

Integration of μ -LED chips toward Next-Generation μ -LED Display

通过微LED芯片集成化创制下一代微LED显示器

Kogakuin Univ. Tohru Honda, Ryosuke Nawa, Tomohiro Yamaguchi, Takeyoshi Onuma

Keywords: LED, Display, Nitride semiconductor

Abstract Micro-LED display is attracting considerable attention as next-generation display based on inorganic LEDs. The rapid growth in industry is sustained by beneficial features of the inorganic LEDs, i.e., very long lifetime, robust, high external quantum efficiency, etc. Nevertheless their potential performance characteristics over LCDs and OLED displays, technological issues and high production cost have prevented their realization. In this study, fabrication of Si micro-cup substrate and its application for integration of μ -LEDs were demonstrated. Emission properties of LEDs with and without the micro-cup clearly showed that Si micro-cup works well as a black matrix.

Introduction 【Future forecast of inorganic LED display】

Present



ALTA vision at Shinjyuku, Tokyo

Future



TV Monitor for home use



Smartphone



Smartwatch



EPSON MOVERIO

Head Mounted Display (HMD)

To be an alternative choice for small display including LCD, OLED, QLED.

【Merits of inorganic LEDs】

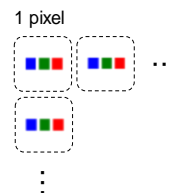
- High luminous efficacy
- High response time
- Low energy consumption
- High definition
- Li-Fi: Wireless visible light communication

【Technological issues】



LED: 3in1chip type SMD

- Miniaturization of the LEDs smaller than 50 μ m
- Integration
- Black matrix: reduction of crosstalk in a densely packed μ -LEDs
- Cost



Product, Standard	size[inch]	Pixel size [μ m]		Number of pixels		
		Length	Width	Length	Width	Sum
I phone 5c,5s	4.0	78	78	1,136	640	727,040
I phone 6	4.7	78	81	1,334	720	960,480
Hi Definition (HD)	5.5	95	95	720	1,280	921,600
Full HD	5.5	63	63	1,080	1,920	2,073,600

* RGB colors are integrated into 1 pixel.

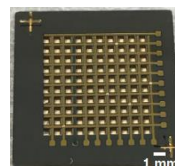
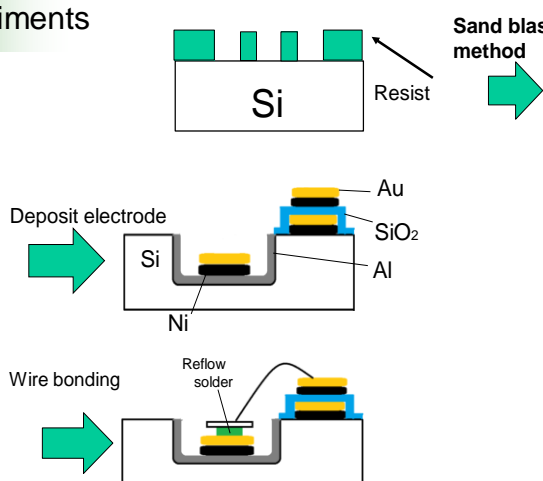
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Experiments



Physical properties of Au-Sn alloy

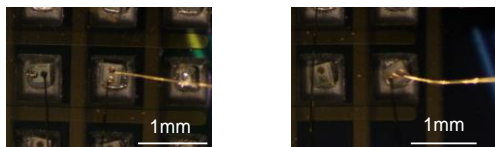
Composition [wt%]	Melting temperature		Hardness [H _B]	Thermal expansion coefficient [10 ⁻⁶ /K]	Thermal conductivity [W/(m·K)]
	Solidus curve [°C]	Liquidus curve [°C]			
Au	1,063	1,063	25	14.2	311
Au-20Sn	280	280	118	17.5	57.3
Pb-63Sn	183	183	17	24.7	49
Pb-5Sn	310	315	8	28.7	23
Sn-3.5Ag	221	221	40	--	33

MITSUBISHI

三菱マテリアル

Results and Discussion

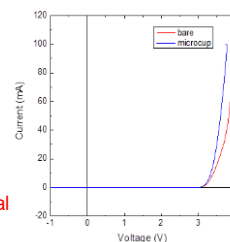
LED mounting



Gold wire is bonded by wire-bonder. LED surface is well aligned to the Si wafer surface.

I-V characteristic of LED mounted in the Si μ -cup

I-V curves show similar characteristics.



Bonding does not affect to their electrical property.

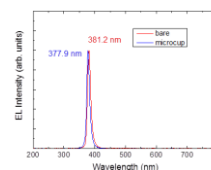
Comparison of emission patterns



- Al film acts as a reflector.
- Si micro-cup works well as a black matrix

Comparison of emission spectra between bare LED and LED embedded in the μ -cup

Emission spectra show similar characteristics.



Bonding does not affect to their optical property.

The results indicate that Si μ -cup is suitable for the black matrix.

Summary

Fabrication of Si micro-cup substrate and its application for integration of μ -LEDs were demonstrated. Emission properties of LEDs with and without the micro-cup clearly showed that Si micro-cup works well as a black matrix.

Acknowledgement

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