energy developed BlinkIT, a device-agnostic patch that sits on the user’s eyelid and is designed to wirelessly power and connect AR contact lenses, smart lenses and other smart ocular devices, like eye implants. Although this technology is not an AR-enabled lens itself, it makes the list for addressing one of the major pain points companies and startups are facing in the space — providing sufficient battery life within such a small footprint. External accessories like BlinkIT that accompany a smart lens could be the quickest way to actualizing autonomous ocular devices.

Azalea Vision's ALMA lens controls light exposure for users with light sensitivities. | Video: Andres Vasquez Quintero

### Azalea Vision's ALMA Lens

Healthtech startup Azalea Vision developed a smart contact lens that offers a non-surgical option for users suffering from keratoconus, corneal irregularities, presbyopia and light sensitivities. While it's not specifically geared toward AR use, this device contains a microchip, micro battery, configurable light filter and radio frequency antennae and contributes to advances in on-eye electronic wearables.

In partnership with Novartis, Google set out to develop a smart contact lens in 2014 that could measure a user's glucose levels through their tears. Using tiny sensors, the device wirelessly transmitted data to an external source via RFID as a prick-free way for people with diabetes to monitor their blood sugar levels, generating a reading once per second. But the project shutdown in 2018 due to technical hurdles.

## Sensimed Triggerfish Contact Lens Sensor

Swiss-based company Sensimed have developed a silicone soft contact lens, the Sensimed Triggerfish, that's designed to provide 24-hour glaucoma monitoring. Although the device doesn't have anything to do with augmented reality, its embedded sensors can track fluctuations in a user's intraocular pressure throughout the day, which may indicate a patient's risk factor for the chronic eye disease. In 2016, it became the first smart contact lens to receive FDA approval.

## Challenges Creating AR Contact Lenses

As an emerging technology, AR contact lenses face a number of setbacks.

## Working on the Nanoscale

Embedding electronics into a contact lens requires working on an extremely small scale with ultra-miniaturized components. This means that researchers have to figure out a way to embed tiny, wireless sensors and microbatteries into a thin, flexible material without interfering with the user's line of vision or blinking. Some aspects of creating a functioning AR contact lens rely on the entire nanotechnology field to advance and innovations that have yet to be discovered.

## Biocompatibility

Any material used in an AR contact lens must be safe for prolonged exposure to the sensitive tissues of the eye. This means rethinking the typical build of electronic components. For example, making microLED displays and sensors without toxic metals and chemicals, batteries without lithium and processors without flame retardants. Figuring out a way to power these devices without overheating, losing connectivity, disturbing the eye's natural moisture and pH levels, triggering an allergic reaction or imposing on the user's line of sight prove to be significant challenges when working within the limited space of a contact lens.

## Regulatory Approval

AR contact lenses are considered to be a medical device through the eyes of the FDA. Gaining regulatory clearance requires a product to pass a thorough, multi-step process — including preclinical research, animal testing and three clinical trial phases — that takes several years to complete, as its strict guidelines are designed to protect potential users. While no AR contact lenses have made it through the clinical trial stage, smart contact lenses with embedded electronics *have* achieved regulatory clearances: In 2016, Sensimed's Triggerfish device became the first smart contact lens to receive FDA approval.

## Marketability

AR contacts have an obvious appeal to those who are visually impaired and other specified medical use cases, for sports enhancement, entertainment and technical training across sectors; however, a major disadvantage smart contact lenses have in comparison to AR glasses and headsets is that users may not actually be comfortable applying an electronically enhanced lens directly onto their eye. As beneficial as a smart contact lens may be for warehouse employees taking inventory or in-field construction workers, for example, it's unlikely that a company would be able to require its employees to wear AR contact lenses — limiting their viability to a certain degree.

## Ethical Dilemmas

AR contact lenses pose several ethical dilemmas related to privacy, consent and information overload. If these devices are built with eye tracking technology, that means data is being collected in an extremely intimate way based on a user's behaviors as they glance around. This information could be used by companies to build a profile in order to generate targeted advertisements based on a user's interests and habits from information that wasn't necessarily gathered in a consensual way. Plus, there's something inherently dystopian about projecting ads directly onto a user's cornea. The advent of AR smart contact lenses also raises concerns about the device being used as a covert surveillance tool — of both the user and those in their line of sight — as well as a hazardous distraction, negatively impacting a person's ability to engage with the real world.
Contact lenses bring 3D holograms to life for augmented reality

*A better way to fabricate metasurfaces allows scientists to create contact lenses capable of projecting 3D holographic images.*

Scientists have developed contact lenses that project 3D holograms using specialized nanostructures embedded on them, known as metasurfaces.

Metamaterials, in general, are engineered materials with properties not found in nature. A metasurface, as the name suggests, is a type of metamaterial simply applied to a surface. These structures are often smaller than the wavelengths of light, enabling them to manipulate electromagnetic waves, such as light and sound, in a unique way.

“[Metasurfaces] manipulate light […] with high precision,” explained the *Advanced Science* study’s author, Junsuk Rho at the Pohang University of Science and Technology in South Korea.

**Why metasurfaces?**

Metasurfaces have been useful in areas like biomedicine, speech recognition, and energy harvesting, but integrating them into contact lenses for virtual and augmented reality remains difficult. However, the potential they hold to surpass current technologies in significant ways makes them compelling.

“These augmented reality contact lenses [would] offer several significant advantages over existing technologies,” Rho explained. “Usually, there are gratings, prisms, or mirrors for delivering a virtual image from a display source located near the temple to the retina. At the same time, the light of the real-scene must be free from unwanted diffraction effects. Due to the complexity of these design requirements, the optical system is bulky.

“Because the lenses are worn directly on the eye, they preserve the natural field of view, providing an unparalleled level of immersion without the limitations imposed by external devices, like headsets or glasses.”

Outside of entertainment and gaming, there are boundless applications, from environmental monitoring, identity recognition, diagnosis, and real-time navigation, providing directions and contextual information directly in the user’s field of view.

“In settings, such as healthcare, the lenses could assist medical professionals by overlaying vital information during procedures,” Rho said. “Additionally, the lenses could serve personal health monitoring purposes, displaying real-time biometric data.”

But before any of this can come to fruition, barriers inherent in metasurface production need to be overcome. “First, ensuring the biocompatibility of the materials is critical, as contact lenses interact directly with the eye,” said Rho. “Traditional nanostructure transfer methods [for their production] often do not account for long-term biocompatibility, raising concerns about safety during extended wear.

“Second, maintaining structural stability is difficult due to the flexible and moist nature of contact lenses, which can lead to deformation or damage of the nanostructures. And finally, achieving precise pattern transfer on a flexible substrate like a contact lens is technically challenging."

**Producing metasurfaces for contacts**

These hurdles only motivated Rho, who has been working in this area since 2008. "I saw a news story about an 'invisibility cloak' being realized using metamaterials," he said. From there, his research has expanded to include reality displays.

He and his team were motivated to overcome challenges around embedding metamaterials into contacts by developing a new production method. Their approach relies on hyaluronic acid, a naturally occurring molecule found throughout the body, particularly in the eyes, joints, and skin.

"We use it as a soft mold that allows for the gentle transfer of complex nanostructures onto the lens surface without compromising the structural integrity of the metasurface," explained Rho. "It plays a crucial role in both the biocompatibility and functionality of the contact lenses."

Metasurfaces are usually created using advanced fabrication techniques like photolithography or electron beam exposure. These methods involve coating a surface with a light-sensitive material, exposing it to light or electrons through a mask, and developing the pattern.

After this, additional desired materials, like semiconductors for electronics, are deposited onto the patterned substrate and etched away to form the final nanostructures that are small enough to alter or shape electromagnetic radiation. Once the metasurface is complete, it is transferred from the temporary substrate to the final material, such as a contact lens.

In the current study, the team's fabrication process involved depositing gold onto a flexible, rubber-like material called polyurethane acrylate, which acts as the first mold for the fabricated surface. This 3D-patterned gold layer is then transferred from this initial mold to a second, hydrated hyaluronic acid film –for its final transfer onto the contact lens — that is then protected with a silicon capping layer.

"The $SiO_2$ capping layer, situated between the contact lens material and the gold patterns, prevents direct contact with the eye, thereby minimizing any potential risk of adverse effects," wrote the team in their paper.

The silicon layer also acts as a waveguide that directs electromagnetic waves from one point to another, not only enhancing the lens' stability, but overall performance.

**Static holograms are just the beginning...**

Now comes the fun part: creating holograms using the metasurfaces embedded in the new lenses. When light hits the metasurface — this could be from a controlled light source from a wearable device or perhaps even sunlight — each tiny, carefully crafted component changes the light's intensity, angle, and direction to create the holographic image that you can see, explained Rho.

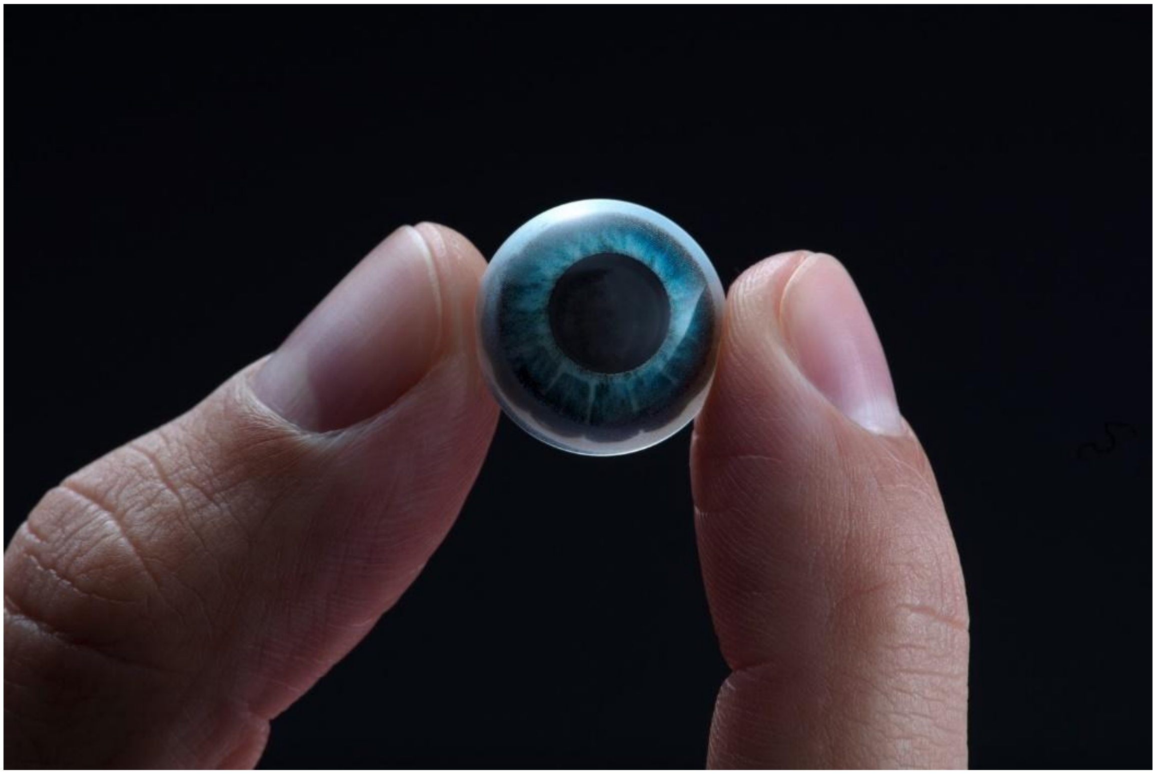
In this iteration of the technology, the images are static, but the team has plans to further develop this. Dynamic holographic videos could one day be generated by embedding a metasurface designed to function as a diffuser and light source, such as a micro-LED, into the contact lens, Rho said.

Before any of this, safety needs to be thoroughly assessed and the technology developed further. "Next steps include extensive live testing to assess the long-term safety and performance of the lenses in real-world conditions," said Rho.

"Additionally, we plan to refine the manufacturing process to ensure scalability and cost-effectiveness for commercial production," he continued. |Regulatory approvals will also be a critical step, as we will need to demonstrate compliance with safety standards for medical devices."

*Reference: Jun-Ho Jeong, Inkyu Park, Junsuk Rho, et al.,Metasurface-Embedded Contact Lenses for Holographic Light Projection, Advanced Science (2024). DOI: 10.1002/advs.202407045*

# The Future of Vision: Augmented reality contact lenses will make you bionic



Augmented reality contact lenses have been "around the corner" for years. They're finally set to arrive. Mojo Vision

## Tech for Change

This story is part of Tech for Change: an ongoing series in which we shine a spotlight on positive uses of technology, and showcase how they're helping to make the world a better place.

Today (-ish): Long a dream, smart contacts are here, Tomorrow: Is infrared vision in your future?

*Technology is reshaping every aspect of our lives. Once a week in The Future of series, we examine innovations in important* *fields, from farming to transportation, and what they will mean in the years and decades to come.*

A decade ago, Google's ambitions seemed unchecked: The company would design self-piloting cars through Waymo, sponsor moonbases, and even conquer death. One of the company's plans: Smart contact lenses to measure the glucose level of your tears — and perhaps help reduce the damage caused by diabetes. "It's still early days for this technology, but we've completed multiple clinical research studies, which are helping to refine our prototype," wrote Google's Brian Otis and Babak Parviz back in 2014.

Seven years later, the company's ego remains just as inflated, but Verily's smart contact lenses are nowhere to be seen; the side project of Google parent Alphabet was officially abandoned in 2018. Yet smart lenses are finally becoming a reality, thanks to the efforts of countless scientists and engineers. And the future of this intriguing technology is nothing like what you might expect.

- FDA approves augmented reality surgery tool that gives surgeons 'X-ray vision'
- **Today (-ish): Long a dream, smart contacts are here**

There have been many efforts to advance contact lenses, of course. Acuvue sells Oasys with Transitions lenses that automatically darken in sunlight, like tiny sunglasses for your pupils, and researchers have been working for years on smart lenses that zoom on demand, measure chemical levels in your body, and administer drugs (notably antihistamines). But smart ones? They've never really made it to market.

InWith Corp. is about to change that. At CES 2021, the company unveiled a method to place augmented vision display chips into the soft hydrogel contact lenses that millions of people wear daily. Smart contact lenses! In early 2020, the company announced a partnership with Bausch + Lomb, showing flexible electronic circuitry embedded directly into lenses. No, you can't buy 'em yet. But they're clearly almost here — and not just from InWith.

"It's closer than you'd think, but it's not tomorrow," Steve Sinclair, senior vice president of product at Mojo Vision, told me. Mojo's the big competitor to InWith, and has been secretly engineering lenses embedded with an enormous array of proprietary technology, including a nearly invisible Micro LED display under half a millimeter in size (think a grain of sand), tiny inertial sensors such as accelerometers and gyroscopes, a super-efficient image sensor to gauge the world around you, adorably tiny batteries, and more.

Mojo Vision's contact lenses promise to enhance our vision. Image used with permission by copyright holder
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Mojo Vision's contact lenses promise to enhance our vision. Image used with permission by copyright holder

Like InWith's lenses, Mojo's are "just around the corner," Sinclair told me. About a dozen people in his company have worn the latest prototypes, and a new model this summer promises even more advancements. What can you do with them? Augmented reality applications probably leap to your mind, at least they do for me: Direction overlays that guide you through unfamiliar city streets, information about the people and buildings you pass by, and so on. But the power of a display in your eye is nothing like what you might expect. Sinclair offers different use cases, things that give you your mojo back (hence the name of the company): The text of a big speech, notes for a presentation, a checklist for a major repair project, and so on.

One area that will be important is performance athletics: Today's runners have a world of metrics on their wrists, but who wants to navigate a menu while sprinting at top speed? Imagine the power of biometric data directly in your field of view.

And as for AR? Eh, we'll get there.

Meanwhile, smart lenses hold huge immediate promise for people with low vision — glaucoma, macular degeneration, and so on. Mojo's chips will be able to take in the scene before a person and in real time add edges to buildings, boost the contrast around signs and people, and help those with dim vision navigate the world around them. This could be a game changer — but it's just the beginning.

## Huge milestone as human subject wears augmented reality contact lens for the first time

- For the very first time, an augmented reality (AR) contact lens was worn on the eye of a human subject.
- AR contact lenses pose wildly difficult engineering challenges, the biggest of which is finding a way to provide these tiny devices with power. A company called Mojo Vision has done that.
- One day, we will look back at the years when people walked down the street, necks bent, staring down at little screens in their hands as an absurdly primitive way to interact with information.

Three decades ago, the first group of human subjects interacted with a mixed reality of real and virtual objects. They did this by climbing into a large upper-body exoskeleton, pressing their face to a vision system hanging from the ceiling, and manually performing tasks that required them to engage both physical and simulated objects. They were testing a prototype augmented reality system at Air Force Research Laboratory (AFRL) known as the Virtual Fixtures platform. The hardware filled half a room and cost nearly $1M, but it worked — showing for the first time that AR could boost human performance in real-world tasks.

Last week, an important new milestone was achieved in the field of AR, and it highlights how far the technology has come over the last 30 years: the first authentic test of an augmented reality contact lens. It was conducted in a research lab at Mojo Vision in Saratoga, California. No, it wasn't a crude bench test of oversized hardware with wires dangling. This was a genuine test of an AR contact lens worn directly on the eye of a human subject for the very first time.

**A wildly difficult engineering challenge**

As someone who has been involved in AR from the early days, I need to highlight the importance of this new milestone. Building a wearable augmented reality contact lens is a wildly difficult engineering challenge. When I say this, people usually ask about the display technology. Sure, the ability to put a high resolution display on a tiny transparent lens is difficult, but it's not the most challenging piece of the puzzle. The harder issue is that this tiny lens, which needs to sit comfortably on the human eye, has to communicate wirelessly with external devices and be fully powered without a physical tether of any kind. That is a daunting task, and yet it is what Mojo Vision achieved in their latest demonstration.

*We will look back at the years when people walked down the street, necks bent, staring down at little screens in their hands as an absurdly primitive way to interact with information.* **Louis Rosenberg**

According to Mojo Vision, the prototype lens includes medical grade micro-batteries. It's unclear what the battery life is for the current prototype, but according to the company, their product goal is power management that enables all-day wear.

Of course, their display technology is impressive too. According to the company, the Mojo Lens has a 14,000 pixel-per-inch MicroLED display with a pixel pitch (the distance between adjacent pixels) of 1.8 microns. For context, an iPhone 13 with a Super Retina XDR Display has 460 pixels per inch resolution. In other words, the Mojo Lens hardware has about 30 times the pixel density of a current iPhone. In addition, these lenses include an ARM processor with a 5GHz radio transmitter, along with an accelerometer, gyroscope, and magnetometer to track eye movements. And all of this sits directly on the human eye.

**AR contact lenses are the future**

Still, many years of development will be required to get from today's prototypes to mass market consumer products that bring immersive AR capabilities to people around the world. I predict that AR eyewear, first as glasses and then as contacts, will eventually replace the mobile phone as our primary interface with digital content. Further, augmented reality will completely change our relationship with information, transforming digital content from discrete artifacts we selectively access into seamless features of our physical world.