TSINGHUA PBCSF
清华五道口

研究报告

TSINGHUA PBCSF
清华五道口

Meta

OPPO

TSINGHUA PBCSF
清华五道口

Research Report

April 12, 2024

Atlas of the Spatial Computing Industry[3]

Research Center for Sci-Tech and Finance

Yashu Zhu, Li An

Abstract:

[3] Thanks to intern Yuhao Zhang of Research Center for Sci-Tech and Finance at PBCSF Tsinghua University for his research assistance in this report. Yuhao Zhang is PhD. student at School of Medicine, Tsinghua University.

[4] “Atlas of the Digital Twin Industry” is a research report produced by the Research Center for Sci-Tech and Finance, PBCSF, Tsinghua University, 2024 series.

2023 6 6 WWDC 2023 CEO

Mac

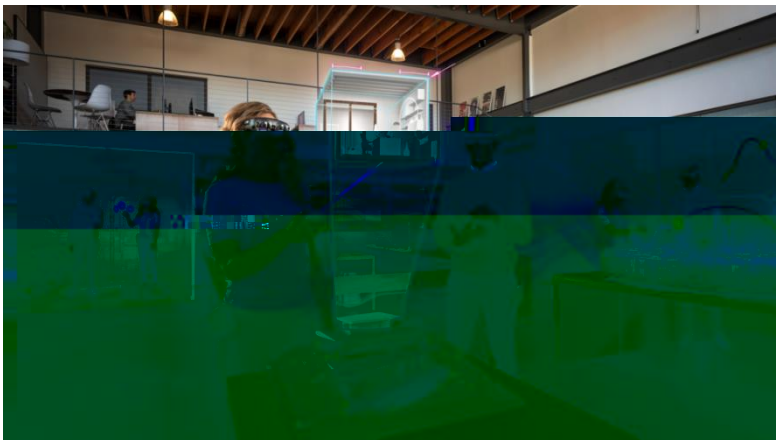
iPhone Apple

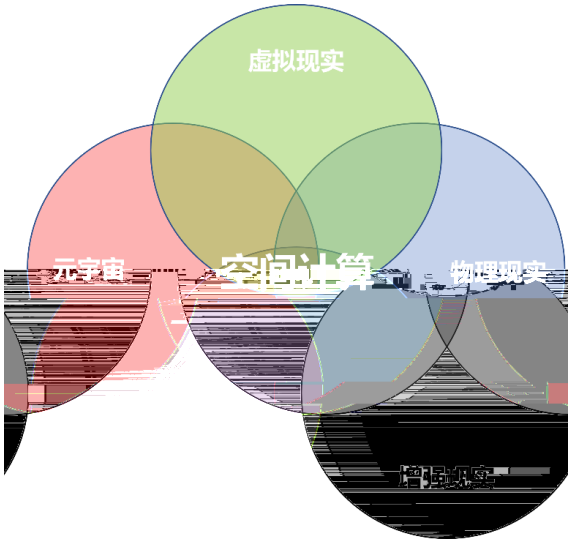
Vision Pro

Apple Vision Pro

Simon

Greenwold 2003





Metaverse Andrew Schwartz

[2]

1838

3D

3D

1900 (Stanley Weinbaum)

1956 Morton Heilig VR Sensorama 3D

Heilig Philco 1961 Headsight VR 1960 (Ivan Sutherland)

VR 1968 Ivan Sutherland AR

20 70

VR

1980 VR VR

VPL Research Inc 1985 VPL

Jaron Lanier 1987 1998

Sportsvision VR

2010 18 Palmer Luckey Oculus Rift VR

90

VR Kickstarter

240 Luckey Oculus VR 2014 Facebook 20

2014 VR
Cardboard Google Glass AR
Gmail
AR

2016 HoloLens
AR 2016
VR AR

2019 Oculus Quest VR Beat Saber 100
Oculus Quest2 Half-
life:Alyx

Web3.0

2021 Web3.0
Meta

2023 WWDC 2023 Apple Vision
Pro

1

NSF

2

3

DARPA XR

4

NIST XR

5

NSF

AR VR MR

6

1

2020 XR

XR

XR

XR

XR

2

XR HUB XR

XR

XR

XR

XR

1

SIP XR

SIP

SIP XR

2

JST XR

XR

1

MSIT

XR XR

XR XR

2

XR

XR

XR

XR

5G XR

5G XR

3

KCC

KCC

4

XR Consortia

1

ARC XR

2

XR

3

XR

2016 3 (2016-2020)

2016 4 5.0

2022 10 28

2022-2026 2026

3500 2500

100

10 10

[3]

2023 3 8

2023 3 6

2023-2025

VR AR 5G +

2023 3 20 3.0

2023 -2025

10 3.0

2023 3 6

GPU

VR(

) AR( ) MR( )

2023 3 23 2022

2023

2023 2 21

XR 15

177 AR

AI

1

Stivr

2

1

Koch

20%

Magic Leap

Case Western Reserve University Cleveland Clinic

2

3

Zillow

NASA

[10]

Immersv 1050

43% VR

11 2024 24

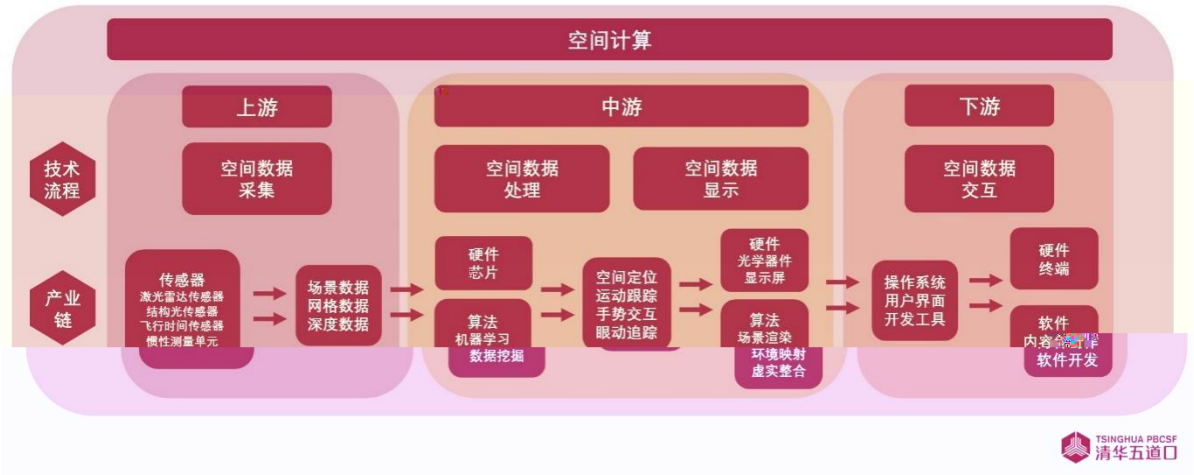
2020 VR

Epic Games

Oculus Rift VR

3D Disney

2017 2018 17%

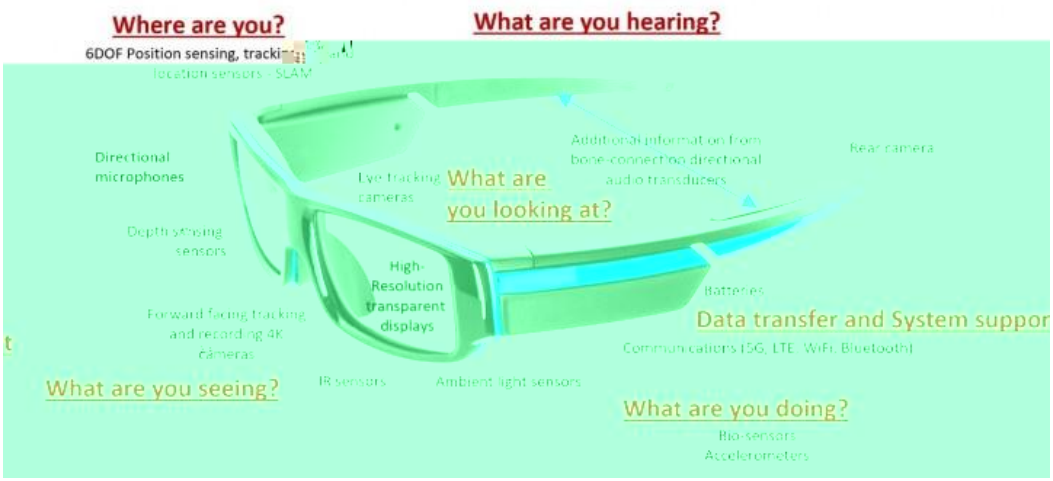

空间计算
上游
中游
下游
技术流程
产业链
空间数据采集
空间数据处理
空间数据显示
空间数据交互
传感器
激光雷达传感器
结构光传感器
飞行时间传感器
惯性测量单元
场景数据
网格数据
深度数据
硬件
芯片
算法
机器学习
数据挖掘
空间定位
运动跟踪
手势交互
眼动追踪
硬件
光学器件
显示屏
算法
场景渲染
环境映射
虚实整合
操作系统
用户界面
开发工具
硬件
终端
软件
内容
软件开发
TSINGHUA PBCSF
清华五道口

1

2

3

[4] 2-2


Where are you?
6DOF Position sensing, tracki
location sensors - SLAM
What are you hearing?
Additional information from bone-connection directional audio transducers
Rear camera
Directional microphones
Eye tracking cameras
What are you looking at?
Depth sensing sensors
High-Resolution transparent displays
Batteries
Data transfer and System suppor
Communications (5G, LTE, WiFi, Bluetooth)
Forward facing tracking and recording 4K cameras
What are you seeing?
IR sensors
Ambient light sensors
What are you doing?
Bio-sensors
Accelerometers

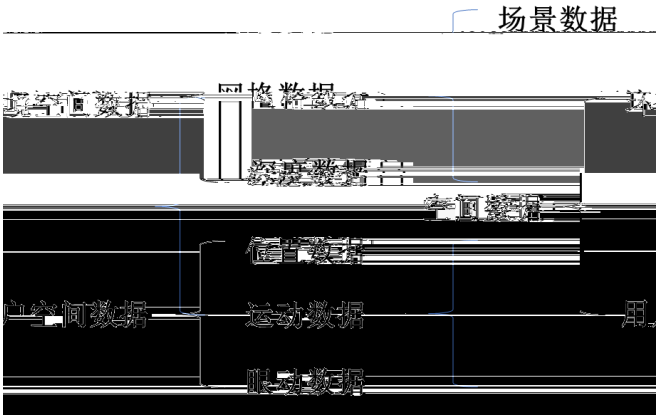
1.

2-3

1

2

(IMU)



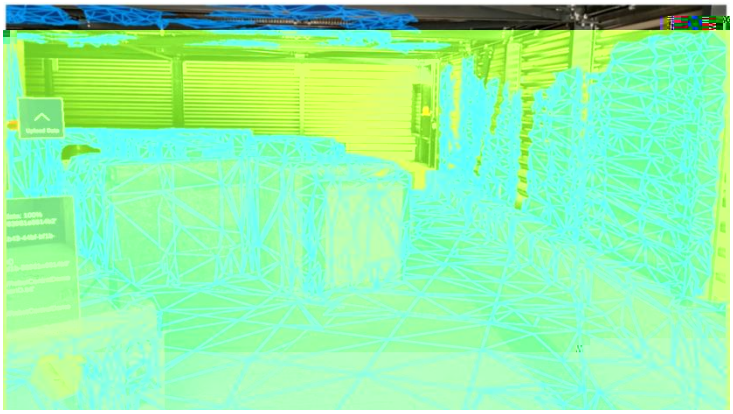
2.

1

2

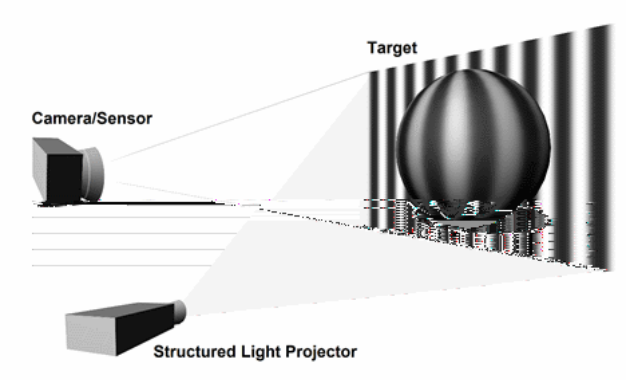
3

PSO



2

3



4

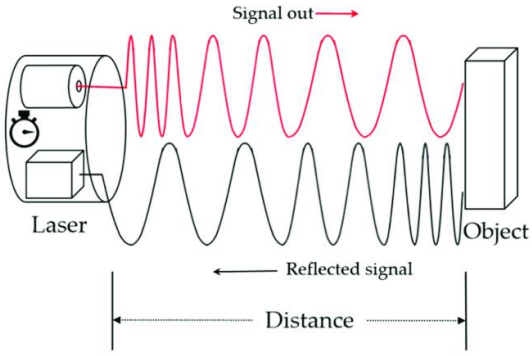
4.

1

2

ToF (Time of flight)

3



4

ToF dTOF

iTOF ToF

ToF

LiDAR

dTOF TOF Camera

iTOF

dTOF LiDAR

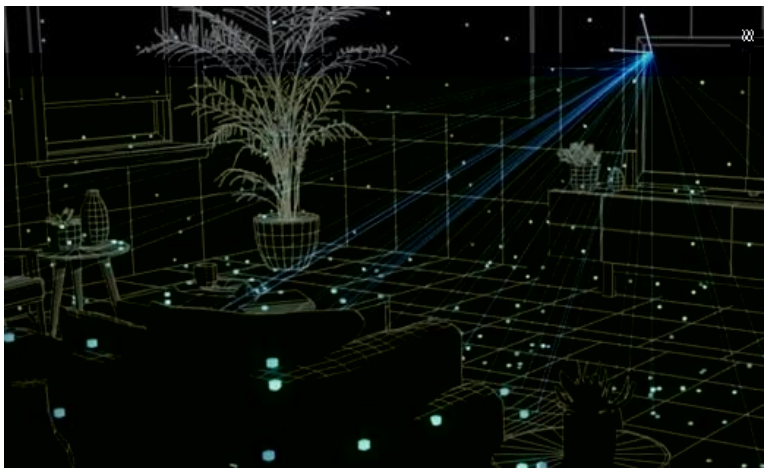
iTOF dTOF

LiDAR iTOF

dTOF LiDAR

5.

1

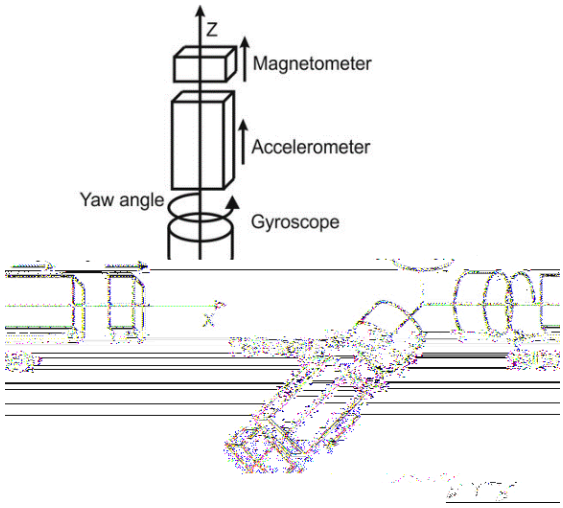


2

IMU

3

●



●

4

IMU

IMU

GPS

LED

1.

1

2

3

5

6

ToF ToF

(CCD)

VCSEL

2.

GPU

GPU

10

3D

Meta

QuestPro

ASIC

1.

1

GPU

3D

2

SLAM

3

2.

1

Pancake

Pancake

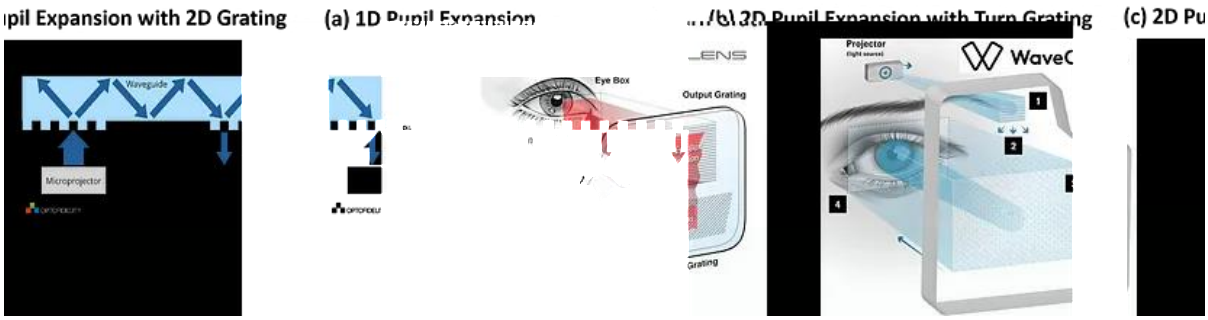
Pancake

Micro-OLED

- -Birdbath-

Birdbath

80g



2

Micro-OLED AMOLED

Micro-OLED

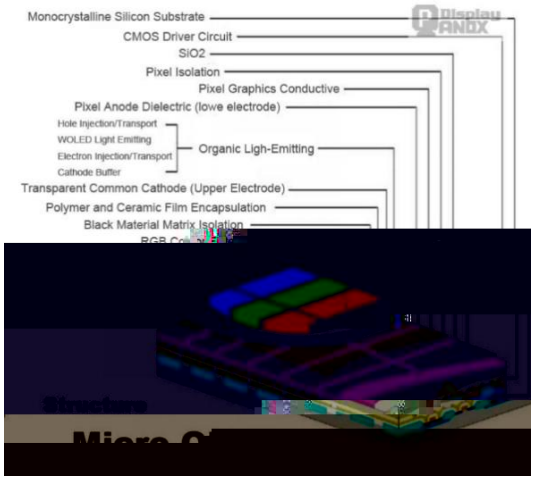
LED Micro Light Emitting Diode Display

Micro LED LED

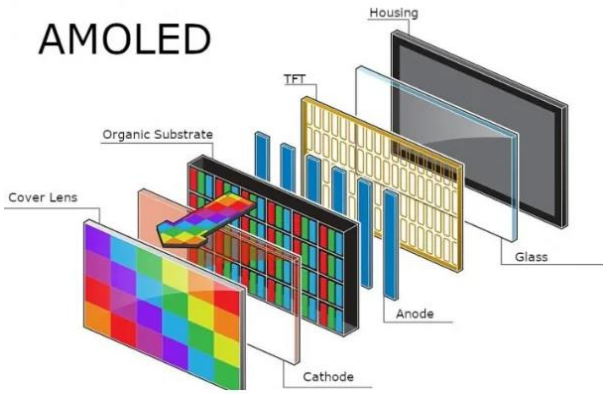
1~10 m LED

Micro LED Micro

OLED



AMOLED Active-matrix organic light emitting diode



SDK Software development kit

SDK SDK

SDK

AI Stable Diffusion 3 OpenAI Sora

Viveport Oculus Store Steam

3-1

			Colibrys Silicon Designs PrimeSense
			AMD
			Valve Doublepoint Eyefluence
			3M
			JBD LG
			vivo PICO TCL Nrea1 HTC STAR VR Meta Magic Leap Varjp LG Snap
			Meta OSVR macOS, Android, Palm os 5, Ubuntu, Microsoft Tesseract
			Unity Cherrypicks Nibiru

2

Birdbath Birdbath

Google Glass Meta2

Birdbath Mirage ODG R9 HoloLens

1 Magic Leap One Lumus Vuzix Waveoptics Digilens

AMOLED

AMOLED LG AMOLED

20ms 30

CINNO Research 2021 AMOLED

6.68 72.3%

4.8 AMOLED

2020 AMOLED 343.24 2025

547.05

Unity Technologies Epic

Games Vuforia

B

C

B B

C B B

1

2016

AR VR MR

3D

1

3-2

SoC System on Chip

GPU Graphics Processing Unit NPU Neural Processing Unit

3-3

3-4

Micro-LED Micro-OLED

3-5

1

2

15 30

GPU

3

4

outside-in inside-out

inside-out

1	An electrosurgical generator	EP1581128A1	723	GYRUS MEDICAL LIMITED
2	Transaction terminal and adaptor therefor	US8723804B2	651	Hand Held Products, Inc.
3	Article locating and tracking apparatus and method	US20050035862A1	560	Timothy D. WildmanWilliams F. CollinsThomas M. FleckCarl W. RileyRichard J. Schuman
4	Methods and systems for monitoring a game to determine a player-exploitable game condition	US7517282B1	494	Microsoft Corporation
5	Virtual display	US7990382B2	456	Masimo Corporation
6	Using multiple simultaneous threads of			

	Pre-A

	[ ] VIAVI [ ] 16 Lumus AR
	[ ] 2015 60% GoPro 2007 VR
Microsoft	[ ] 2016
	[ ] 2017 AR
	[ ] 2018
	[ ] Hololens Oculus
	[ ] 2020 microLED AR
	[ ] 2019 AR infinity AR
Google	[ ] 2017 MicroLed Glo AB [ ] 2020 AR

	[ ] AR ,
	[ ] AR FOV
	[ ] AR VR
	[ ] DOE HoloLens AR
	[ ] ODG AR ODG AR AR
	[ ] 3D 3D 7Fresh Vmall 3D 3D
	[ ] CG VR [ ] 2016 VR VRC VR VR

[ ]

	[ ] AR AW70 AW81 85% 10
	[ ] 2015 AR ThinkReality A3 AR
Oculus	[ ] Oculus
Meta	[ ] Facebook 2014 7 20 Oculus Oculus
	[ ] Rokid Glass 2 AR
	[ ] 1-2 XR
	[ ] HTC Vive 1993 2015 301292 KPS 9.4%

	AMOLED 1994 4 AMOLED VR
	AMOLED 1994
	AMOLED 1993 4 2016 5.5 AMOLED 2014 2015
	OLED Micro-OLED OLED IC OLED VR/AR LCD OLED
	Micro-LED Micro-LED Micro-LED 2-6
	OLED OLEDoS OLEDoS 43,000 12 OLEDoS
JBD	Micro-LED JBD / AM-uLED AM-uLED AM-uLED IC MOCVD Micro-LED

1.

VR 2022

95% 2022 110

C B

Pico 2022

43% DPVR 36% HTC NOL

Metaverse Meta

Facebook Oculus

OPPO

2.

1

NPD Group 2022 VR

2% CCS Insight 2022 AR/VR

12% 960

2

C B

AR/MR

3

IDC (International Data Corporation) 2024 XR

2090

1000

2025 35 650

94.8%

Apple Vision Pro

AR B

VR C

vision pro

3.

Apple Vision Pro

4.

1

HTC Vive X

Cardboard

2

+

2016 5 VR/AR

/

Microsoft Magic Leap Google Apple Facebook Nreal 4-1

4-2

4-3

VC

IPO IPO

3. (AR) (VR) AR VR

4.

5.

Stable Diffusion 3 Sora

5-1

(VR) 3D

(AR)

AR

3D

Extended Reality XR

AR

VR MR

(Fresnel lens)

Micro Light Emitting Diode Display

Micro LED LED

1~10 m LED

Micro LED Display

(Simultaneous localization and mapping

SLAM)

GraphSLAM SLAM

Metaverse

5G

[1] News (2023) Homepage. Available at: https://www.magicleap.com/blog-staging/spatial-computing-for-enterprise-rewrite-the-rules-of-your-industry (Accessed: 24 December 2023)

[2] What leaders need to know about spatial computing (2023) Harvard Business Review. Available at: https://hbr.org/2023/11/what-leaders-need-to-know-about-spatial-computing (Accessed: 24 December 2023).

[3]

. 2022—2026

2022 148 [EB/OL].[2022 10 28].

https://www.gov.cn/zhengce/zhengceku/2022-11/01/content_5723273.htm.

[4]

[8] Zheng, L.; Li, B.; Yang, B.; Song, H.; Lu, Z. Lane-Level Road Network Generation Techniques for Lane-Level Maps of Autonomous Vehicles: A Survey. Sustainability 2019, 11, 4511.

[9] Belau, B. (2021) Facebook establishes New Metaverse Project Group as it focuses on the next connectivity shift, B2 Web Studios. Available at: https://b2webstudios.com/facebook-establishes-new-metaverse-project-group-as-it-focuses-on-the-next-connectivity-shift/ (Accessed: 24 December 2023).

[10] i, Jacek and Pelc-Mieczkowska, Renata. "Concept of AHRS Algorithm Designed for Platform Independent Imu Attitude Alignment" Reports on Geodesy and Geoinformatics, vol.104, no.1, 2017, pp.33-47.

[11] Rokid (2019) Understanding waveguide: The key technology for augmented reality near-eye display (part II), Medium. Available at: https://arvrjourney.com/understanding-waveguide-the-key-technology-for-augmented-reality-near-eye-display-part-ii-fe4bf3490fa (Accessed: 24 December 2023).

[12] Specialist LCD/OLED supplier (no date) What is micro OLED? Micro OLED Display Product List - OLED/LCD Supplier. Available at: https://www.panoxdisplay.com/micro-display/ (Accessed: 24 December 2023).

[13] Display, H. (2023) What is the difference between PMOLED and Amoled?, What is the Difference Between PMOLED and AMOLED? -. Available at: https://www.hongguangdisplay.com/blog/what-is-the-difference-between-pmoled-and-amoled/ (Accessed: 24 December 2023).

0 1

“ ”

/

“

”

1

2

/

3

/

4

/

Apple Meta

Magic Leap

“ ”

TSINGHUA PBCSF
清华五道口

zhuysh@pbcsf.tsinghua.edu.cn