喷墨打印技术的原理及其在 AR/VR 微型显示中的应用

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Micro-LED 具有优异的光学性能和长的寿命，被认为是下一代终极显示技术。最小像素尺寸达到数十微米，高像素密度为其在 AR/VR 提供了可能。近年来，压电/热喷墨打印、气溶胶喷墨打印、电流体动力喷墨打印、超级喷墨打印等技术被用来沉积色转换层，为实现 Micro-LED 全彩化表现出极大潜力。

厦门大学张荣教授团队与台湾交通大学郭浩忠教授介绍了喷墨打印技术的原理，并展示了其在 AR/VR 微型显示中的应用。首先介绍了 AR/VR 技术的研究进展；然后讨论了 Micro-LED 显示技术的研究进展及其在 AR/VR 中的适应性，通过喷墨打印技术制备 Micro-LED 色转换层的优势，非辐射能量转移机制以及色转换层的厚度对色转换效率的影响；介绍了 SIJ 相对于其他打印技术在分辨率上的优越性。其次，介绍了各种喷墨打印技术的打印原理；两个关键问题：墨水的流变学参数优化和解决咖啡环效应的方案；每种打印技术适合的墨水流变学参数及流变学参数对打印效果的影响。综述了咖啡环效应的两种解决思路及具体的改善方法。最后，强调了与色转换层相关的一些潜在问题，包括光串扰、蓝光吸收以及自吸收效应。

Micro-LED 为 AR/VR 的商业化铺平了道路，而高像素密度的全彩化 Micro-LED 的制造是瓶颈之一。色转换层方案是实现 Micro-LED 全彩化的有效途径，喷墨打印技术的发展为高分辨色转换层的制造提供了技术支持。

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The principle of inkjet printing and its applications on AR/VR micro-displays

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In recent years, inkjet printing technology shows great potential in microfabrication due to its advantages of digitalization, patterning, additive manufacturing, low waste of material, and large-area printing.

The research groups of Prof. Rong Zhang from Xiamen University and Prof. Hao-Chung Kuo from Chiao Tung University overview the principle of inkjet printing technique and its application on micro-display for AR/VR. In this review, the progress of AR/VR technologies is first introduced, followed by the discussion of the adaptability of micro-LED display technology in AR/VR and the advantage of printing color conversion layer for micro-LED by inkjet printing technology. The non-radiation energy transfer mechanism and the influence of color conversion layer thickness on color conversion efficiency are discussed. The advantages of SIJ over other printing technologies in resolution are introduced. In the second part, the printing principle of various inkjet printing technologies, as well as two key issues — the optimization of ink rheological parameters and the reduction of coffee-ring effects, were introduced. The rheological parameters of ink suitable for each printing technology and the influence of rheological parameters on the printing effect were introduced. Two solutions to the caffeine ring effect and specific improvement methods were reviewed. Finally, some potential problems associated with the color conversion layer are highlighted, including light crosstalk, blue light absorption and self-absorption effect. This review article servers as a reference for those who are about to get access to the areas of inkjet printing technologies, micro-LED full colorization and its application in AR/VR.

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