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전자신문

TECH-BIZ KOREA 2019

기술과 비즈니스의 만남

2019. 10. 10.(목) ~ 11.(금)
서울 삼성동 코엑스 아셈볼룸

고기능/다기능성
나노하이브리드 습식절연소재기술

강동준/한국전기연구원
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나노하이브리드 습식절연소재기술

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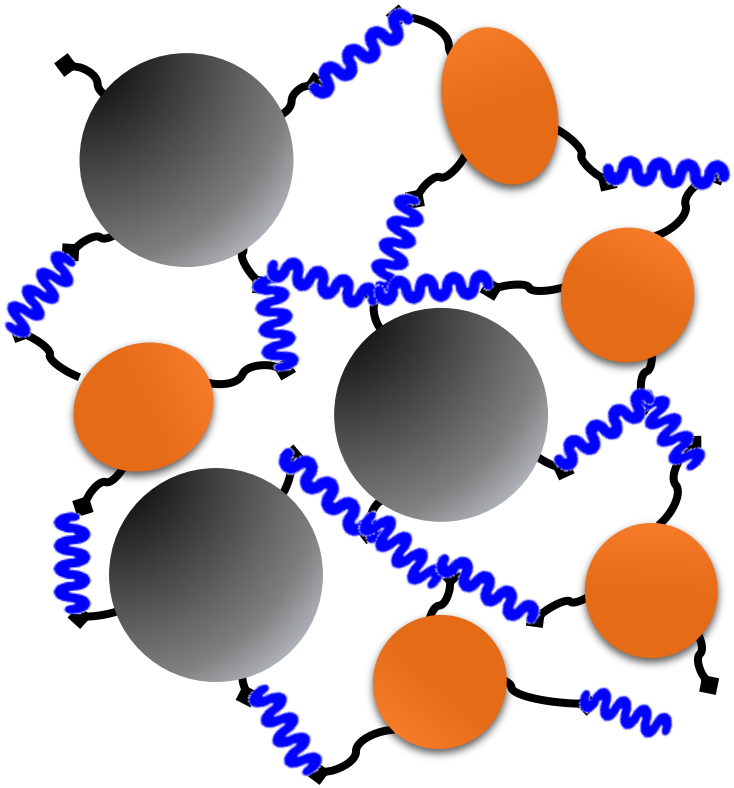
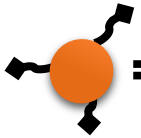
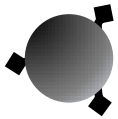
❖ 고기능/다기능성 나노하이브리드 습식절연소재 미세구조



- Reliable Insulation Performance
- Electrochemical Resistance
- Property-Tunability
- Solution Process
- UV / Thermal Curing(fast)
- Optical Transparency


= 나노하이브리드 수지


= 기능성 나노입자

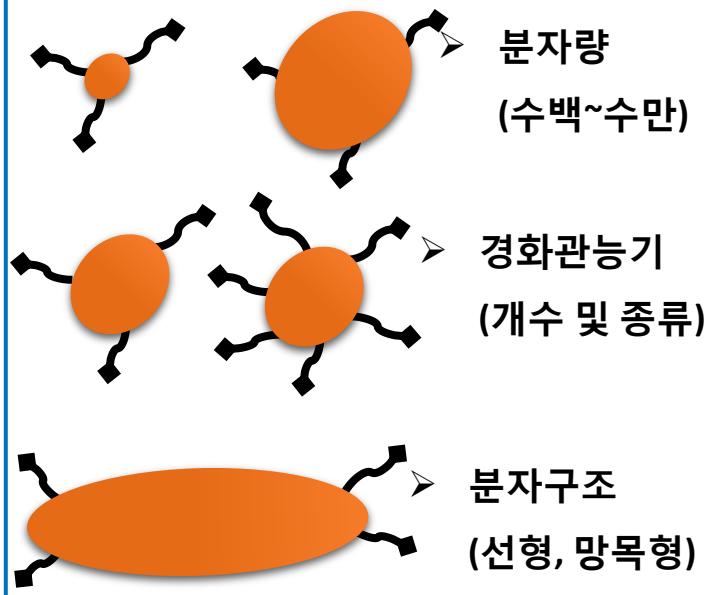

= 기능성 가교제

나노하이브리드 습식절연소재기술

TECH-BIZ KOREA 2019

❖ 고기능/다기능성 나노하이브리드 습식절연소재

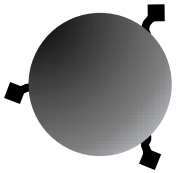
나노하이브리드 수지



- 분자량 (수백~수만)
- 경화관능기 (개수 및 종류)
- 분자구조 (선형, 망목형)

화학적 물성제어

기능성 나노입자



- 유기, 무기
- 크기 (수 ~ 수백 nm)

물리적 물성제어

기능성 가교제

- 유기, 무기, 유무기
- 모노머, 올리고머

공정 및 기능성 제어

→ 화학적 조성 · 물리적 특성 · 공정성 제어

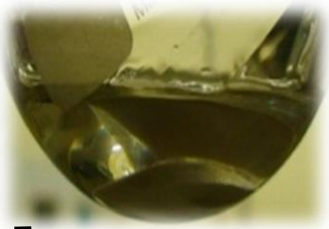
→ 산업계 핵심 요구 물성 확보 가능 !!

→ 코팅(박막~후막), 페이스트(인쇄)

무용매 점도제어 특성

Organic/inorganic Nanohybrid Materials

Components



Nanohybrid Resin

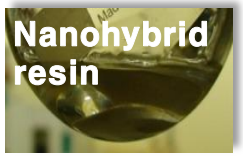
1 nm

Nanoparticles

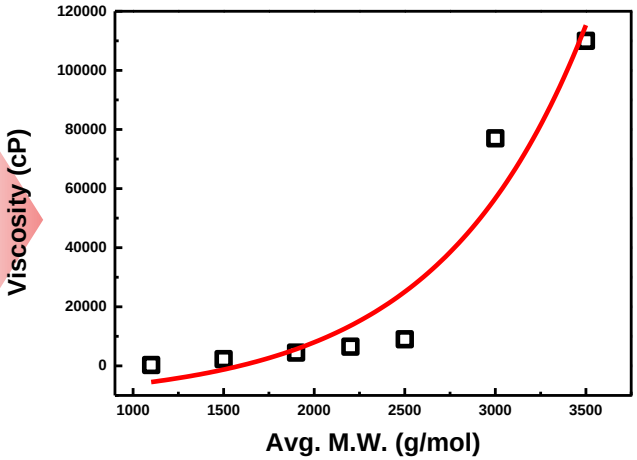
M–RR' = Functional Components

← Synthesis/Functionalization/Modification/Dispersion/Blending

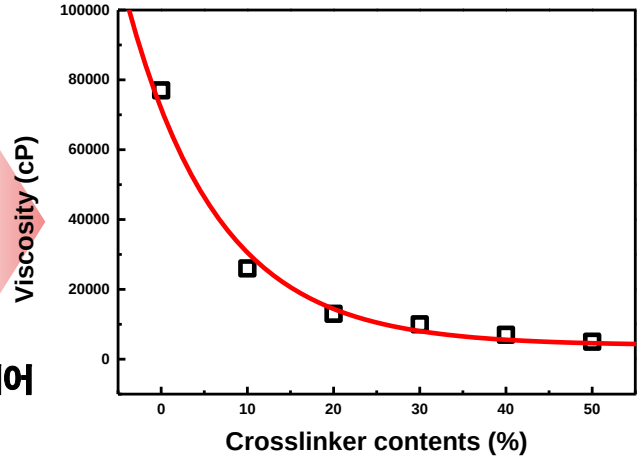
습식 공정성 : 무용매 점도 제어, 100 ~ 100,000cP → 습식 인쇄성/습식 코팅성



✓ M.W. 제어
✓ Content 제어



✓ Content 제어
✓ Blending ratio 제어



저온 속경화 및 광경화 특성

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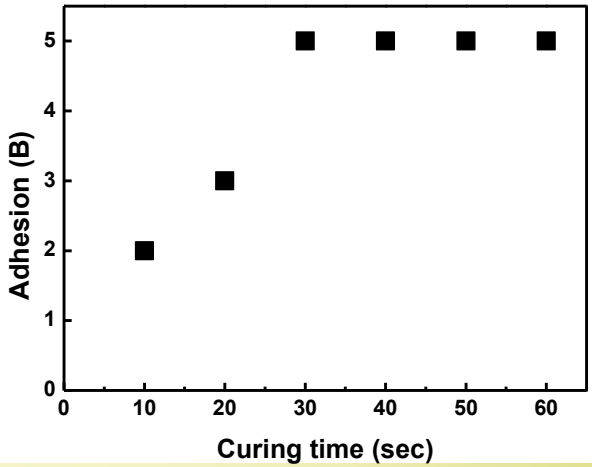
Nanohybrid Materials : 광경화 및 저온 속경화 공정 가능 소재

KERI Nanohybrid Materials

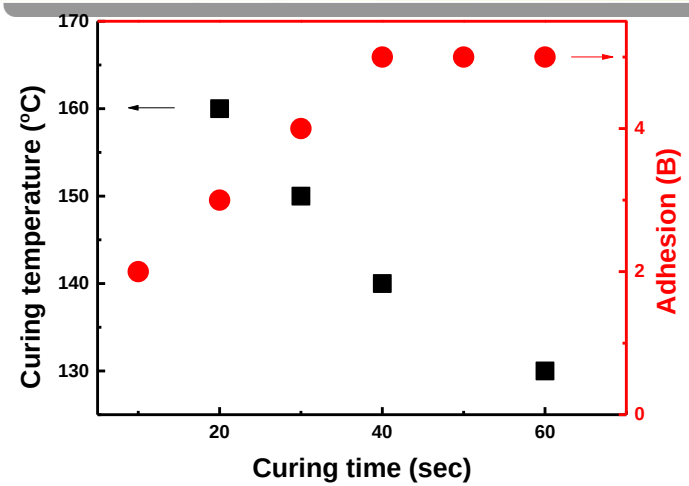
광경화성 : UV 속경화성 : 1분이내 → ~ 5B Adhesion Force



- ~ 5B : Rapid curing (UV).
- ~ 5B after 30 sec (on glass)

  → Highly rapid curability
- 필름기반 적용 가능 소재

저온 속경화성 : 저온 1분 이내 경화 → ~ 5B Adhesion Force



- Curing condition control

  → Curing temp. & time
- ~ 5B : Rapid curing @ low temp.
- ~ 5B @130℃, 40 ~ 60sec

  → Highly rapid curability
- 하드 및 유연기판 적용가능 소재

습식 공정성

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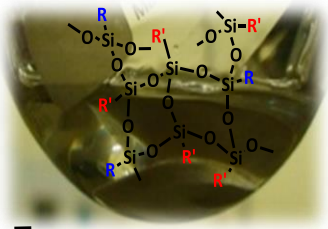
Nanohybrid Materials : 습식 코팅 및 인쇄 적용 가능 소재

KERI Nanohybrid Materials

Components



Nanohybrid Resin

1 nm

Nanoparticles

M-RR' = Functional Cross-linker

← Synthesis/Functionalization/Modification/Dispersion/Blending

Homogeneous Dispersion

Wet Coating & Rapid Curing

Spin-coating

Meyer Rod Coating

Screen Printing

Solution coatability

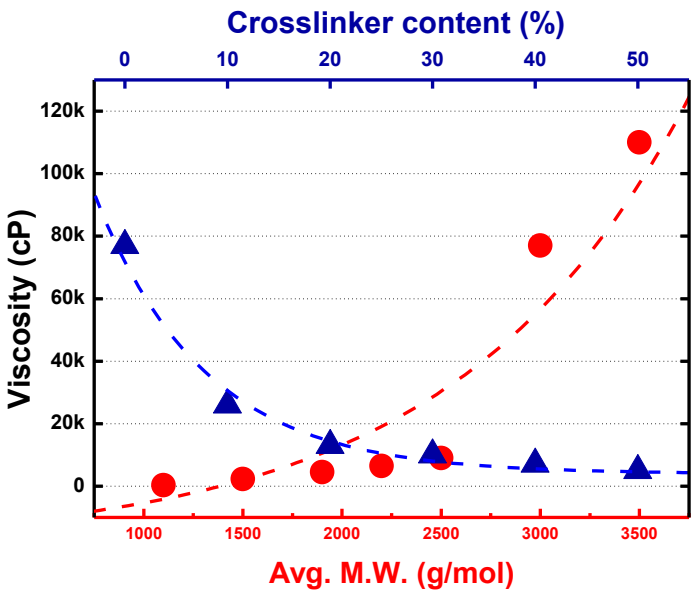
Solution printability

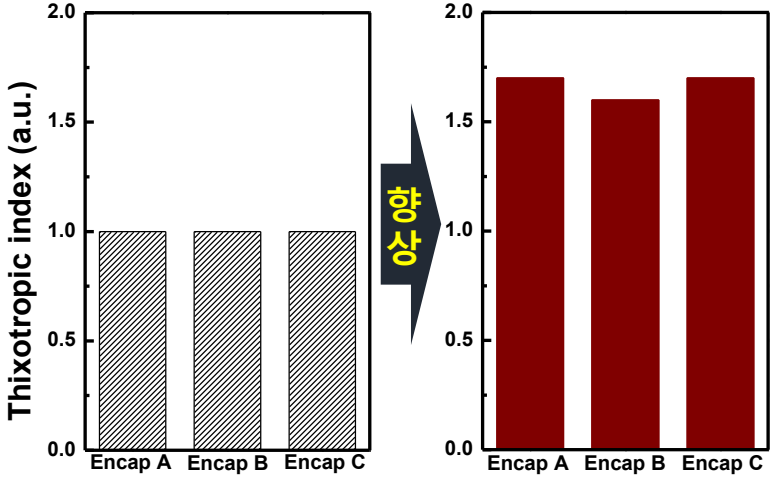
습식 인쇄성 및 코팅성 제어

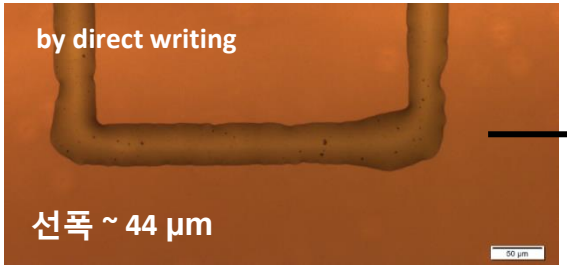
Nanohybrid Materials : 점도제어성- 습식공정성

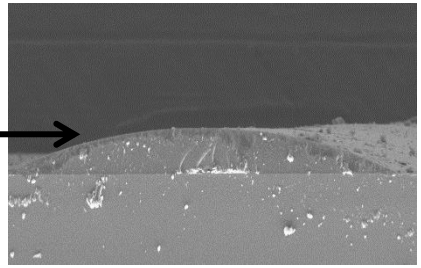
$$Thixotropic\ index\ (TI) = \frac{\eta_{rpm1}}{\eta_{rpm2}}$$

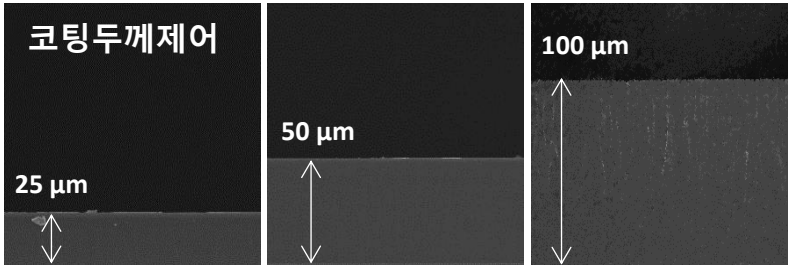
η_{rpm1} = viscosity at rpm1
η_{rpm2} = viscosity at rpm2
rpm2 = 10 x (rpm1)









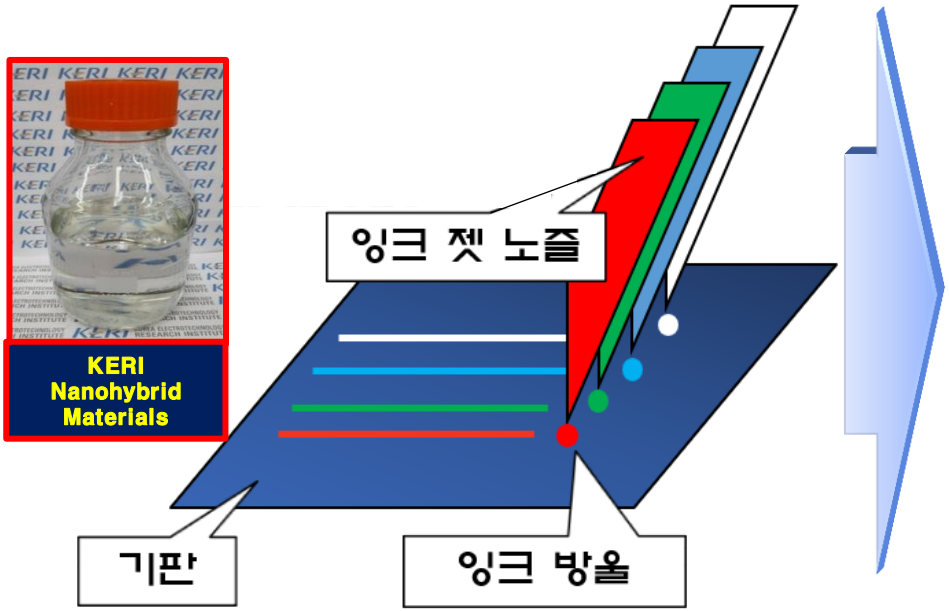


❖ 습식 공정성

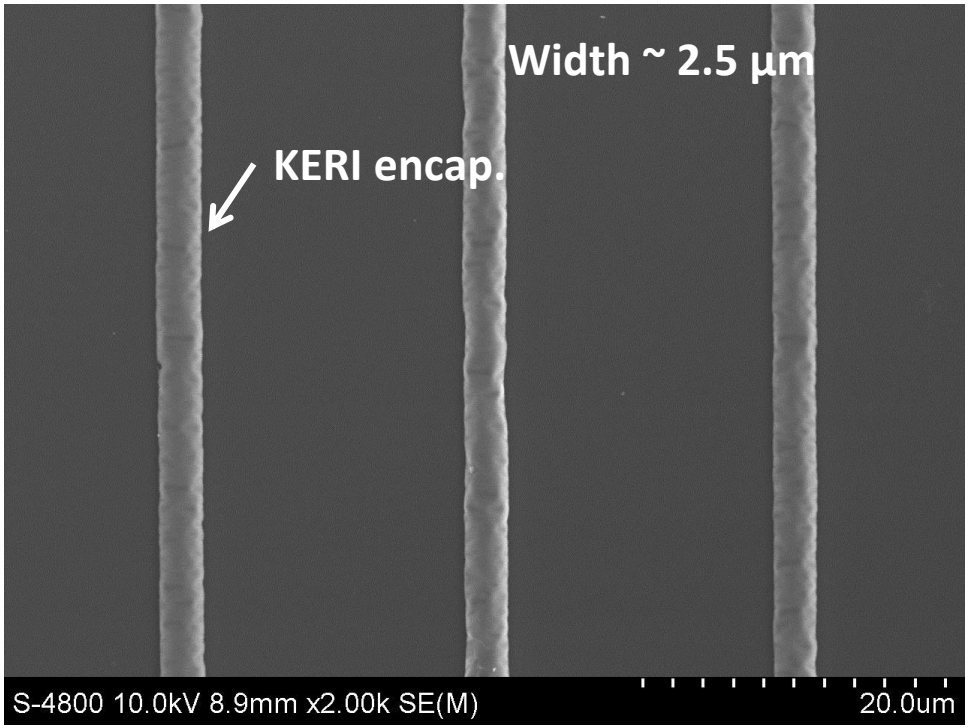
- 무용매 점도 제어, 100 ~ 300,000cP → 습식 인쇄성/습식 코팅성
- Thixotropy → 습식 인쇄성 및 인쇄안정성 확보 → Scale-up 습식 공정성 확보

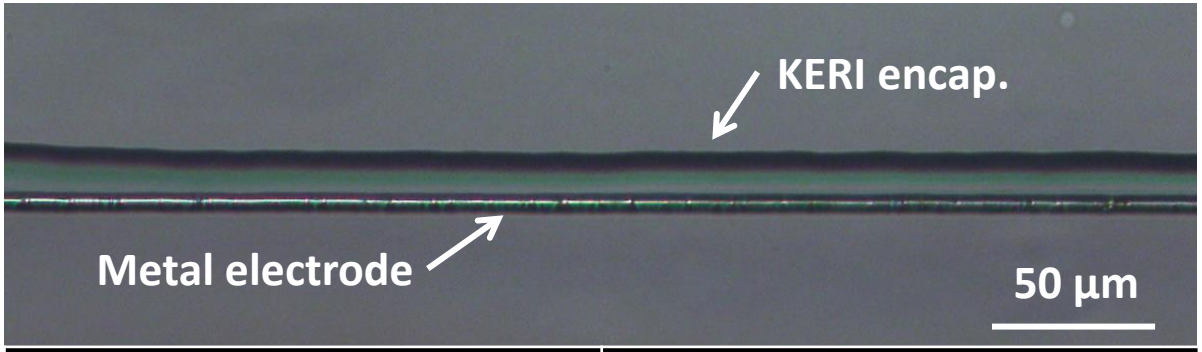
미세 인쇄 특성

Micro-Patternability (Direct-printing)



* 그림 출처 : Alled OLED





Metal electrode 선폭	KERI encap. 선폭
~ 8 μm	~ 22 μm

- 우수한 공정성 (Inkjet-printing, direct-printing 등)
- 미세 선폭 패터닝 가능 (sub-micrometer)

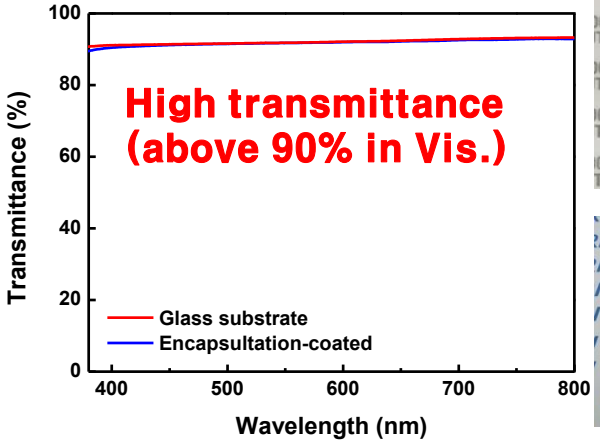
Insulation Materials Research Center

광투과성 및 고접착성

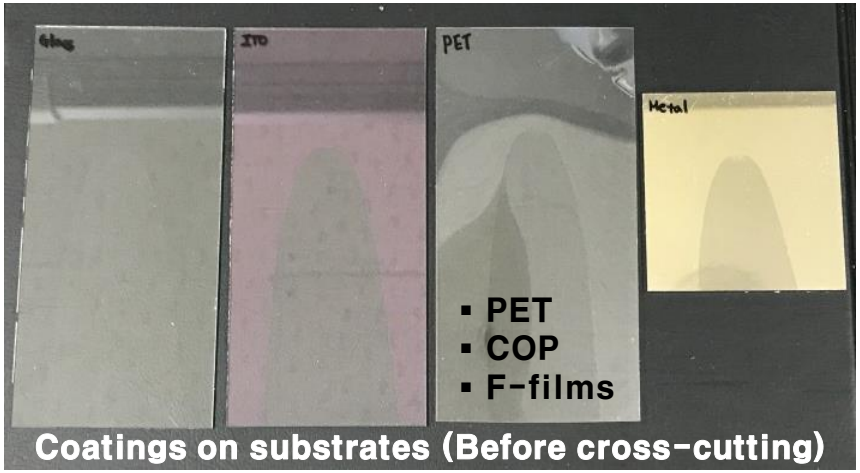
광투과도 : 구성 소재 → 균일 혼합 분산 → 투명 Encap. 절연소재 → 높은 광투과도

Homogeneous Dispersion

Wet Coating & Rapid Curing

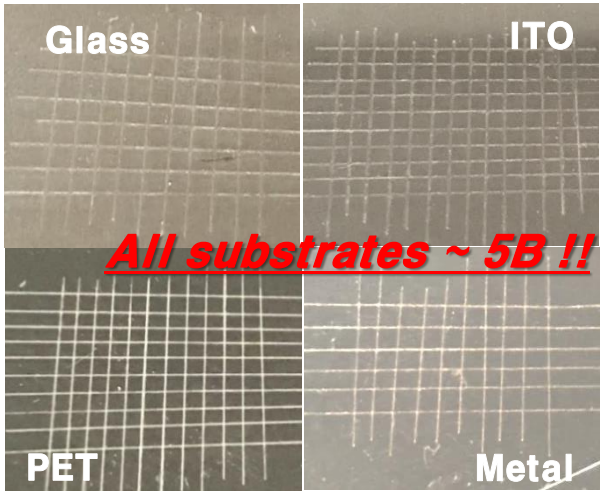


부착성 : Glass/TCO/Film/Metal → ~ 5B (@130℃, 60s)



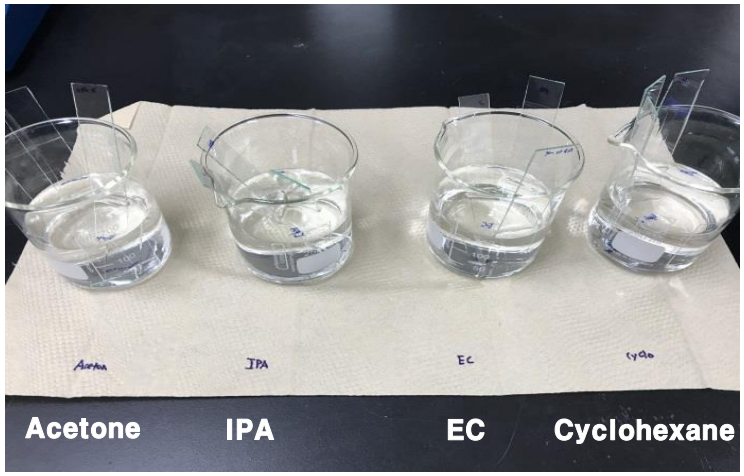
Coatings on substrates (Before cross-cutting)

After Cross-Cut Tape Test

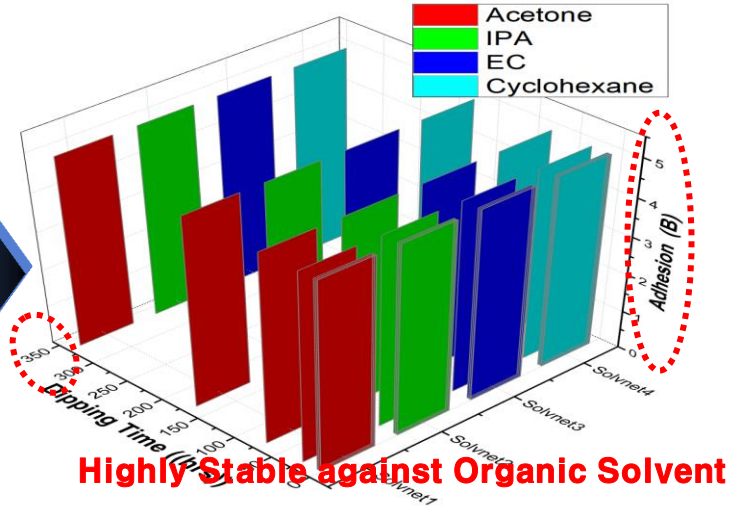


내화학성 및 전기화학 안정성

내화학성 : Dipping & Cross-Cut Adhesion Test → Strong Solvent Stability



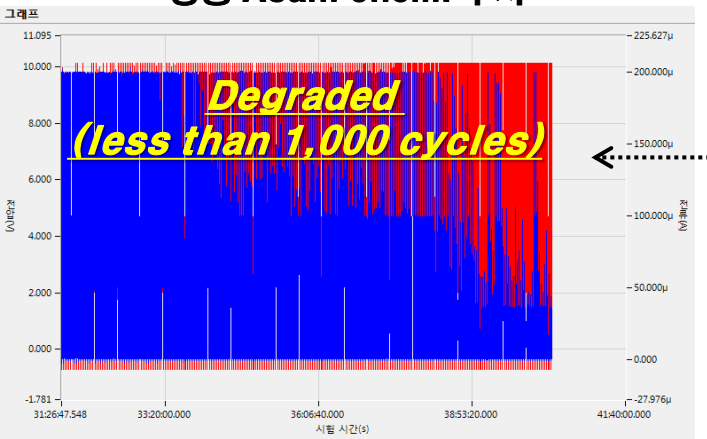
Dipping in solvent
& Cross-Cut
Tape Test

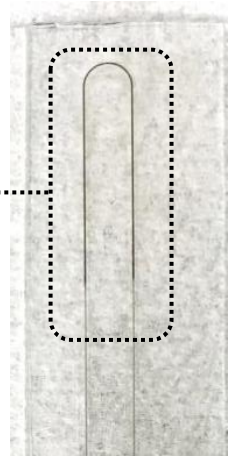


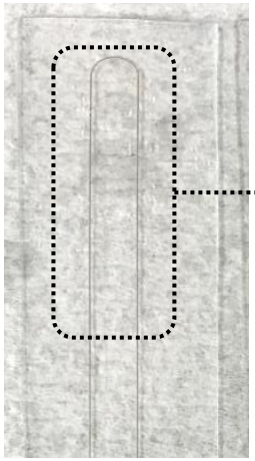
Highly Stable against Organic Solvent

전기절연 내화학성 : Potential Test in Liquid Electrolyte → Long Term Stability

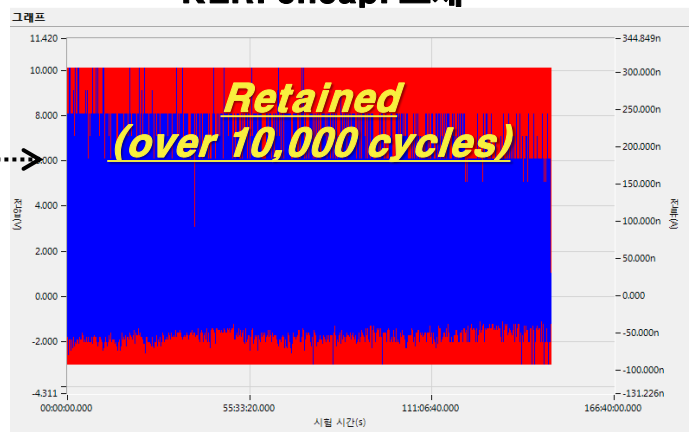
상용 Asahi chem. 수지





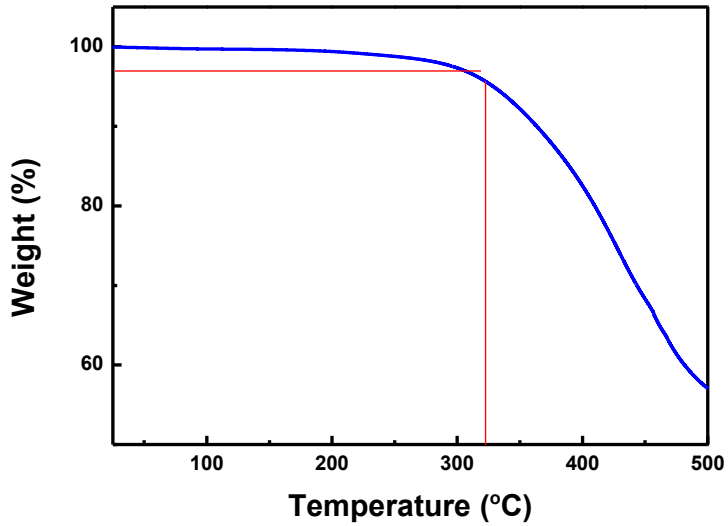


KERI encap. 소재



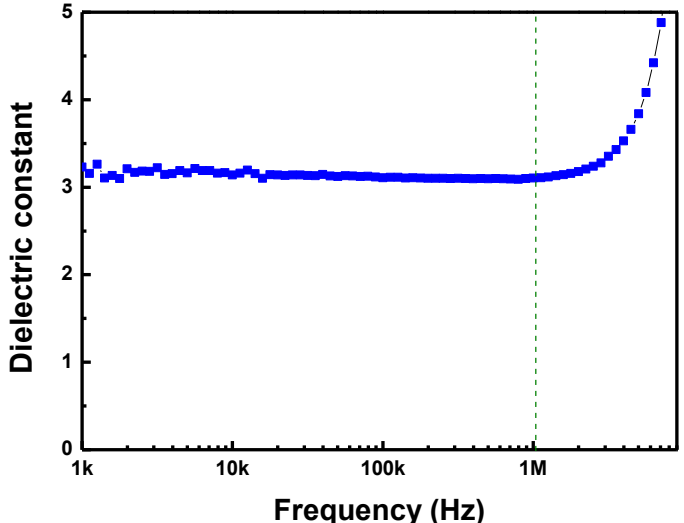
열안정성 및 유전특성

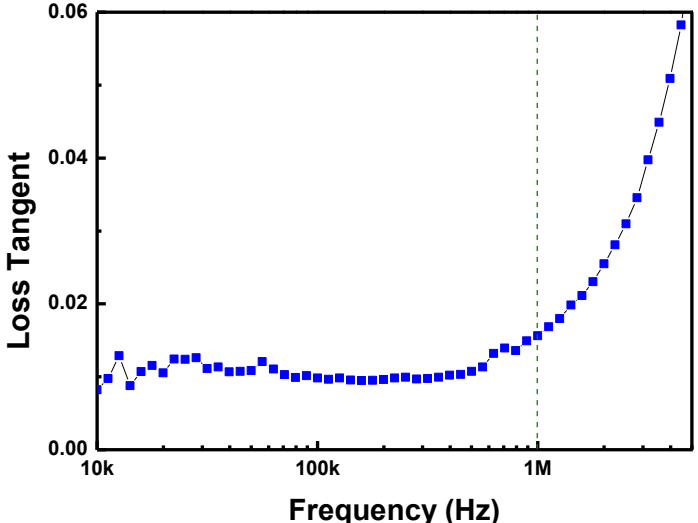
Thermal Property : TGA (ramp rate :5 min/°C in air)



- 우수한 내열성
  (5% loss temp. : 330°C)
- 다양한 전기전자에너지 소자 적용 가능

Dielectric Constant & Dielectric Loss





요약 : 핵심물성 및 기술적 우수성

TECH-BIZ KOREA 2016

❖ KERI-투명 나노하이브리드 습식절연소재 핵심 물성 (해외 선진사 대비)

	KERI - Nanohybrid	Asahi Chem. Res. Lab. Co., LTD 상용제품	SEKISUI Sealant 상용제품	기술적 우위
Insulation Resistance	1EX16Ω≥	1EX13Ω≤	-	1,000≥
Electro-chemical Resistance (I-V test)	10,000≥ (I-V Cycles)	1000≤ (I-V Cycles)	-	10배 이상 안정성
Curing Condition (Heat) (5B 기준)	1min @ 130℃ 110℃ @ 10min	110℃ @ 30min	110℃ @ 30min	속경화성
Viscosity(cps)	100-100,000	2000-6000	270-350,000	폭넓은 점도 제어성
Printability (T. I.)	1.5 - 2.0	1.5 - 2.0	-	미세패터닝성
Permeability (WVTR)	10^{-1}-10^{0} g/m²day		10^{1} g/m²day	배리어 특성
Adhesion	5B	5B	5B	
Transmittance (T%)	~ 91	~ 91	-	

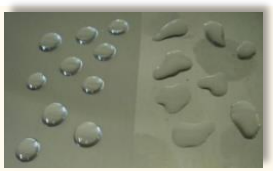
- 세계 유수 기업 기술대비 우수한 물성 발현
- 나노소재기반 고기능 다기능성 절연소재 : 스마트 전기 · 전자 · 에너지 기기 관련 적용다변화 기대

Multidisciplinary Applications

TECH-BIZ KOREA 2010

❖ KERI Nanohybrid Materials : 우수성 및 파급성

Functional Coating Solution




- Barrier/Passivation Coatings
- Insulation/Antistatic Coatings
- Refractive Index Tunable Coatings
- Radiation Coatings

Functional Paste Binders

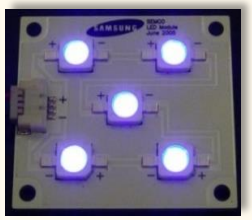

- Conductive pastes
- Electrochromic binders
- Paints

"Multi-funtional Nanohybrid Solutions"

Functional Sealants


- Low WVTR-Sealants
- High performance UV sealants
- Fast-Curable Adhesives

Encapsulation/packaging

- Encapsulation for Displays
- Packaging molds

감사합니다.

KOREA ELECTROTECHNOLOGY
RESEARCH INSTITUTE