Study on increasing durability of wrap around black material for tiled displays

2024.08.21.

Nakcho Choi

Samsung Display

Contents

Introduction

1. Tield Display with Micro LED

The Wall : https://www.samsung.com

Crystal LED : https://pro.sony

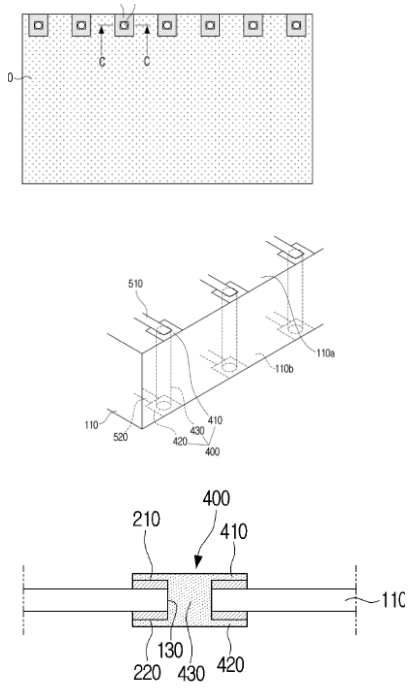
Seamless Design : Modular Flexibility

Modular Display

Prior Art Search

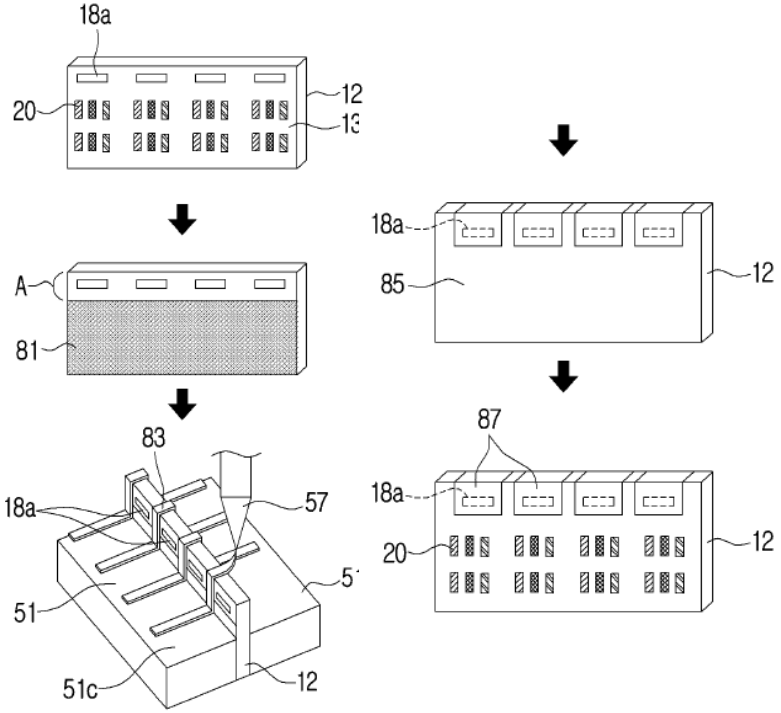
2. Wrap Aroud Electrode Process

Hole Process (Through Glass VIA)



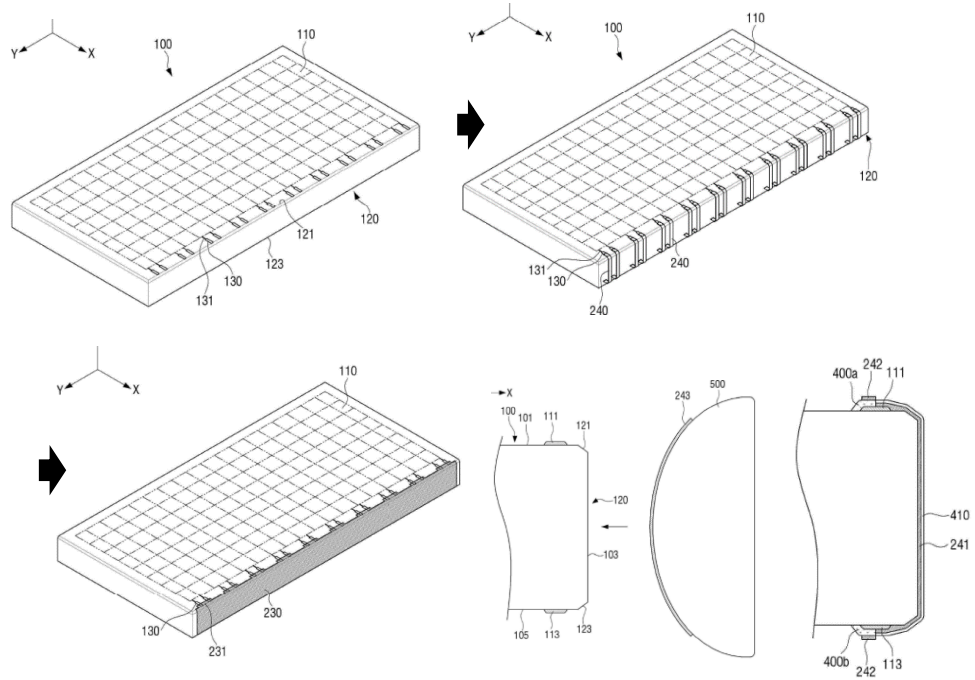
KR 10-2022-0054034

Dispensing Process



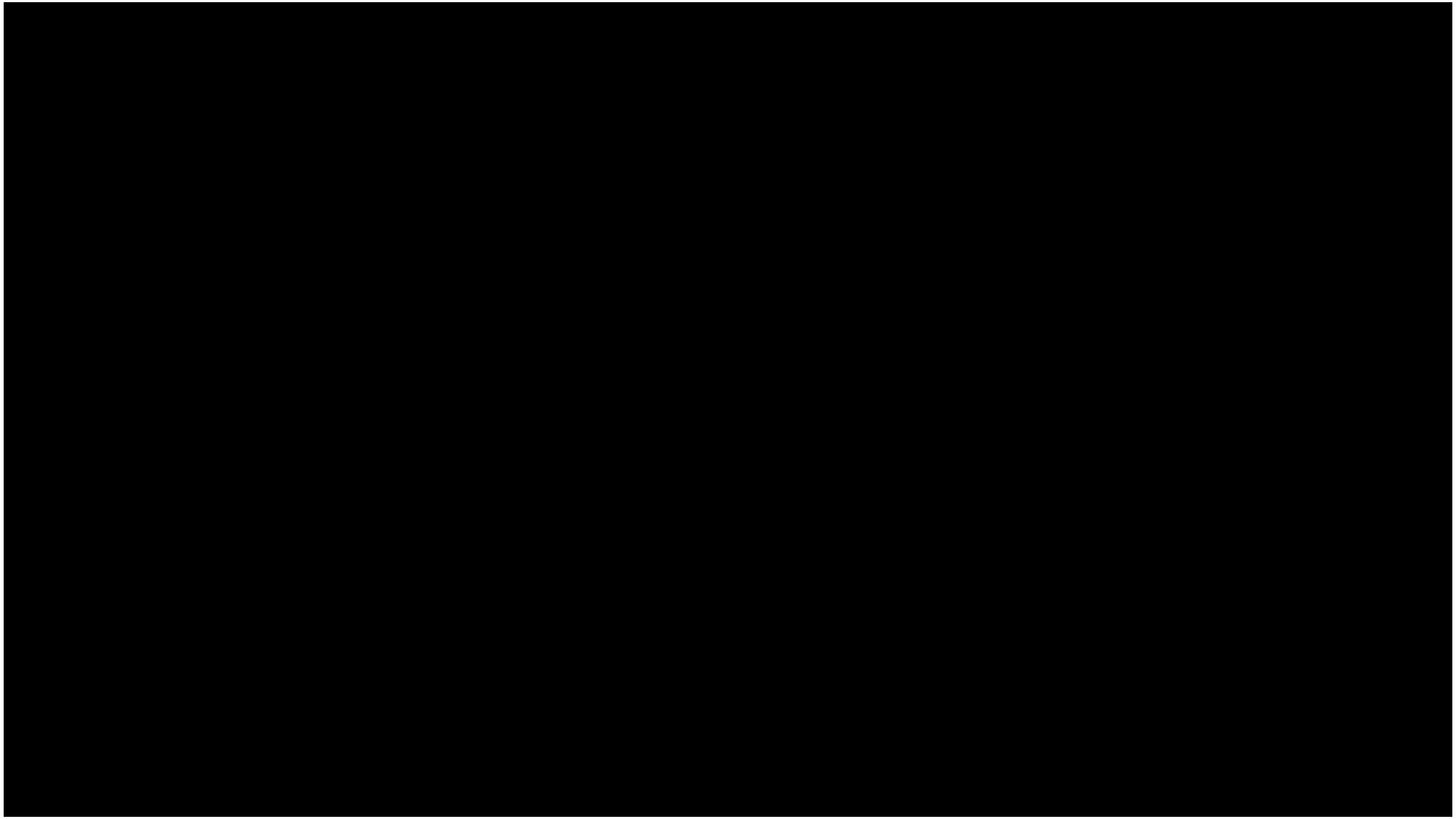
KR 10-2022-0039448

Pad Pringing Process



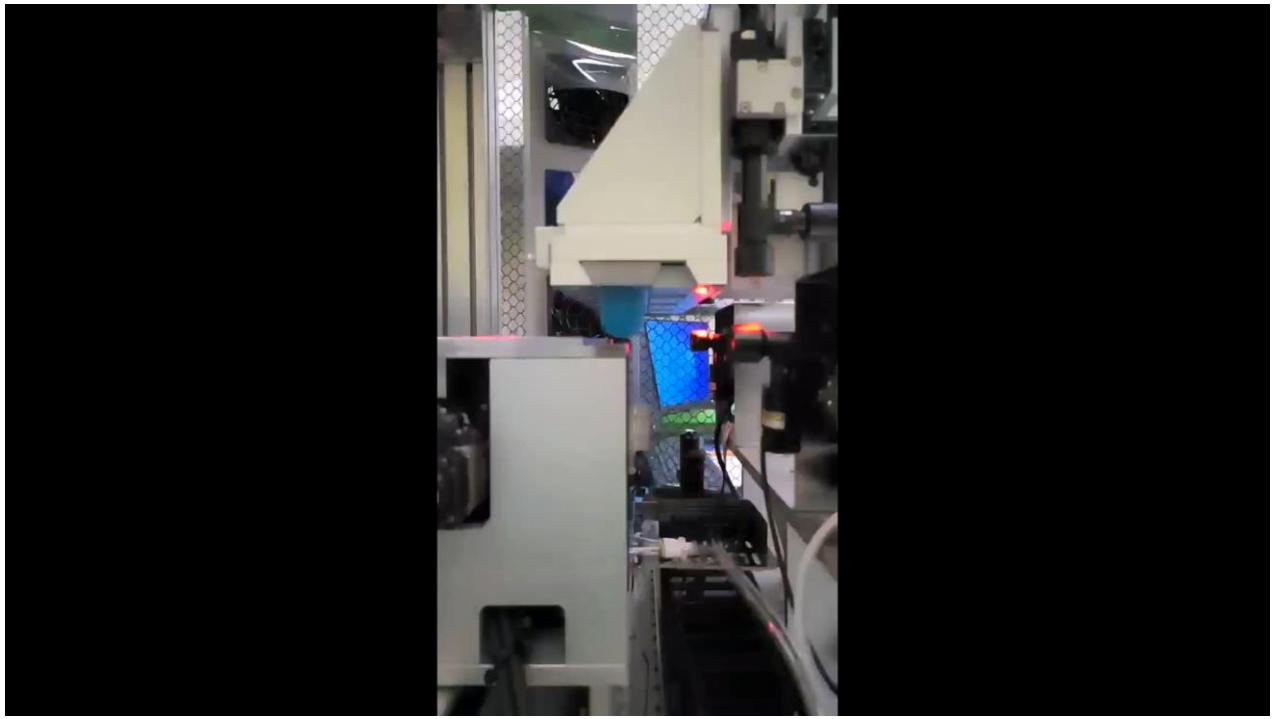
KR 10-2021-0068356

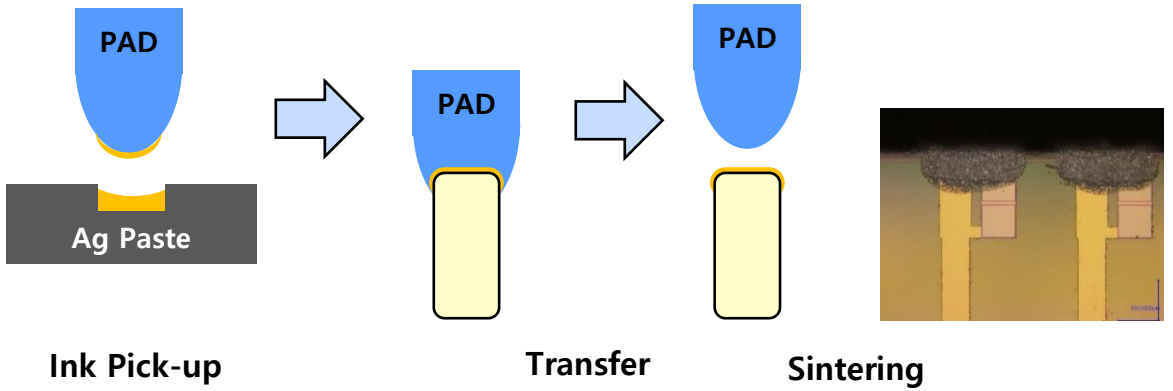
Pad Printing

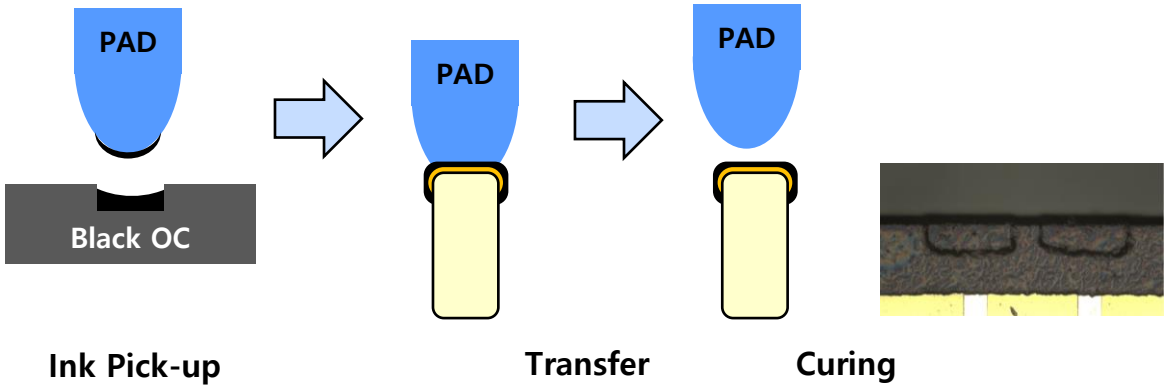


Source : EC Printing Machine Factory Limited : https://www.ecpnp.com/

Wrap around Electrode and Black OC

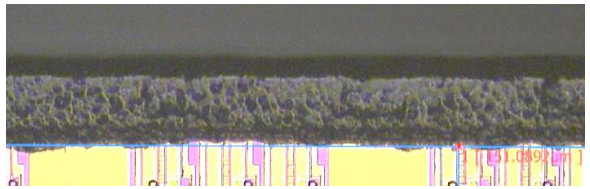




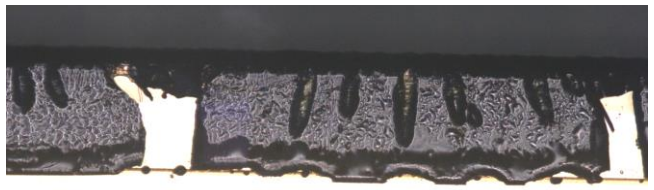


Description of Problem and Analysis

1. Water Humidity Temperature Storage (WHTS, 85℃, 85%, 500h)



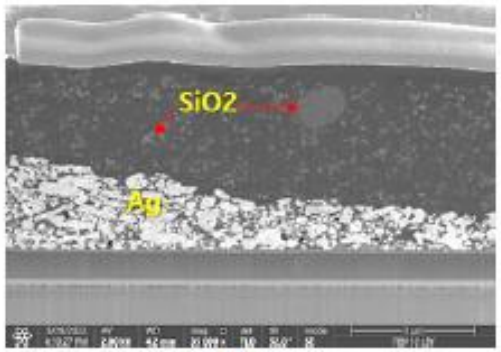
Initial State



Swelling and Delamination

2. Cross Sectional Analysis of Delamination

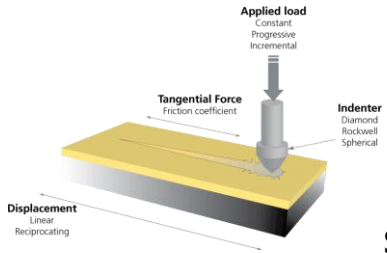
(a)

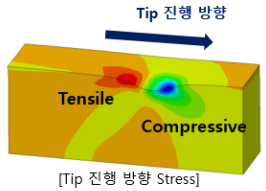


(b)

Description of Problem Phenomenon

3. Scratch Test

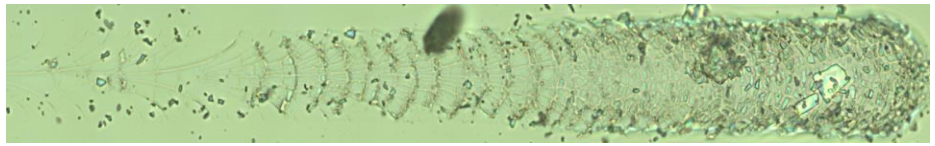


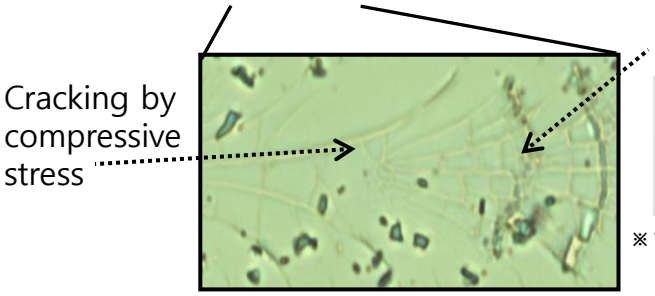


[Tip 진행 방향 Stress]

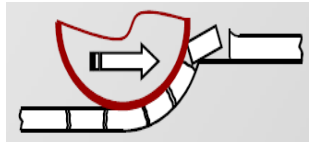
※ courtesy: CAE팀 박병욱 책임

Scratch 방향



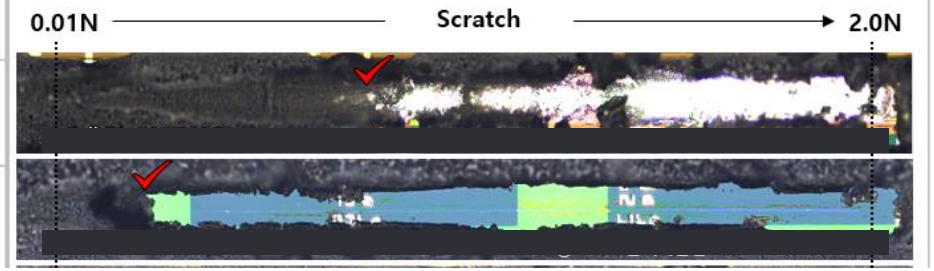


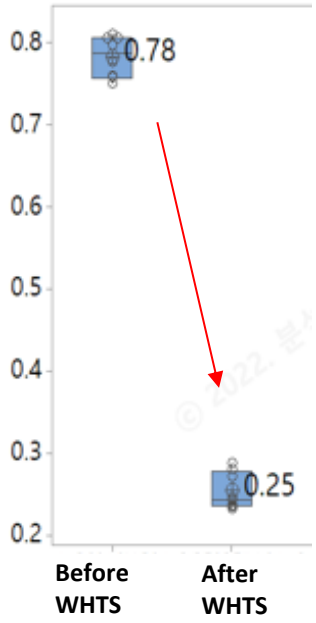
Adhesion failure(L_C)



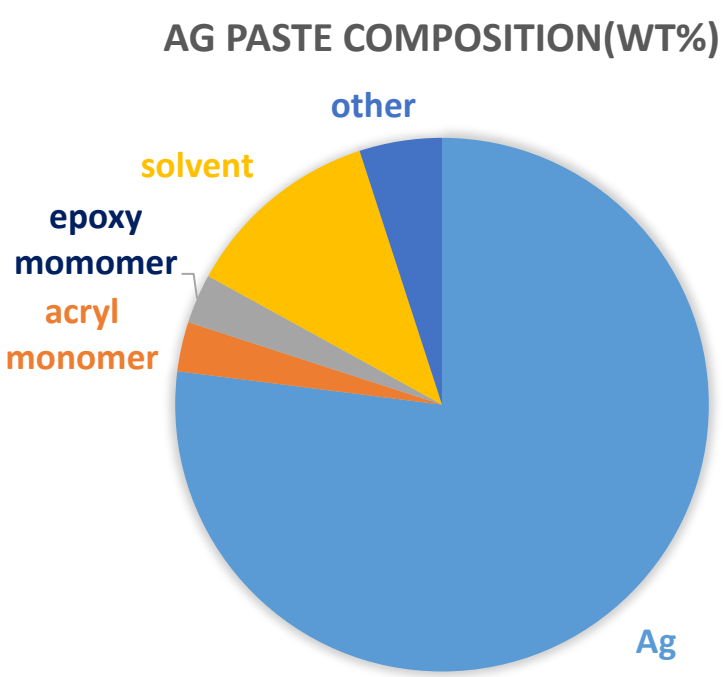
※ Thin Solid Films, 154 (1987) 403-416

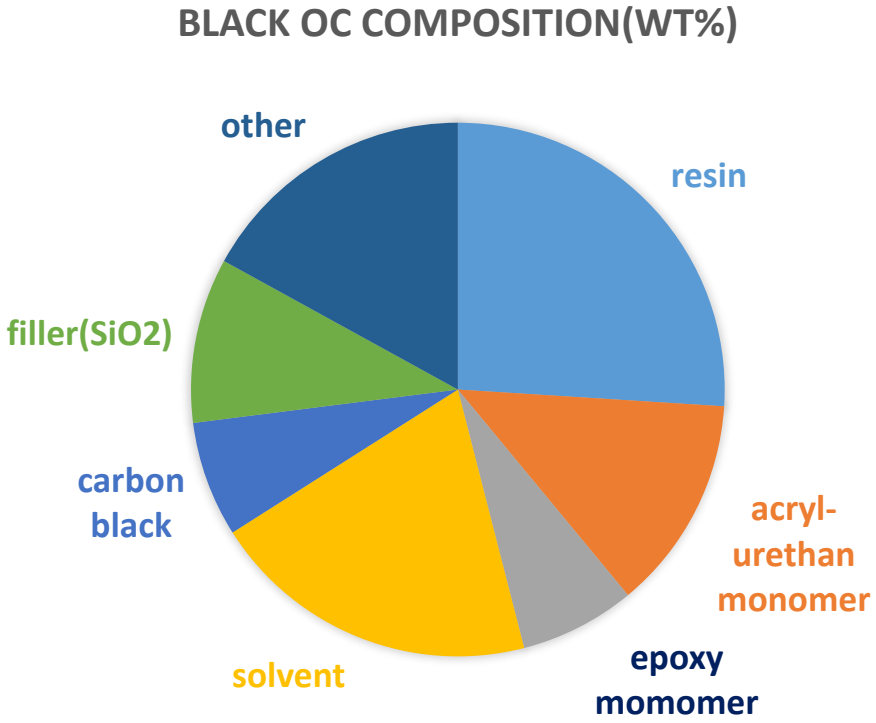
Sample	Scratch Crack Force(N)
Before WHTS	0.78±0.03
After WHTS	0.25±0.02





Iingredient ratio (Ag Paste, Black OC)

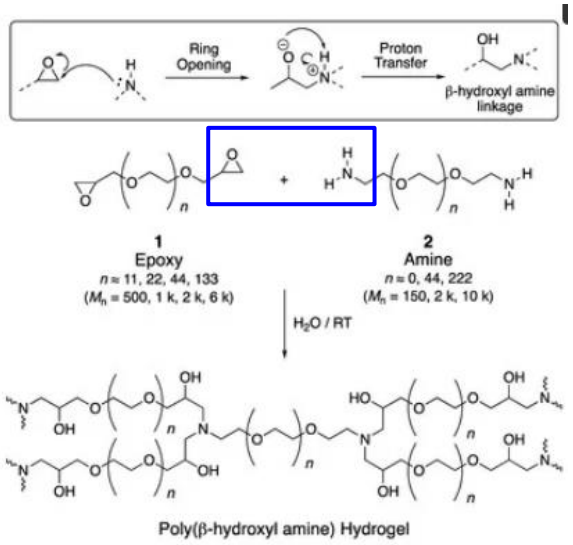




※ MSDS (material safety data sheet)

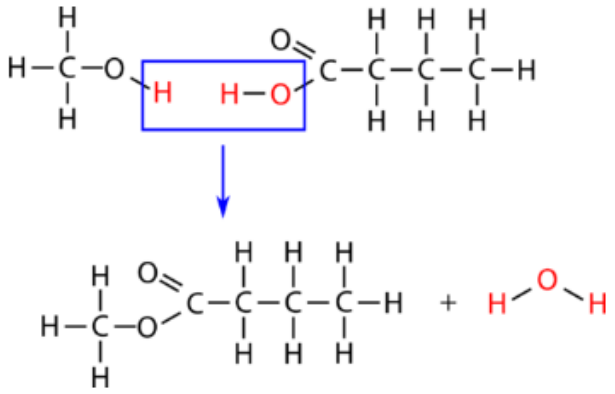
Hypothesis

1. Epoxy Binder + Amine → Polymerization (OC)



Polymers 2019, 11(9), 1491

2. Esterification reaction (OC)



https://chem.libretexts.org/

3. CaCO3 filler with SiO2+H2O → C-S-H (OC)

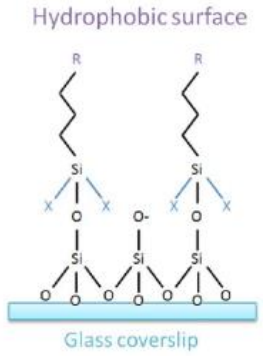
Pozzolanic Reaction

$$CaCO_3\,(s) + heat \rightarrow CaO(s) + CO_2(g)$$

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2\,(aq) + 280\text{Kcal}$$

$$3Ca(OH)_2(aq) + 2SiO2(s) + 3H_2O(l) \rightarrow 3CaO, 2SiO_2, 3H_2O\ (s)$$

4. Sillane adhesion promoter (Ag paste)

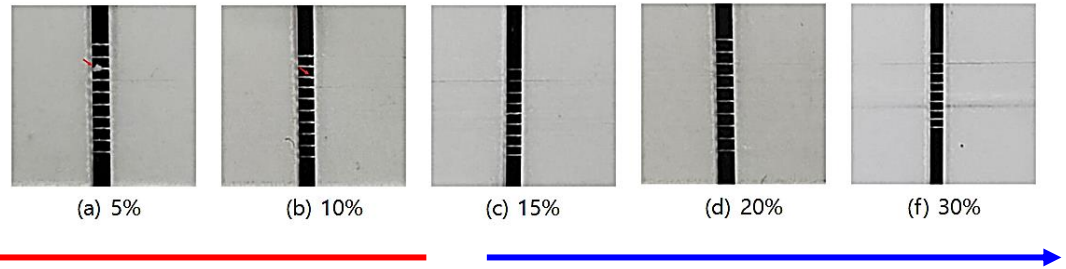


Experiments and Results

1. Composition Change (Black OC)

No.	Sample	Scratch Test after 85℃, 85% 72hours
1	reference	NG
2	Reference + amine hardener	NG
3	Reference + filler($CaCO_3$)	5B
4	Binder (epoxy -> ester)	4B

2. CaCO3 contents Change (Black OC)



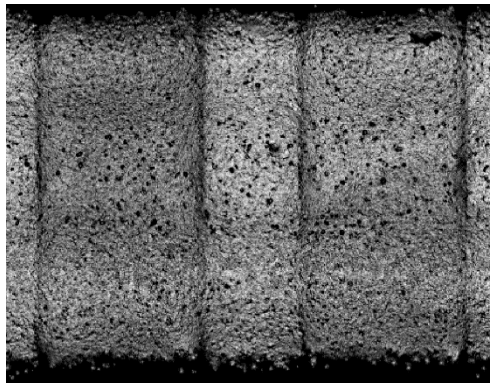
3. Silane Coupling Agent(Ag paste)

Test Condition	0.8wt% added	1.5wt% added
Room temperature(24h)	Good	Good
boiling water storage(4h)	poor peeling	Good
boiling water storage(18h)	poor peeling	Good
Ag Resistance (Initial)	1.0 Ω	1.0 Ω

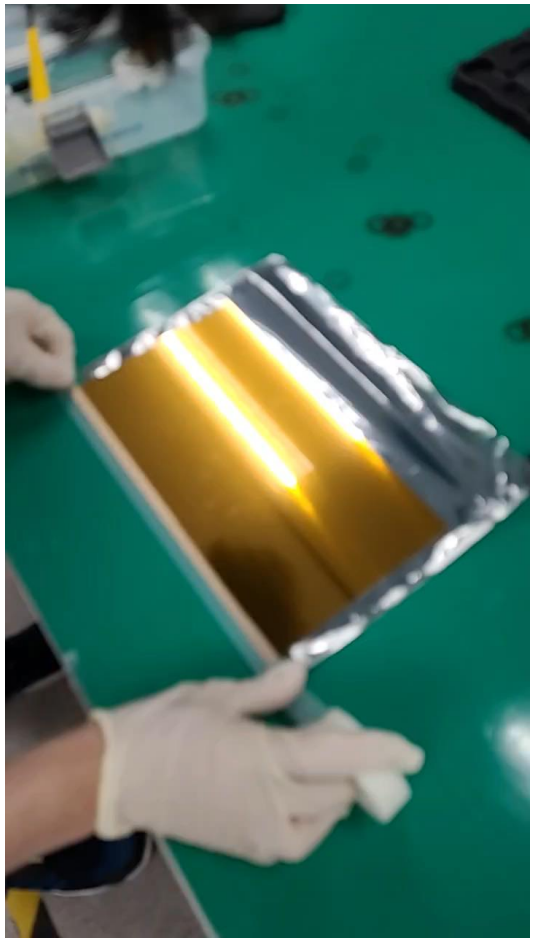
Experiments and Results

4. Peel off Test Results after WHTS

No.	Sample	Peeling Result
1	Ag paste + OC	3/3
2	Ag paste with 1.5wt% C.A. + OC	3/3
3	Ag paste + OC with 15wt% CaCO3	1/3
4	Ag paste with 1.5wt% C.A. +OC with 15wt% CaCO3	0/3



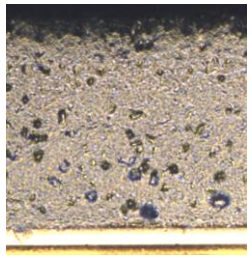
Side View of Glass



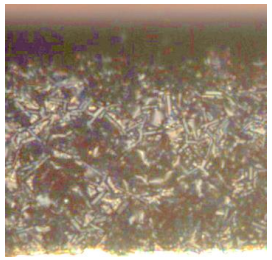
No.	Tapint Test Images		Peeling
1	Before		3/3
	After		
2	Before		3/3
	After		
3	Before		1/3
	After		
4	Before		0/3
	After		

Discussion

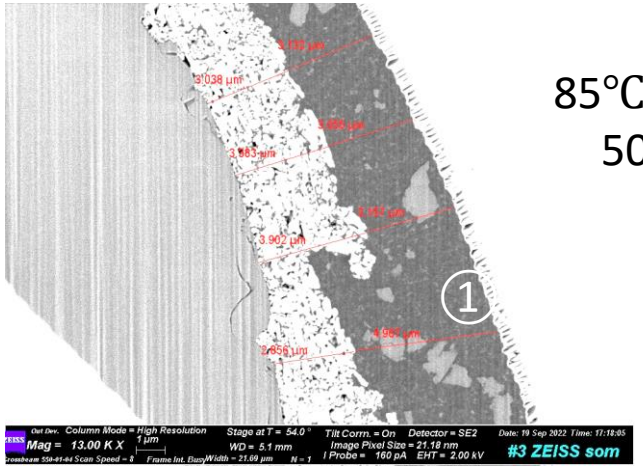
Why does the improved material have increased adhesion?



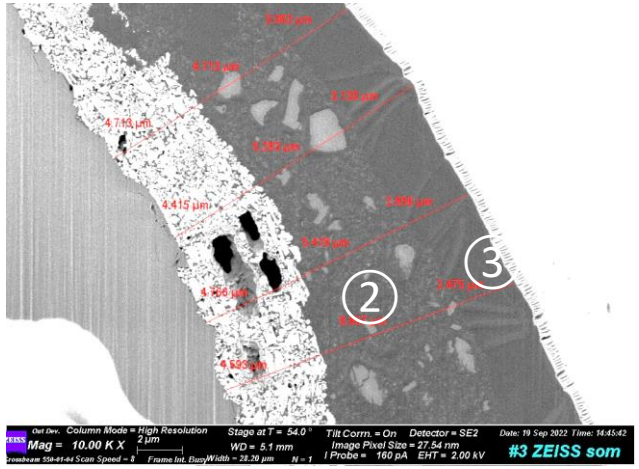
Before Test



After WHTS



85°C/85%
500h

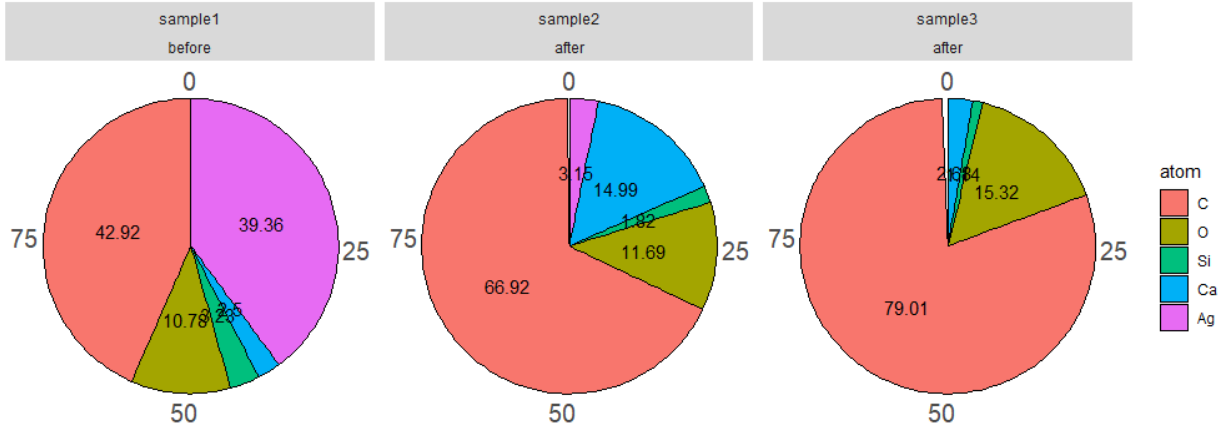


Pozzolanic Reaction

1. **CaCO3 열분해**:
   $CaCO_3 \rightarrow CaO + CO_2$
2. **CaO와 물의 반응**:
   $CaO + H_2O \rightarrow Ca(OH)_2$
3. **Ca(OH)2와 SiO2의 반응**:
   $Ca(OH)_2 + SiO_2 \rightarrow$ C-S-H (Calcium Silicate Hydrate)

EDS Aanlysis result (atomic percent) of OC

WHTS condition(8585, 500h) / before and after

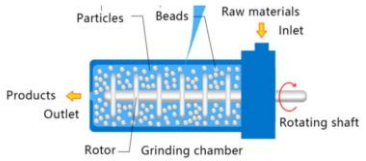


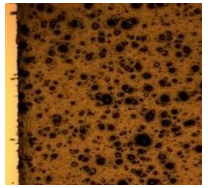
Conclusion

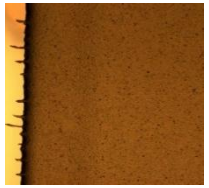
- The novel approatch of integrating CaCO3 filler into Black OC material, coupled agent with Ag paste, significantly improves adhesion and durability
- This advancement paves the way for robust and reliable wrap-around electrode for micro LED tiled display, enabling the production of ultra-large premium TVs.
- We applied for a patent on the Black OC composition and evaluated its product application. (KR,US,CN)
- Further research on exploring alternative filler of Black OC and optimizing the Ag paste sintering process to achive even greater adhetion and durability

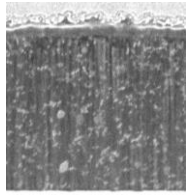
Thank you !

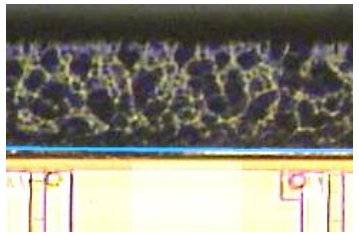
supplement

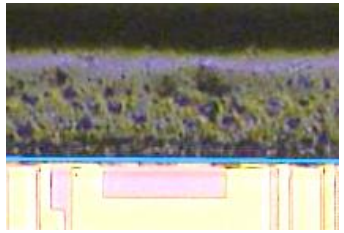

Particles
Beads
Raw materials
Inlet
Products
Outlet
Rotating shaft
Rotor
Grinding chamber

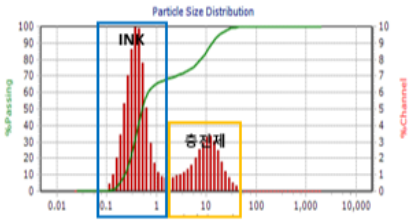


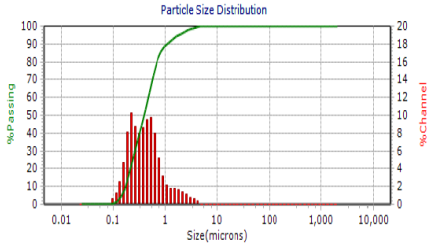


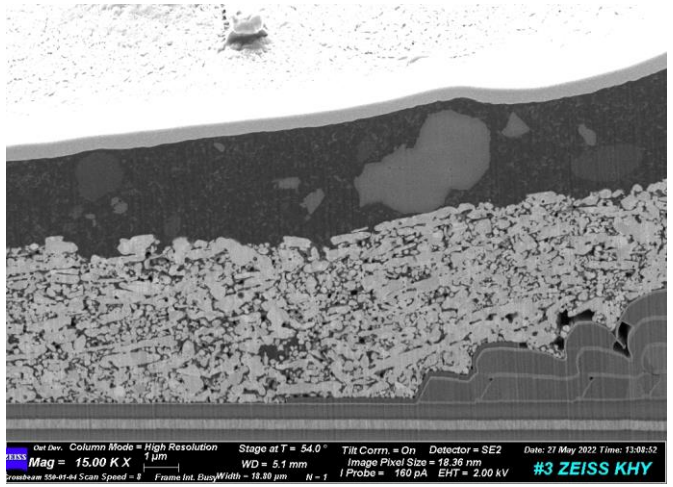


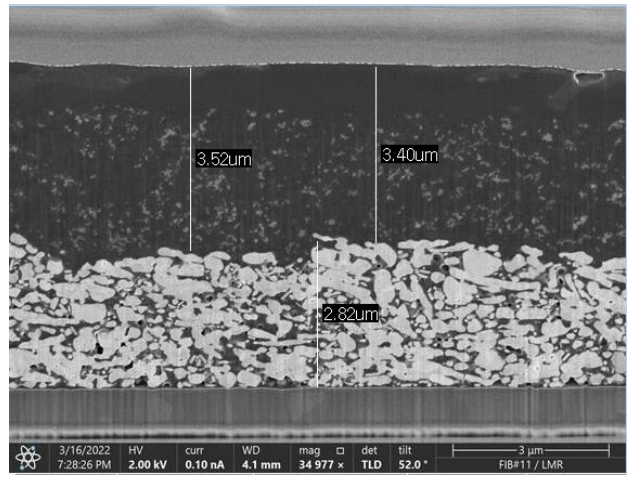





Particle Size Distribution
INK
후제제
%Passing
%Channel


Particle Size Distribution
%Passing
%Channel
Size(microns)


Mag = 15.00 K X
WD = 5.1 mm
#3 ZEISS KHY


3.52um
3.40um
2.82um