Low Temperature Curable Polymer dielectrics for Substrateless package

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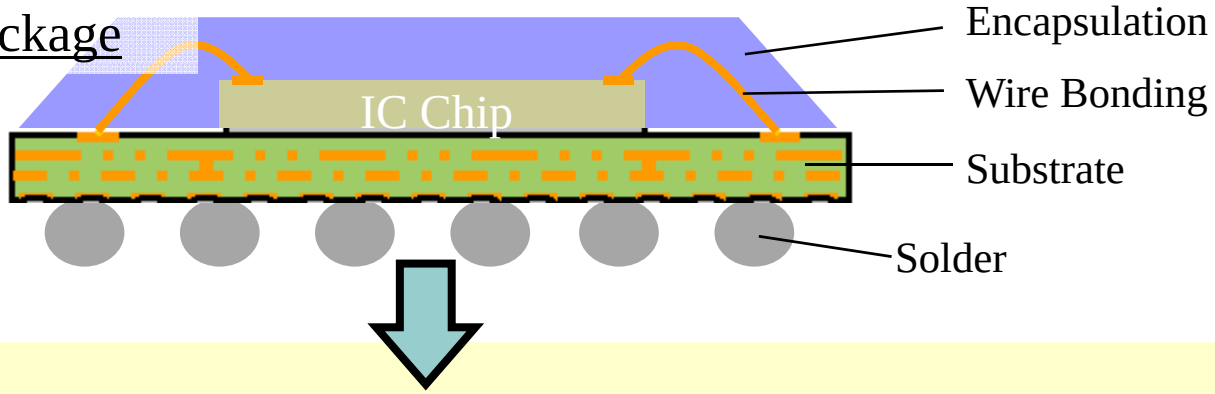
Outline

- Introduction
- Properties
- Process
- Reliability
- Summary

Packaging is getting smaller and smaller

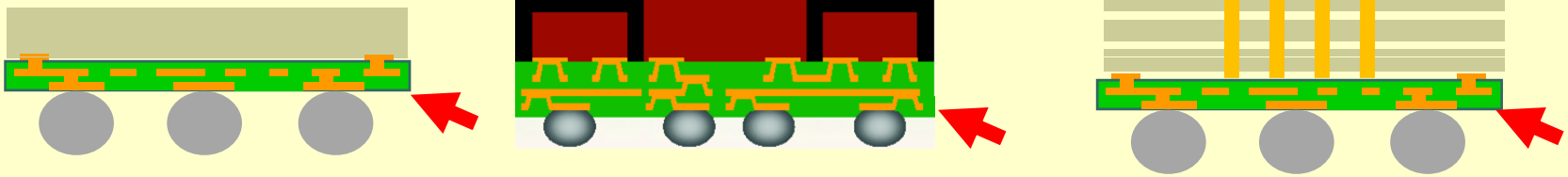
Conventional Package



WL-CSP, IPD

Fan-out

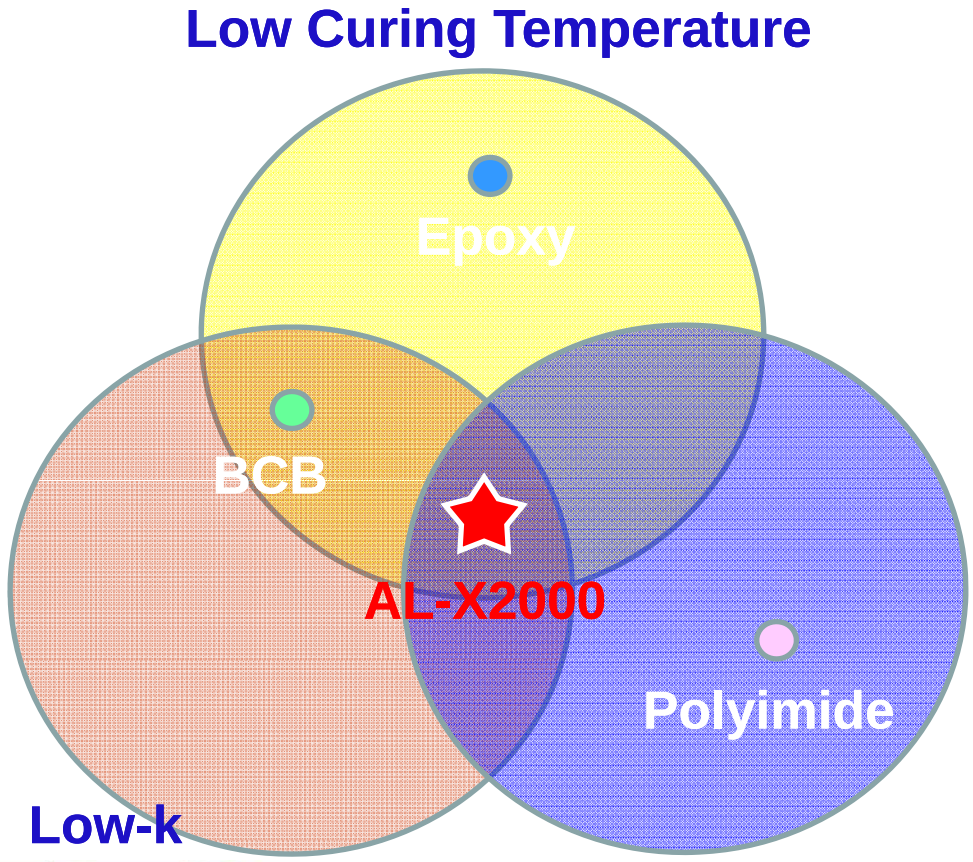
3D



Packaging is getting smaller and smaller especially for mobile application. Substrateless packaging (e.g. WL-CSP) is promising technology, and polymer dielectric plays more important role than before.

AL-X2000 Series

- **AL-X2000 has good electrical and mechanical properties as well as good processability.**

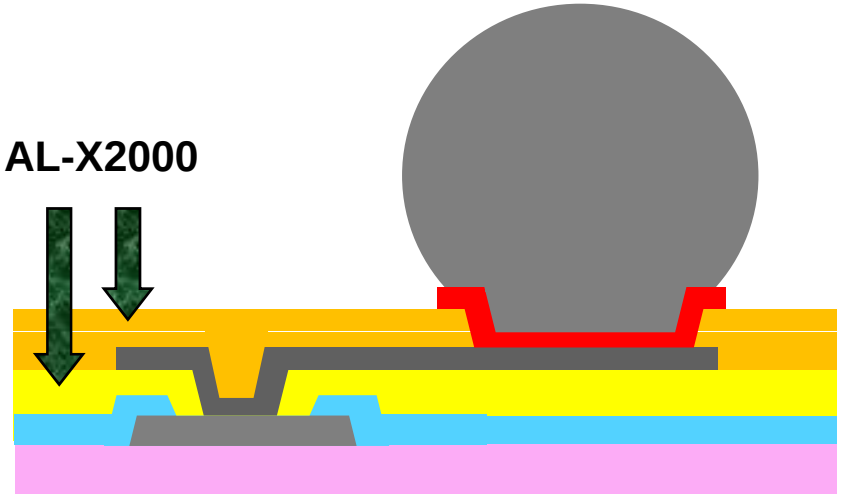


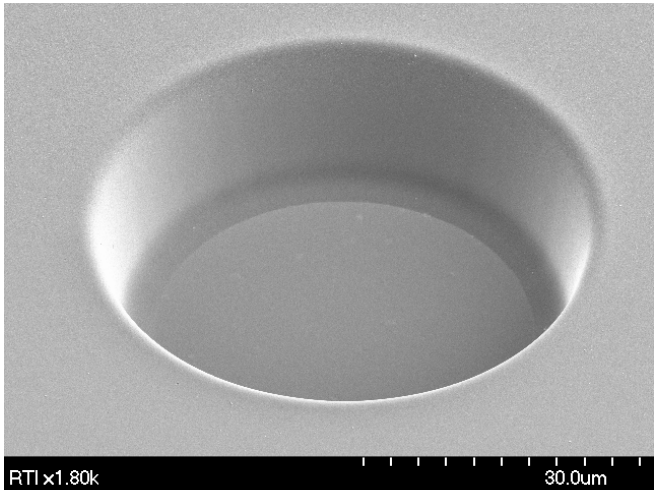
- **Low-K:**
  Dk=2.6~2.7@1MHz-10GHz
- **Low curing temperature**
  180℃~250℃
- **High elongation**
  30%

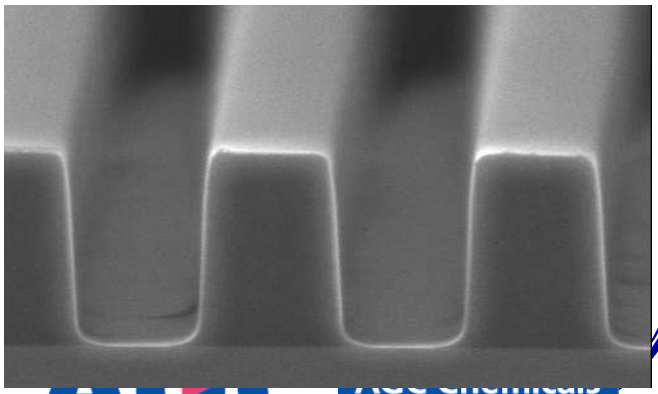
Applications

AL-X2000 is a fluoropolymer based spin-on dielectric for;

- **Redistribution, repassivation of WLPs**
- **Dielectric layer for IPDs**
- **Redistribution of 3-D packaging**
- **Bonding material for MEMS**
- **Buffer layer for general devices**







Properties of AL-X2000 (1)

➢Electrical Properties

Dielectric Constant : 2.6-2.7 @1MHz-1GHz

Dissipation Factor : 0.003 @1MHz-1GHz

Breakdown Voltage: 5.5MV/cm

Volume Resistivity: $>10^{-16}$ Ω·cm

➢Mechanical Properties

Elongation : ~30%*

Tensile Strength : ~100MPa*

Young's Modulus : ~2.6GPa*

CTE : 60ppm

Poisson's ratio : 0.44

Residual Stress : 32MPa

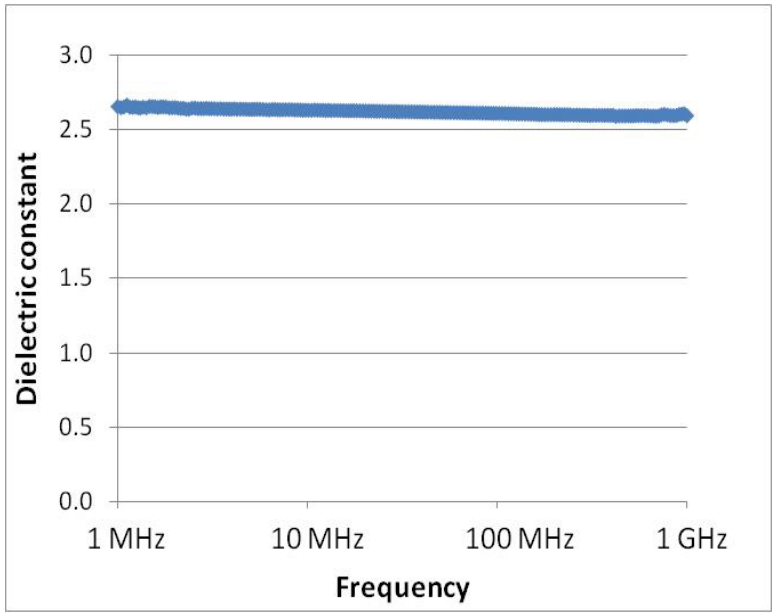
* A. Huffman et al., ECTC 2011, pp. 401-405.

Properties of AL-X2000 (2)

- **Optical Properties**
  - Transparent（UV-Vis, near IR）
  - Refractive Index: ~1.55

- **Others**
  - Thickness Range： 1.5～30um
  - Cure temperature： 180℃～320℃(350℃)
  - Water Absorption： < 0.2%
  - Low outgas
  - Good Planarization
  - Wide Processing Window
  - Excellent stability (Chemical, Thermal)
  - Excellent Reliability

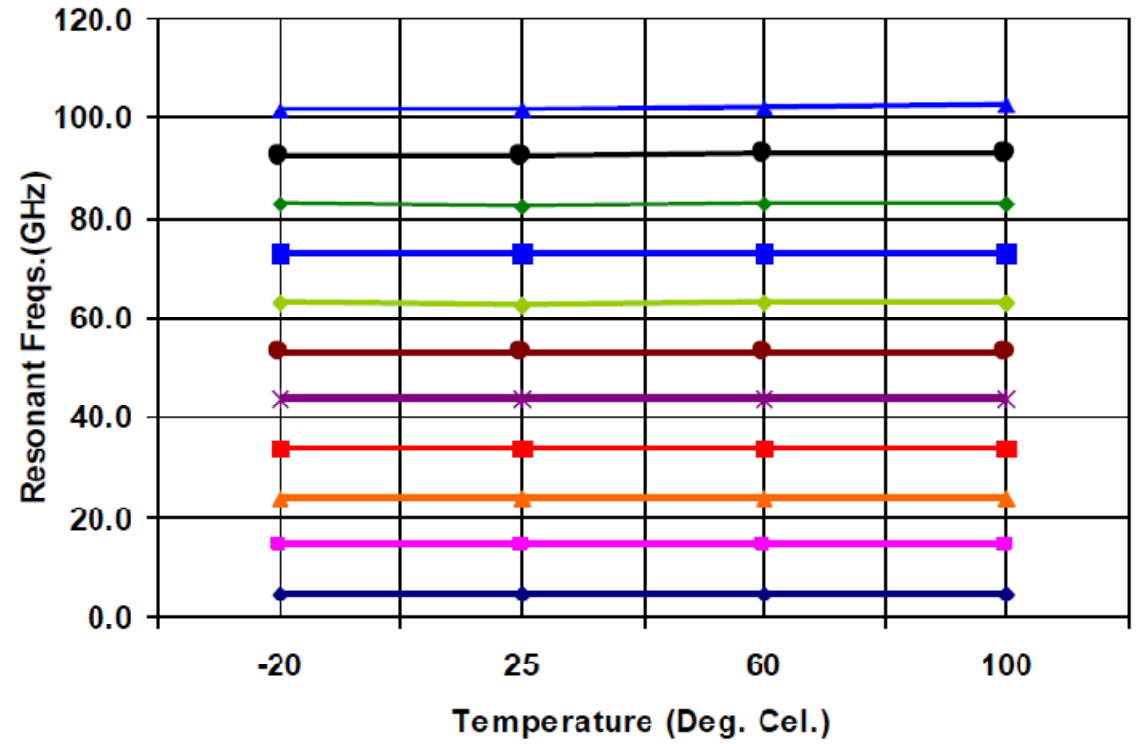
Electrical Properties



Dielectric Constant : 2.6-2.7 @1MHz-1GHz
Dissipation Factor : 0.003 @1MHz-1GHz

Electrical Properties

Very stable frequency response up to 100GHz over wide temperature range



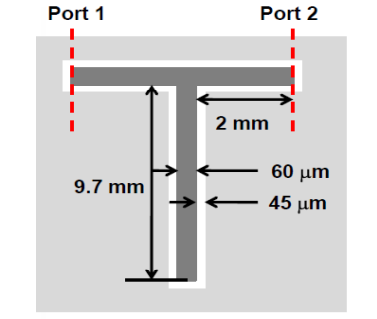
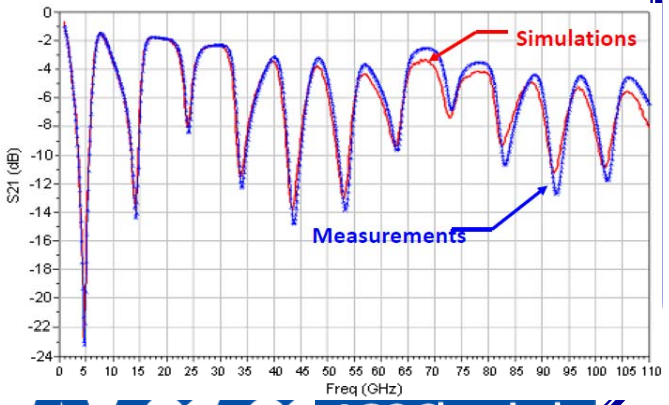


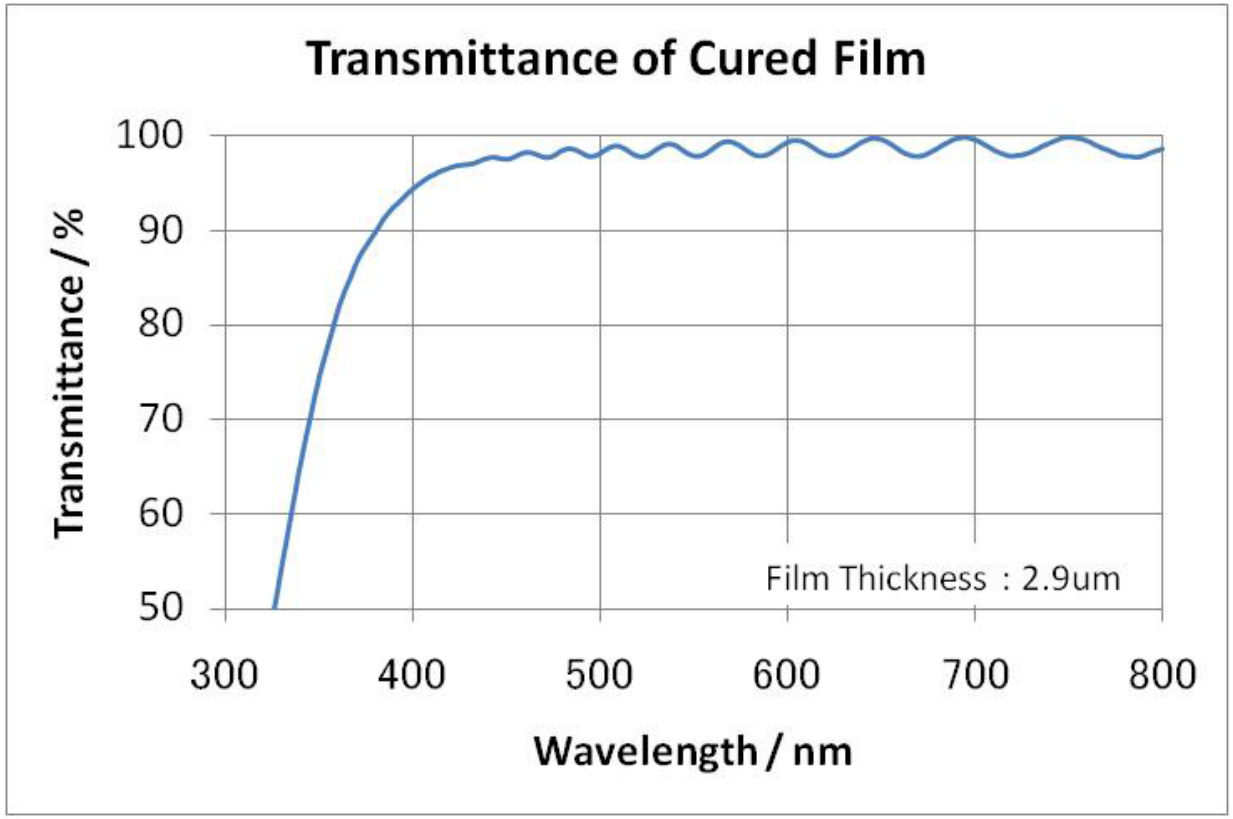
Fig. T-resonator



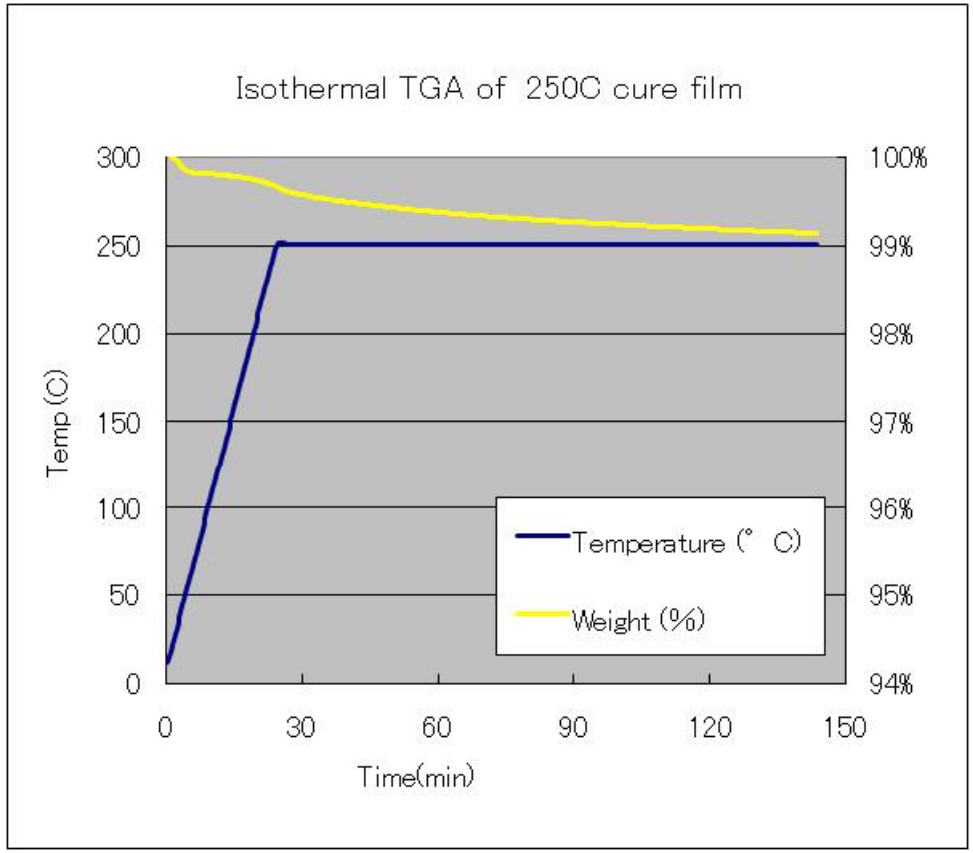
L. Y. Ying et al., EPTC 2009, pp. 518-523.

Optical Properties

Transparent from visible to near-IR region



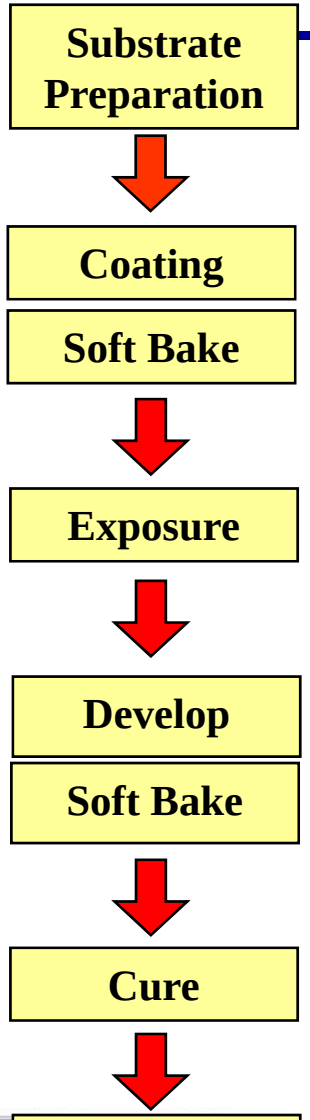
Others (Isothermal TGA)



	Wt loss / hr (%)	
Isothermal Temp (° C)	190° C cure film	250° C cure film
250	< 0.5	< 0.5
300	< 0.5	< 0.5
350	~ 2	~ 2

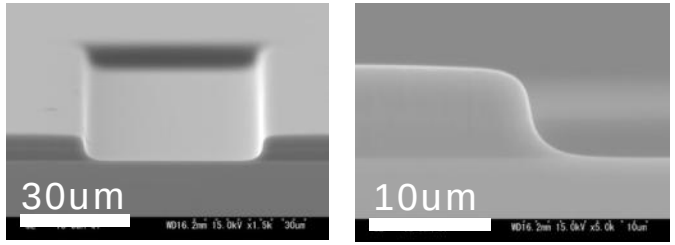
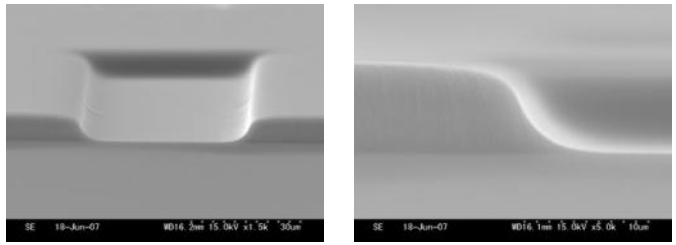
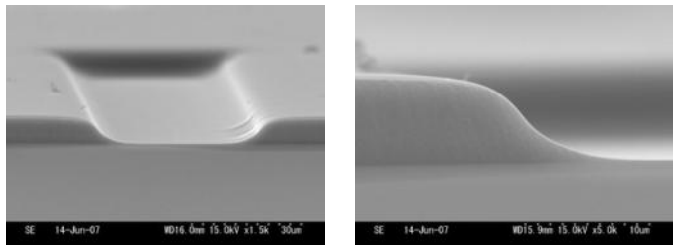
Test sample :Cure at 190 C for 2 hrs ~25um thick, full process
Atmosphere : N2
temp ramp: 10C / min to 250 or 300 or 350C then hold 2Hrs

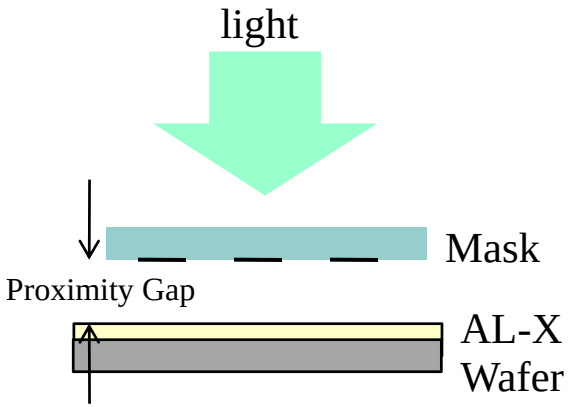
AL-X2000 Processing Summery



Substrate Preparation			
Solution	AP-903		
Spin coat	500rpm/1sec + 3000rpm/30sec		
Bake	100°C/90sec		
AL-X2 series			
Solution (thickness)	AL-X2003 (1.5-3.5um)	AL-X2010 (3.5-10um)	AL-X2030 (8-30um)
Spin coat	500rpm/5sec + [final spin speed]/30sec		
Soft Bake	60C/90sec	60C/90sec	60-90C/90sec
Exposure	100 – 400 mJ/cm2		
Development	PS-201 : Puddle 20s+rinse30s		
Bake	100°C/90sec		
Cure	190°C/2h		
Descum	O_2 or O_2/CF_4=4/1		

Sidewall Angle Control

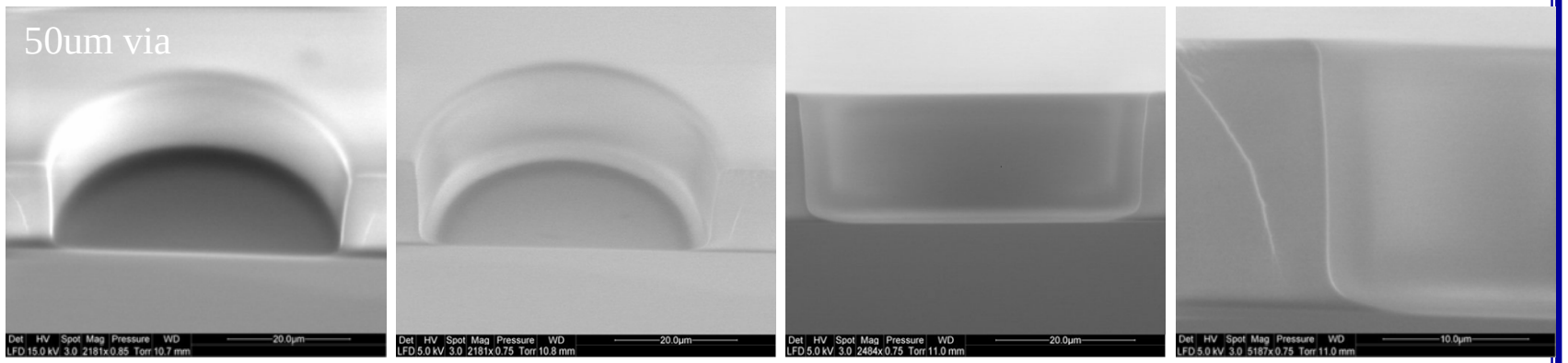
Proximity Gap	SEM image
25um	
50um	
75um	



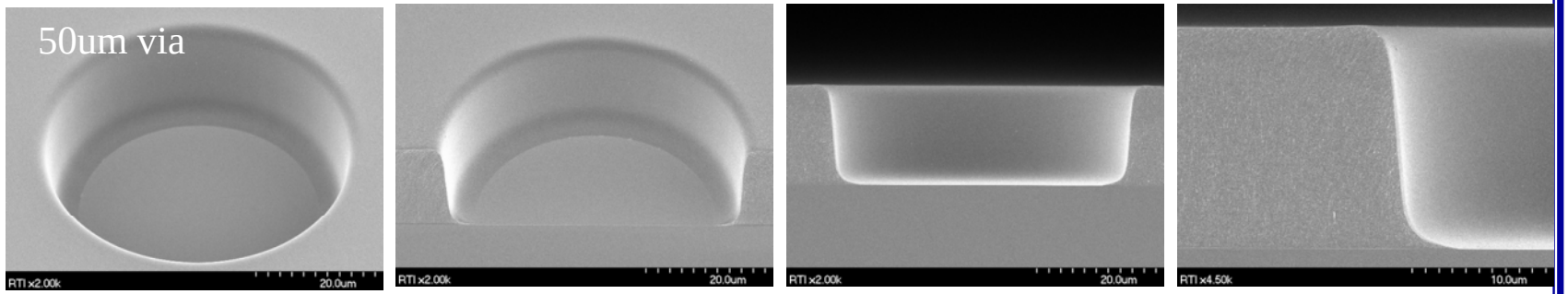
Film thickness : ~7um

Via Shape Change During Cure

Before Cure

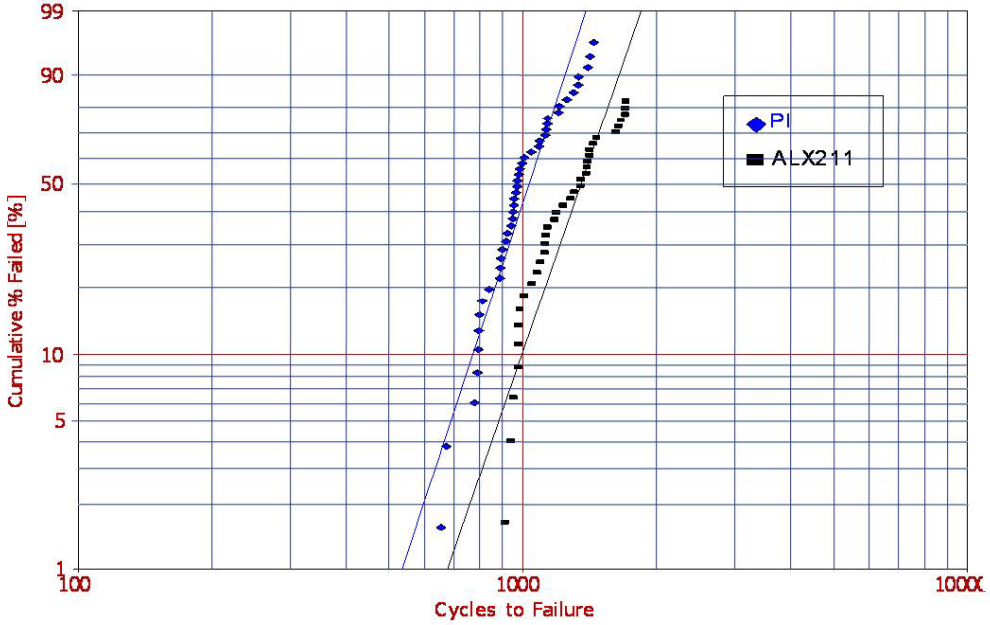


After Cure (After descum)

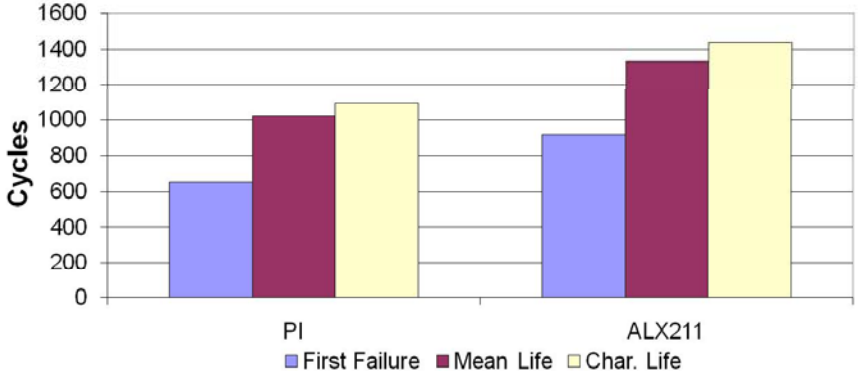


Via shape is almost the same before and after curing

Reliability Test (Board)



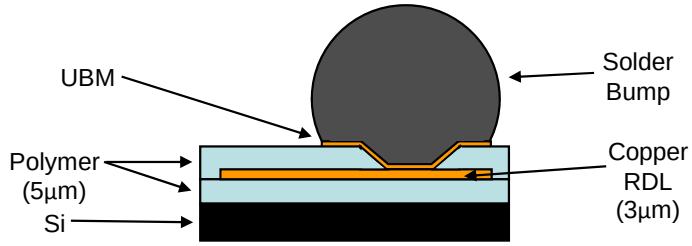
Weibull Plot of Thermal Cycling Results for PI and ALX211



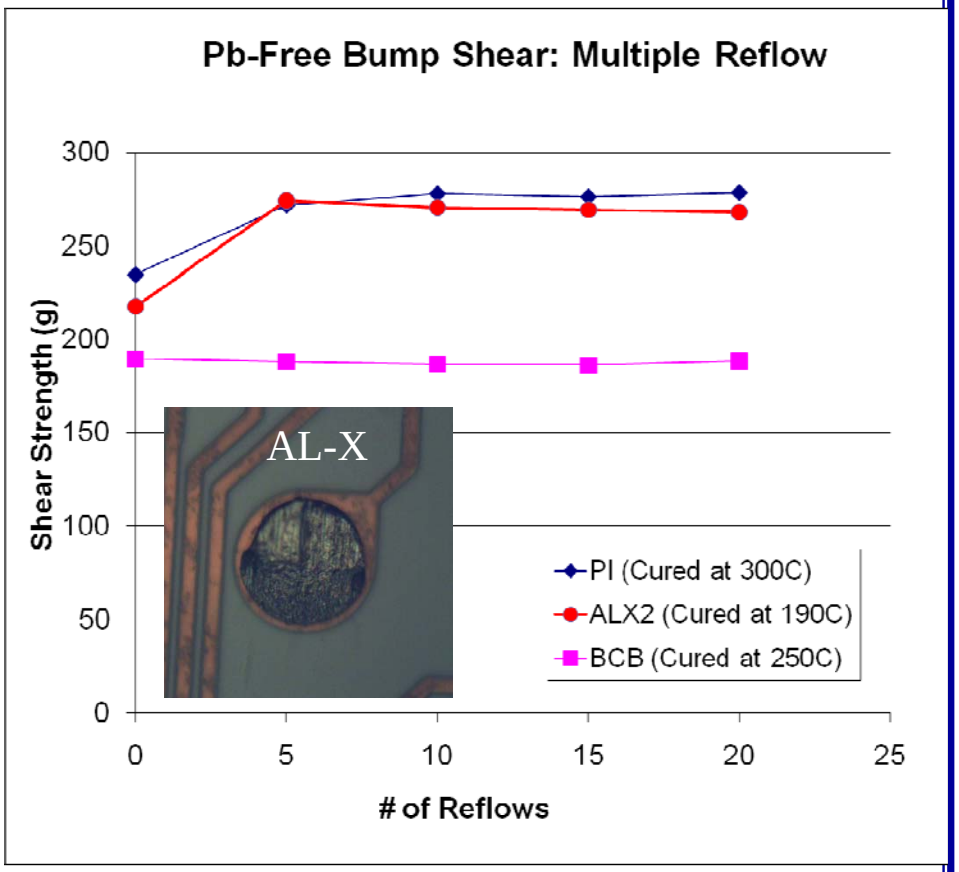
Thermal Cycle Testing Milestones for PI and AL-X

Alan Huffman et. al, ECTC 2010, pp. 1794-1797.

WLCSP Evaluation
Pb-Free Bump-on-Polymer Structures



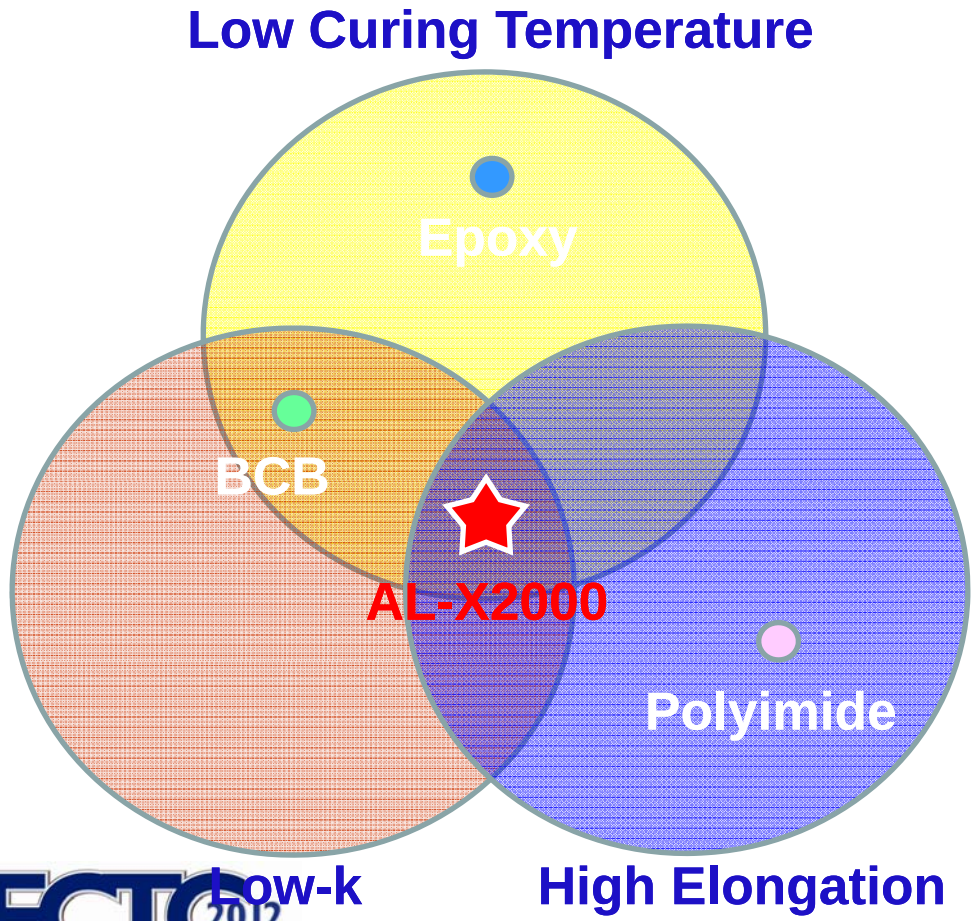
- 5µm/3µm/5µm polymer/Cu RDL/polymer test vehicle, unpatterned polymer base layer
- 12 x 12 bump array, 250µm ball place bumping process with SAC405 spheres
- Test vehicles built with PI (300˚ C cure), BCB (250˚ C cure), and ALX2 (190˚ C cure) polymers



The reliability of WLP structure on AL-X is comparable to PI and better than BCB.

Sammary

- **AL-X2000 has good electrical and mechanical properties as well as good processability.**



WLPs, IPD, 3Ds, MEMS, Rf, LED
- **Redistribution**
- **Repassivation**
- **Bonding material**
- **Buffer layer**