

China Passenger Car HUDIndustryChainDevelopmentResearchReport, 2023

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As HUD technology advances, AR-HUD, which can combine virtual information and real road scenes in the form of images, is favored by automakers. With maturing technology and declining cost, HUD has begun to penetrate into low-price vehicle models, and will become a "standard configuration" for smart cars in the future. For example, Changan Deepal S7, a model unveiled in early March 2023 with starting price of RMB169,900, cancels the dashboard and uses a 53-inch holographic AR-HUD system instead. The AR-HUD supplier is Zhejiang Crystal-Optech.

The AR-HUD industry chain covers suppliers of picture generation units (PGU), optical mirrors, glass, software and other components. Among them, the PGU plays the most crucial part at the upstream end, making up 50% of the total cost of HUD, and the optical mirror follows, taking a 20% share. The lower cost of the two major components, namely PGU and optical mirror, means a reduction in the total cost of AR-HUD, bringing an extremely fast progress in the implementation of AR-HUD. Therefore the new technologies related to the two components have developed rapidly in recent years.



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Schematic Diagram of LCoS Projection



Source: White Paper on Augmented Reality Head-Up Display (AR-HUD)



In September 2021, Huawei introduced its AR-HUD product, and in April 2023, Huawei released the xHUD AR-HUD. Both products use LCoS projection technology and feature small size and large format. HUAWEI xHUD AR-HUD can display a 70-inch image at a distance of 7.5 meters, and a 96-inch image at 10 meters. This product can support such applications as intelligent driving visualization, lane-level navigation, reversing camera, Digital Elf, and giant screen viewing.

Automotive Optical Imaging Module for HUAWEI xHUD AR-HUD

Automotive LCoS Micron-level pixel unit: 2K resolution Short focus lens Clearer image, distortion: <2%

Source: Huawei Smart Car Solution

HUAWEI AR HUD VS HUAWEI XHUD AR-HUD

Product	AR-HUD	HUAWEI xHUD AR-HUD	
Time	Sept. 2021	Apr. 2023	
Technology	LCoS projection technology	Huawei AutOptiX intelligent vehicle lighting technology - automotive LCoS	
Volume	10L	-	
Resolution	1920 x 640	1920 x 730	
Proj <mark>ection</mark> distance and size	Display a 70-inch image at a distance of 7.5 meters	Display a 70-inch image at a distance of 7.5 meters and a 96-inch image at 10 meters	
Other	Combining the real scene map POIs, display 3D information, e.g., parking lots, restaurants, shopping, entertainment, and gas stations in real time during driving	Deeply integrated with the intelligent driving system for the first time, replace the dashboard, and enable such functions as lane-level AR navigation, reversing camera, giant screen viewing, and Digital Elf	
Application	First mounted on Rising Auto R7 and launched on market in September 2022	First mounted on AITO M9, and expected to be released in 2023Q4, and to be available to more models in the future	

Source: Public Data



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LBS Solution of LM

LBS, a laser scanning and projection technology, uses lasers as the light source, and realizes projection via a MEMS micro-mirror. It offers the following benefits: 1. Greatly simplified optical engine, and small size; 2. High contrast, easily up to 7000:1; 3. High brightness and wide color gamut (>150%); 4. Low power consumption (<4-6W), and low heat generation. Nevertheless, for the temperature-sensitive laser diodes fall short of the working requirements of 85°C, LBS has yet to be mature enough to be applied.

Founded in 2021, LM Jade Chip Technology is a Chinese company engaged in development and industrial application of MEMS chips and laser scanning micro-display modules. For AR-HUD, it has developed a complete LBS-based solution LM-PGU-1000 and provided to its partners such as Sunny Optical Technology, OFILM and Aptiv. LM-PGU-1000 has the following features: 1. A solution to display speckle, speckle contrast: <4%; 2. Higher horizontal resolution and larger horizontal FOV; 3. Lower power consumption and higher brightness; 4. Higher contrast.



Parameters of LBS Solution of LM Jade Chip Technology

Source: LM Jade Chip Technology



Waveguide technology will become the ultimate optical display solution.

Too large installation size and fairly high cost of AR HUD are currently the sore points for the industry. The waveguide technology allows for removal of the mechanical and optical mechanisms inside conventional HUDs, which means the first two reflections are omitted so that the information from the light source is directly projected onto the windshield. AR HUD occupies space one tenth of conventional mechanical solutions. In addition, the optical waveguide solution delivers high light transmittance, large FOV, and good display effect.

Optical waveguide falls into geometric optical waveguide and diffractive optical waveguide. Wherein, the diffractive optical waveguide technology is the key development direction of AR-HUD, and is divided into surface relief grating waveguide and volume holographic grating waveguide.

Surface relief grating waveguide, a mature technology often seen in AR near-eye display devices, provides thinness, large field of view, and large eye movement range. At present, it is a mainstream optical waveguide solution for AR-HUD, and manufacturers such as Suzhou SVG Tech Group and Greatar Tech are all making layout of it.





Principle of Optical Waveguide HUD

With independent R&D of 3D lithography equipment as the core driver, Suzhou SVG Tech Group works on research and industrialization of optoelectronic materials and devices for the fields of information photonics and new displays. In June 2021, the joint-stock private company announced a large-format optical waveguide module for AR-HUD. This module offers the display effects of ultra-thinness, large field of view, and long virtual image viewing distance. Based on the self-developed micro-nano lithography equipment and platform, this module can process about 2x1011 nanometer units on the 20cmx20cm waveguide surface, and provide a projection distance longer than 15 meters. Currently this module has been used in AR-HUD and installed in Huawei's intelligent driving system.

 Display Effect of AR-HUD Based on Suzhou SVG Tech Group's Large Format Optical Waveguide Module



Source: Suzhou SVG Tech Group



The volume holographic grating waveguide can reduce the volume of AR-HUD to one fifth to one tenth of the conventional geometric optics ones. Compared with reflector-type AR-HUD with a volume of 22L, the holographic optical waveguide enables a volume of only 2.4L; the main imaging module can also standardized and mass-produced at low cost. Such AR-HUD is promising. However the production process is complicated, and currently few manufacturers have the ability to produce in quantities. It is in 2023 that the application of corresponding AR-HUD products will start.

Tripole Optoelectronics began to deploy volume holographic diffractive optical waveguide technology in 2019. In June 2021, Tripole Optoelectronics worked with BAIC and TCL CSOT to promote holographic optical waveguide AR-HUD. In January 2022, the company built a holographic diffractive optical device production line with the annual capacity of millions of holographic diffractive elements, providing large-area holographic optical waveguide AR-HUD products for manufacturers in automotive industry.

Large-area Holographic Waveguide Display Device of Tripole Optoelectronics



Source: Tripole Optoelectronics



Summary of Development of Companies That Deploy Optical Waveguides

Co	ompany	Technology	Development
Tier 1	Continent al	Holographic optical waveguide technology	Worked with DigiLens to develop AR-HUD and waveguide technology. According to their plan, the commercial use of laser + optical waveguide AR-HUD in vehicles is expected to be realized in mid-2023.
	ADAYO	Holographic optical waveguide technology	In September 2022, Foryou Multimedia Electronics (ADAYO) and Lochn Optics signed a cooperation agreement to expedite the layout of optical waveguide AR-HUD. Products have yet to be available.
	Huawei	Holographic optical components, optical waveguide, glasses-free 3D	In April 2023, Huawei announced that it is exploring next- generation HUD technologies such as holographic optical components, optical waveguide, and glasses-free 3D, and has made phased progress. Together with its industry partners, Huawei has made breakthroughs in technical challenges in 2D pupil-expanding optical waveguide design and processing, and is working hard on volume production of optical waveguide devices.

Tier 2	Suzhou SVG Tech Group	Surface relief grating waveguide technology	In June 2021, developed a large-format optical waveguide module for AR-HUD (ultrathin diffractive optical waveguide AR-HUD), which has been applied to AR-HUD and installed in Huawei's intelligent driving system.
	Greatar Tech	Surface relief grating waveguide technology	The company boasts a full-featured grating master processing center and diffractive optical waveguide production line, and has the mass production and delivery experience on the client. It can provide customers with one-stop solutions from design and platemaking to materials and process, as well as fast, stable, reliable and low-cost diffractive optical waveguide production and delivery schemes.
	WayRay	Holographic optical waveguide technology	In October 2021, released the laser holographic AR HUD; in May 2023, announced that the holographic display technology will be applied to Tesla cars.
	DigiLens	Holographic optical waveguide technology	It used to produce waveguide products for consumer electronics. In January 2017, Continental invested in DigiLens to jointly develop a diffractive optical waveguide HUD. DigiLens thus entered the automotive field. Its holographic optical waveguide AR-HUD is expected to be mass-produced in 2023.
	Tripole Optoelect ronics	Holographic optical waveguide technology	In June 2021, BAIC, TCL CSOT and Tripole Optoelectronics worked together to promote holographic optical waveguide AR HUD. In January 2022, built China's only holographic diffractive optical device production line, with the annual capacity of millions of holographic diffractive elements, providing HUD core optical modules for manufacturers in the automotive industry.
	Lochn Optics	Holographic optical waveguide technology	The company established the Holographic and Precision Optics Research Center in 2019, and has realized the full- screen lighting of the highly controllable holographic AR-3D HUD display prototype and the large-format 2D pupil- expanding holographic waveguide HUD. In December 2022, the company made major breakthroughs in holographic waveguide automatic exposure and full-color display techniques. It now has completed theoretical research, solution verification and sample trial production process. In September 2022, inked a strategic cooperation agreement with ADAYO on the development of optical waveguide AR-HUD technology. AR-HUD products have not yet been mass-produced.

Source: Public Data



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