

IR Filter Bonding Reliability of Camera Module for Mobile Phone

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/OS Precision Optical Special Tool Group
Samsung Electro-Mechanics



- ▶ Introduction
 1. Image Sensor module for mobile phone
 2. Motivation of Research
 3. Reliability Test

- ▶ Failure Modes

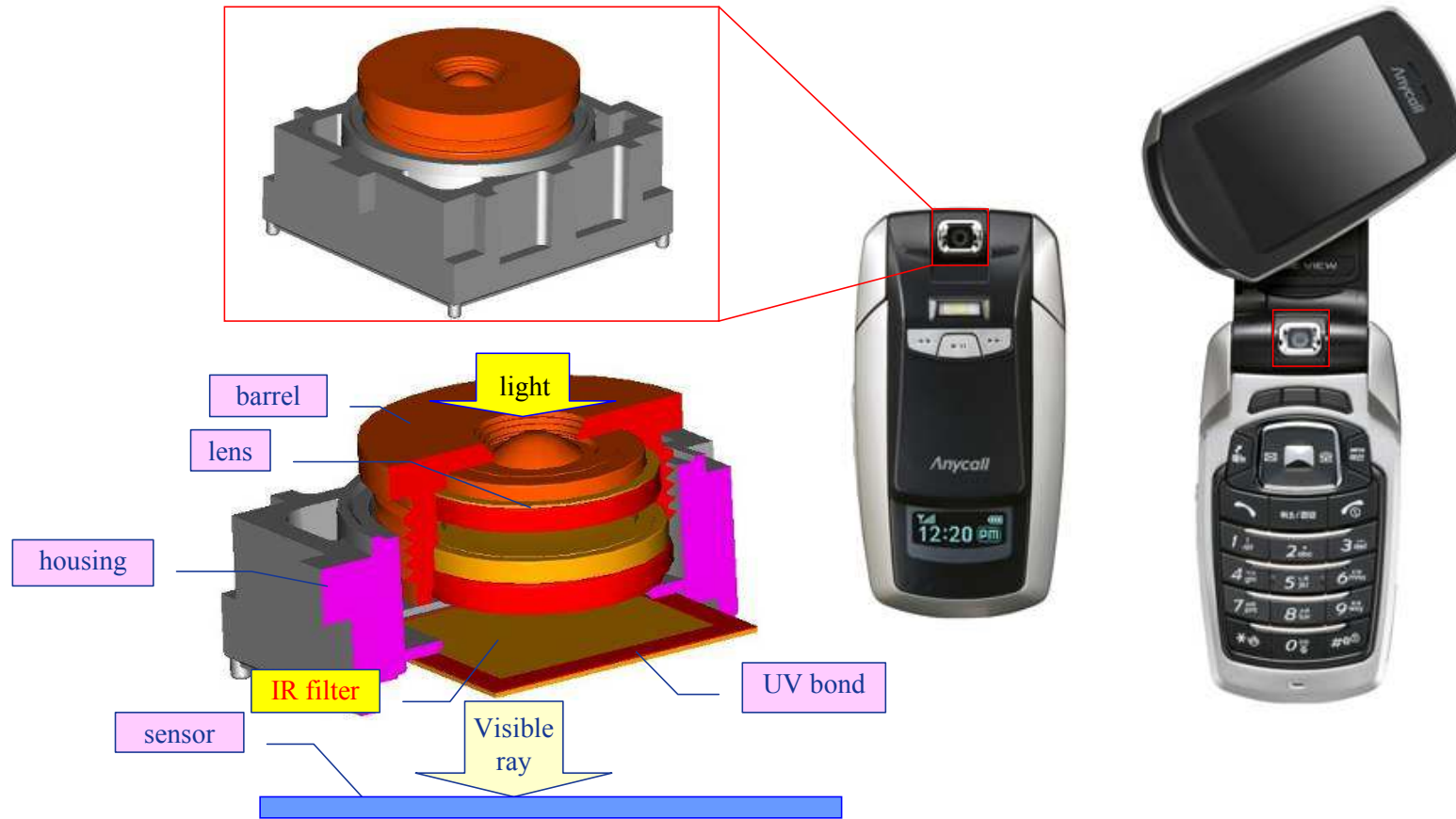
- ▶ Root Cause Analysis & Failure Mechanism
 - SEM, X-ray
 - Injection Mold Process Analysis
 - Thermal Stress Analysis

- ▶ Corrective Action

- ▶ Summary & Conclusion

Image Sensor Module of Mobile Phone

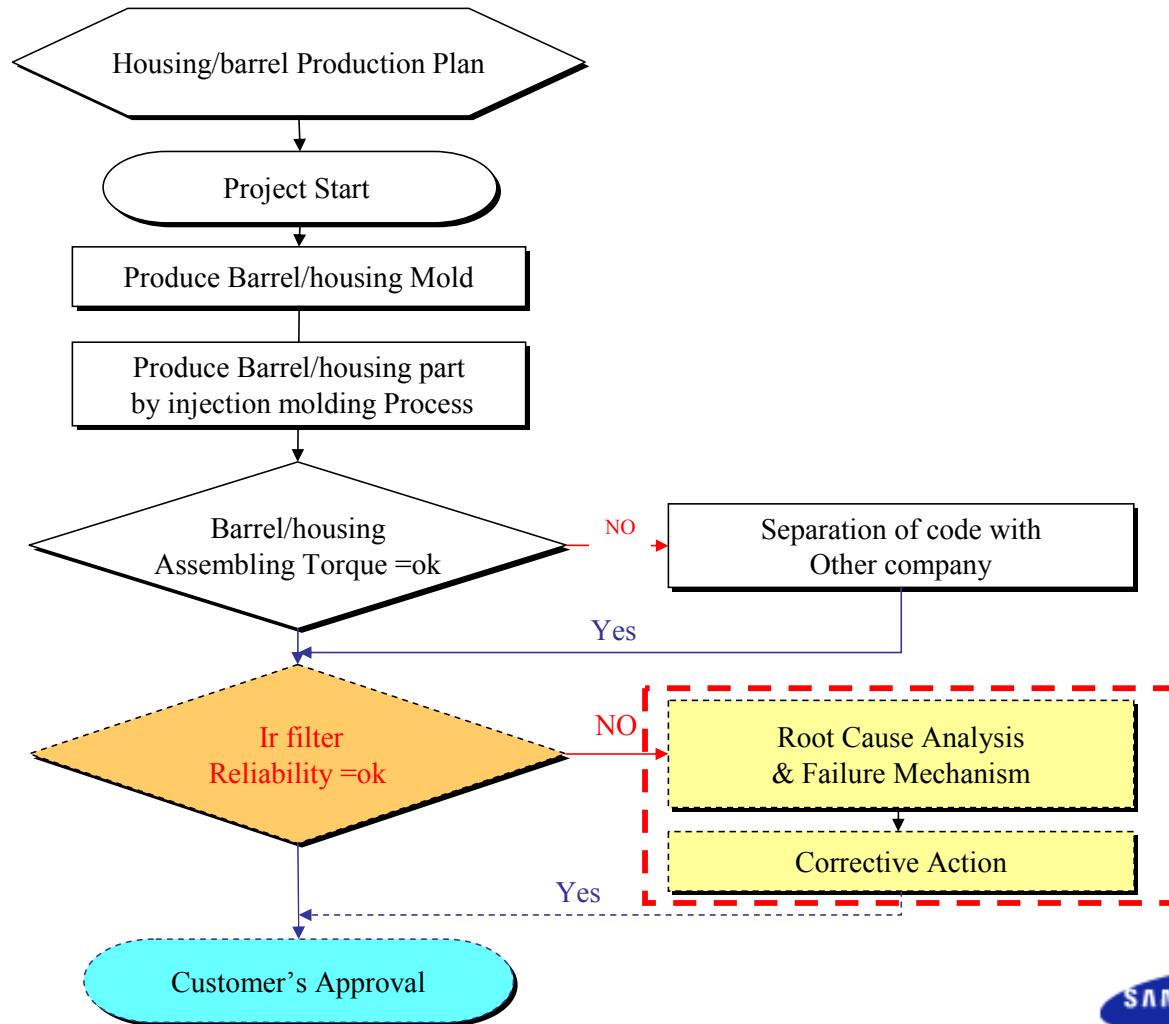
Leading the Next 



Cross Section of Image Sensor Module


SAMSUNG
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Motivation of Research

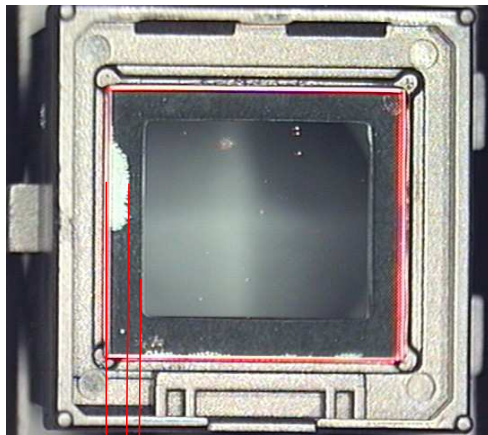


Reliability Test

- ▶ High humidity, High Temperature Reliability test
 - Temperature : 85°C
 - Humidity : 85%
 - Test period : 120 hrs

- ▶ Reliability Specification

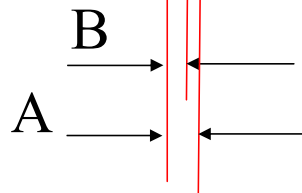
After High humidity & temperature reliability, At Housing IR filter bonding part

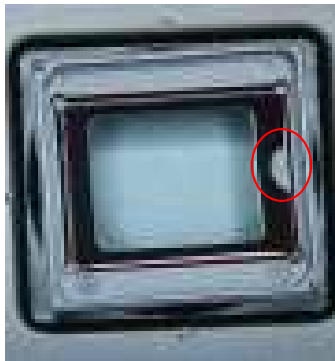


$$\frac{B}{A} = \frac{\text{detached width after reliability test}}{\text{bonded width before reliability test}} < 0.5$$

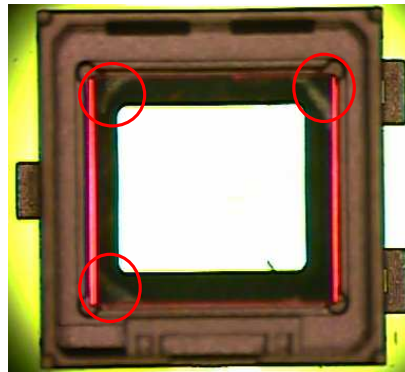
&

Bonding strength of Ir filter $> 3k_g$

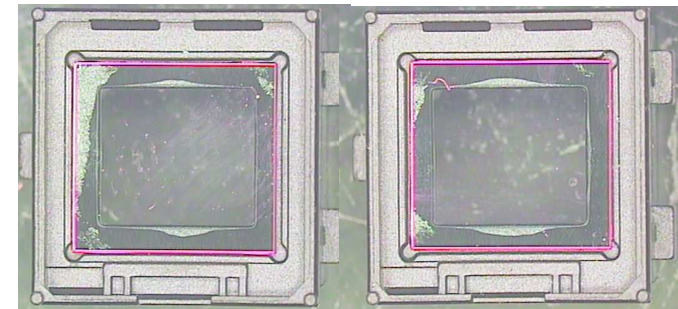




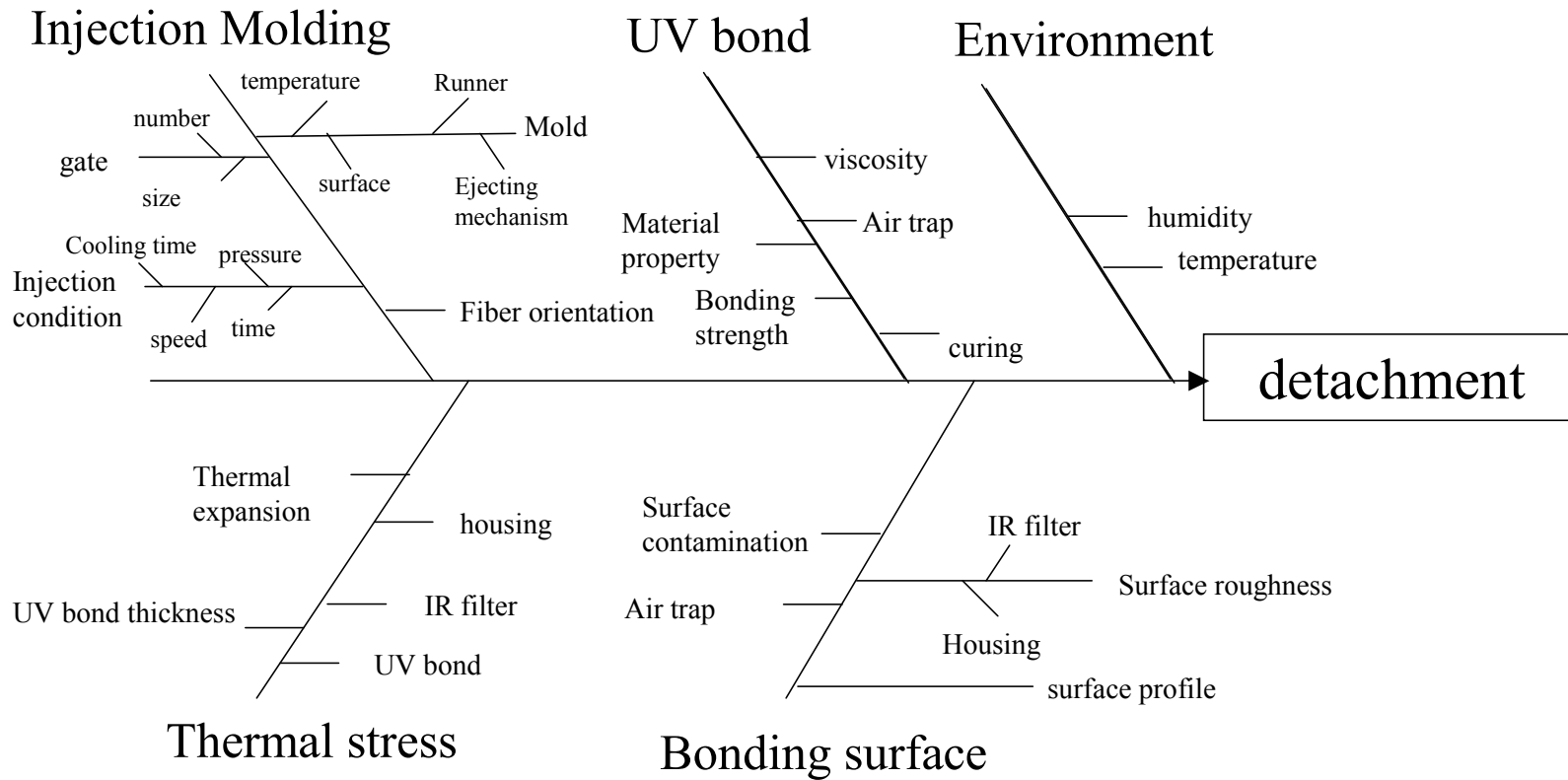
(a) mode I



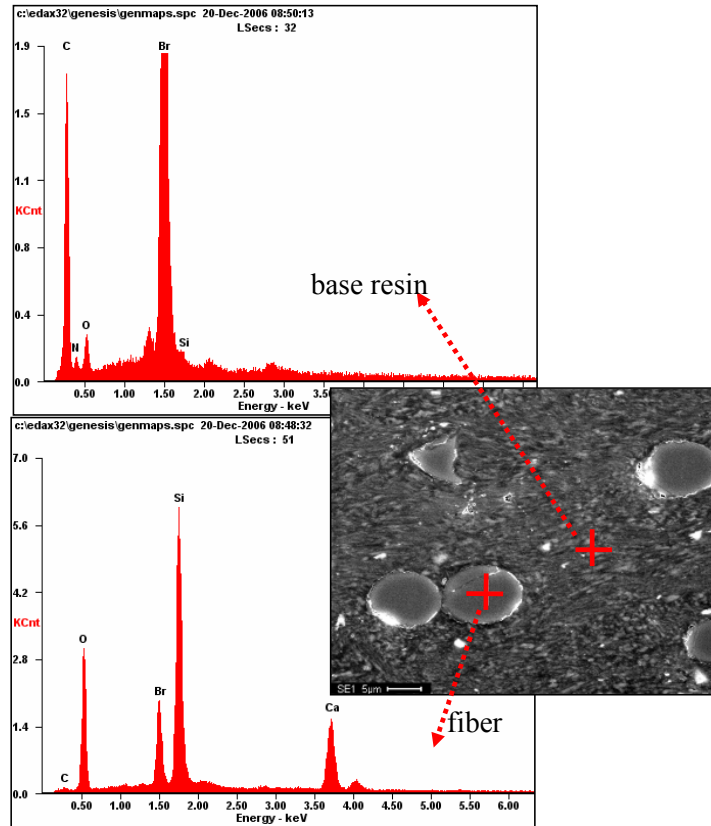
(b) mode II



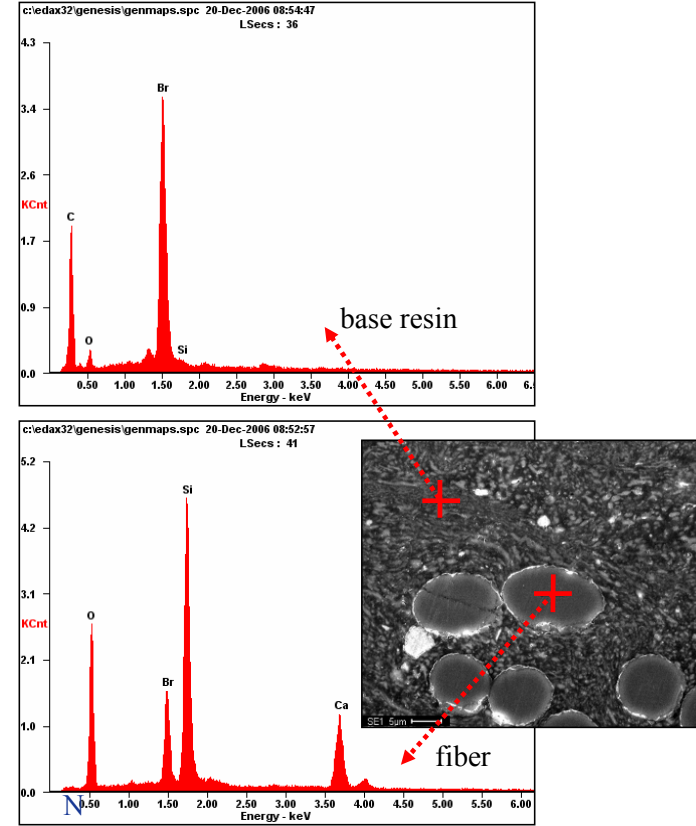
(c) mode III



Component Measurement of Housing

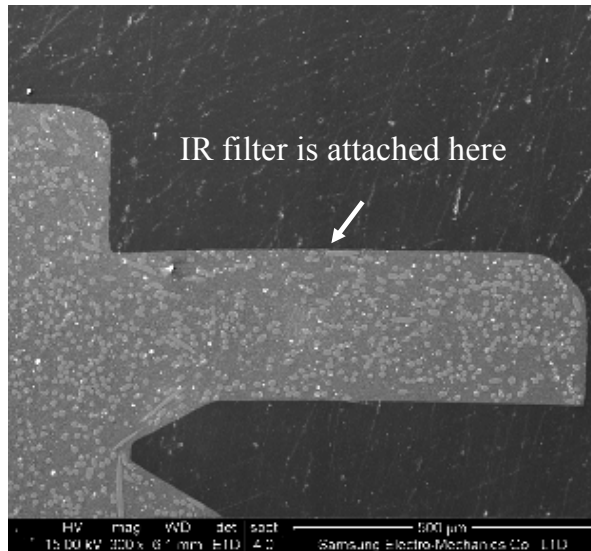


(a) failure sample

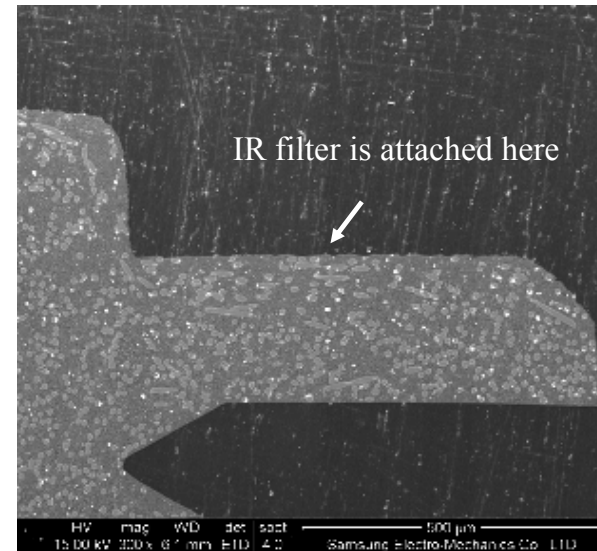


(b) success sample

Component measurement of base resin and fiber in housing using EDS

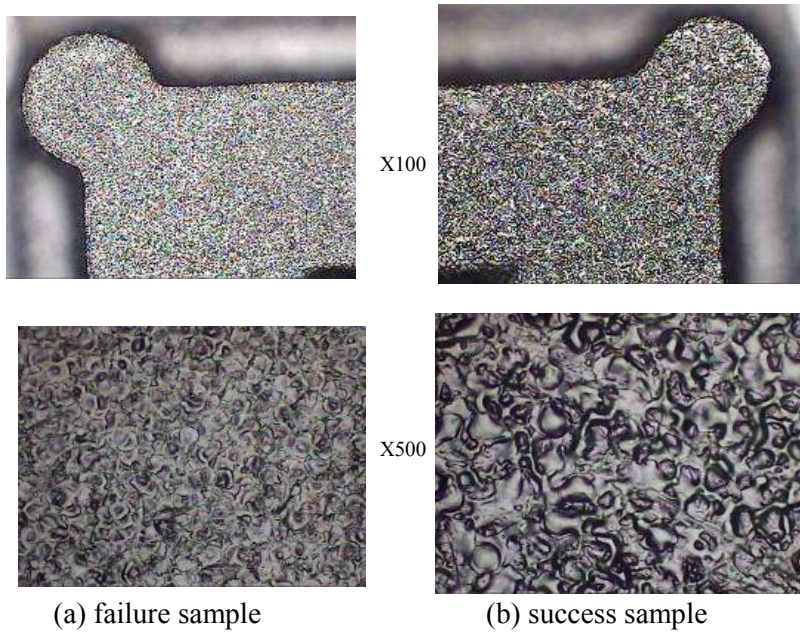


(a): failure sample (fiber 26%)

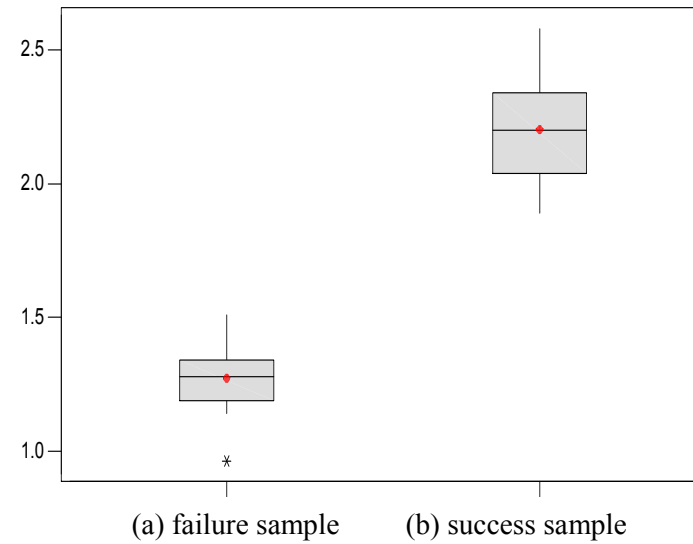


(b) : success sample (fiber 27 %)

Cross Sectional view of housing at the place IR filter is attached

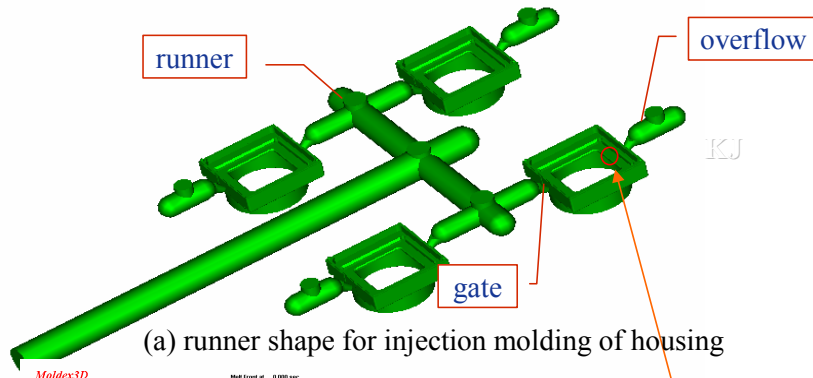


SEM pictures of housing Surface

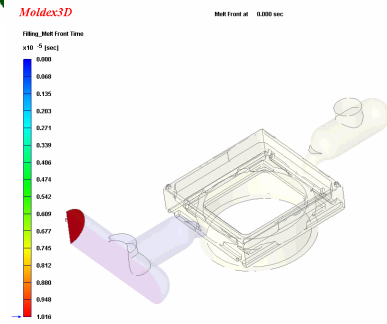


Box-plot of Surface roughness (RMS)

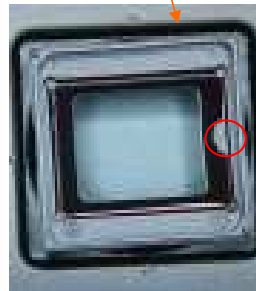
Injection Mold & Failure Mode I



(a) runner shape for injection molding of housing

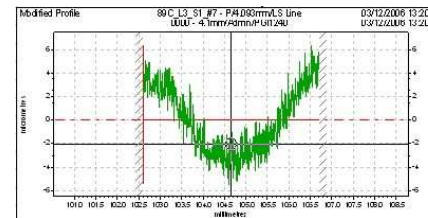


(b) Filling pattern

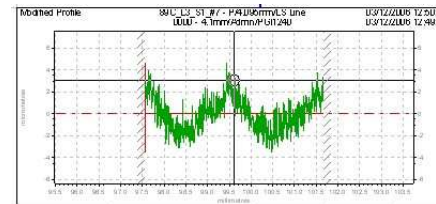


(c) failure mode I

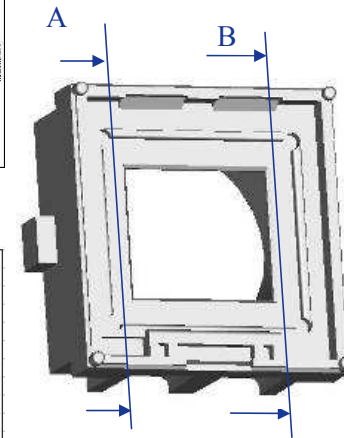
The detached place between IR filter and housing



A Profile

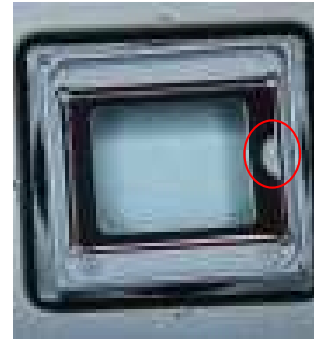
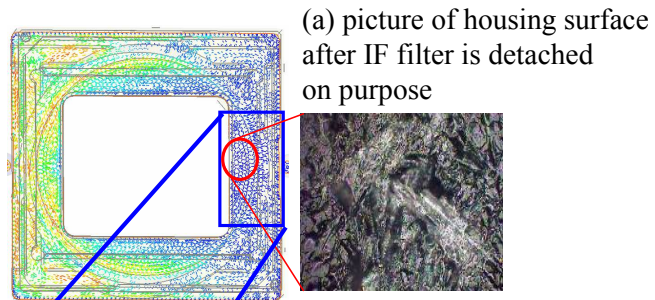


B Profile

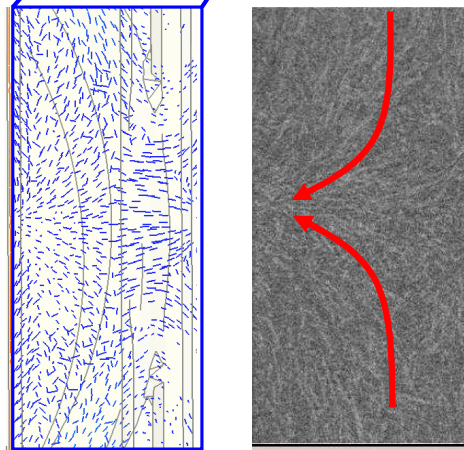


Surface Profile of cross section A and B of housing where IR filter attached.

Air Trap, Fiber Orientation & Failure Mode I



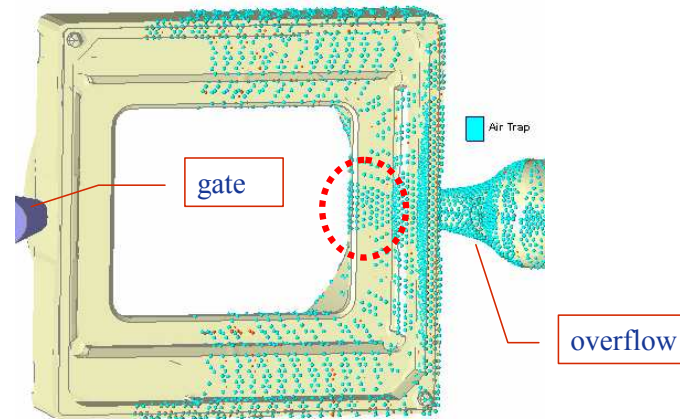
Failure Mode I



(b) simulation

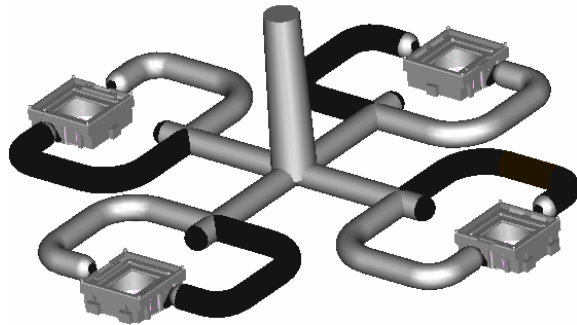
(c) 3D NDT

Fiber Orientation

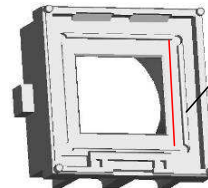


Air Trap (simulation, Failure Mode I)

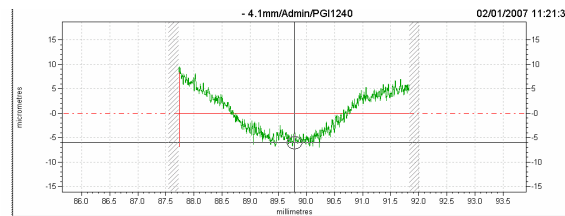
Corrective Action for Failure Mode I



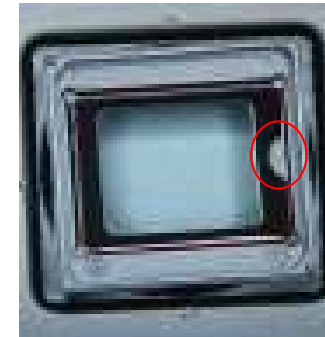
Runner and cavity of the improved design (2 point gate)



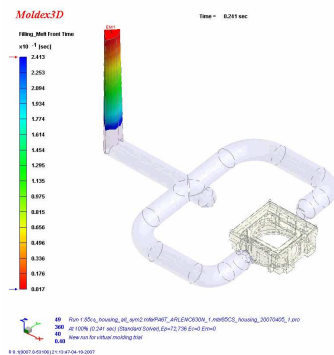
The line profile is measured



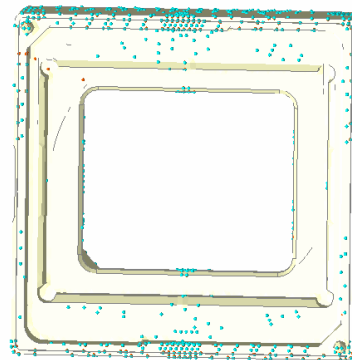
Surface Profile of housing surface that IR filter is attached (Pt: 7~16 μ m)



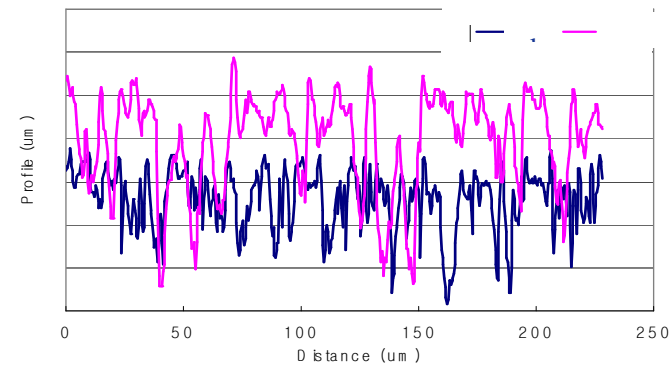
Failure Mode I



Filling Process

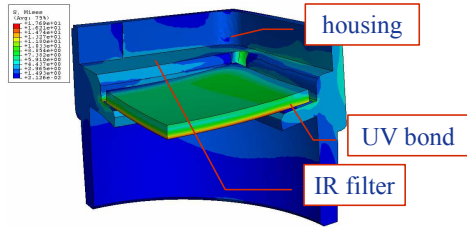


Air-trap distribution (2 point gate)



Surface roughness of housing surface that IR filter is attached ((a): initial state :RMS 1.3 μ m, (b): improved state : RMS 2.2 μ m)

Thermal Stress & Failure Mode II

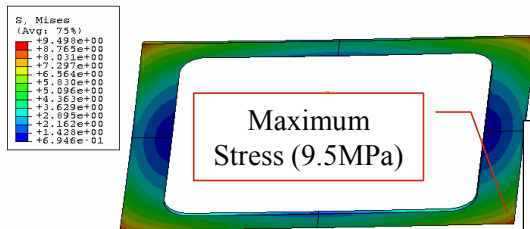


Thermal stress distribution as a result of thermal Stress Analysis

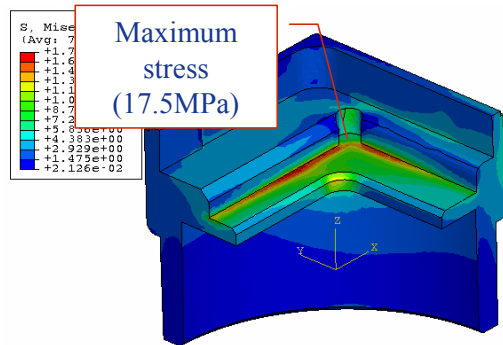
Material Properties

part	Housing	UV bond*	IR-filter
material	Nylon 66	Loctite 3103*	glass
Density	1.39 g/cc	1.1 g/cc	7.98 g/cc
Modulus of elasticity	10.5 Gpa	0.207 MPa	193GPa
Poisson's ratio	0.3	0.3	0.3
CTE	23 E-6 /°C	15 E-6 /°C	7.1 E-6 /°C
Tensile Strength, Ultimate	110~186 MPa	17 MPa	-

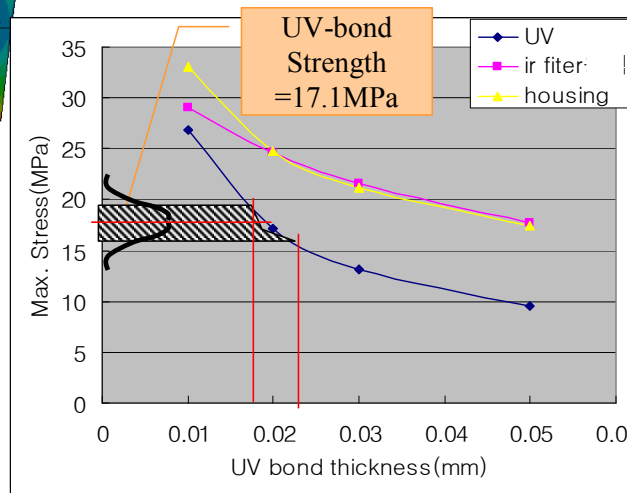
* After cured 80 second @ 30mW/cm² using metal halide light source



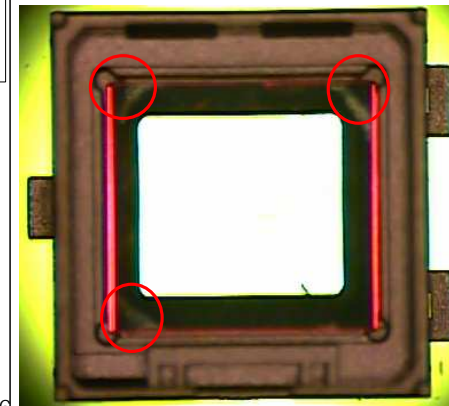
Stress distribution of UV bond



Stress distribution of housing



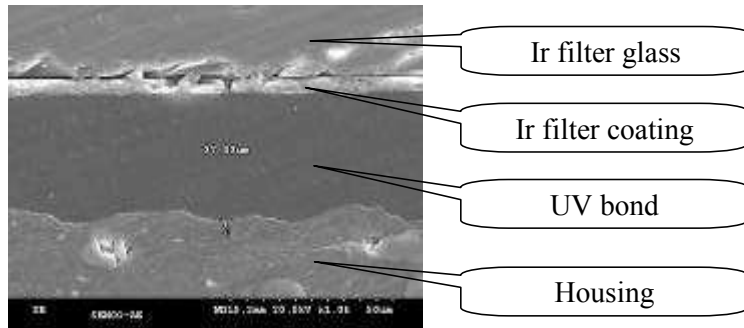
Graph of maximum stress according to UV bond thickness



Failure Mode II

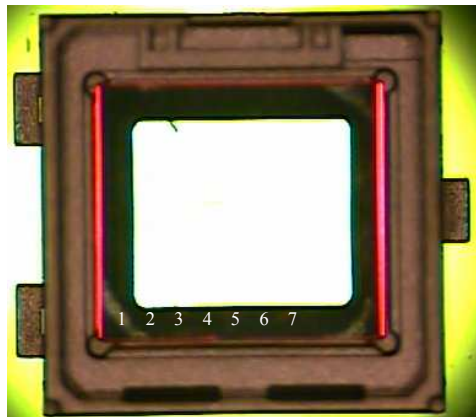


Corrective Action for Failure Mode II

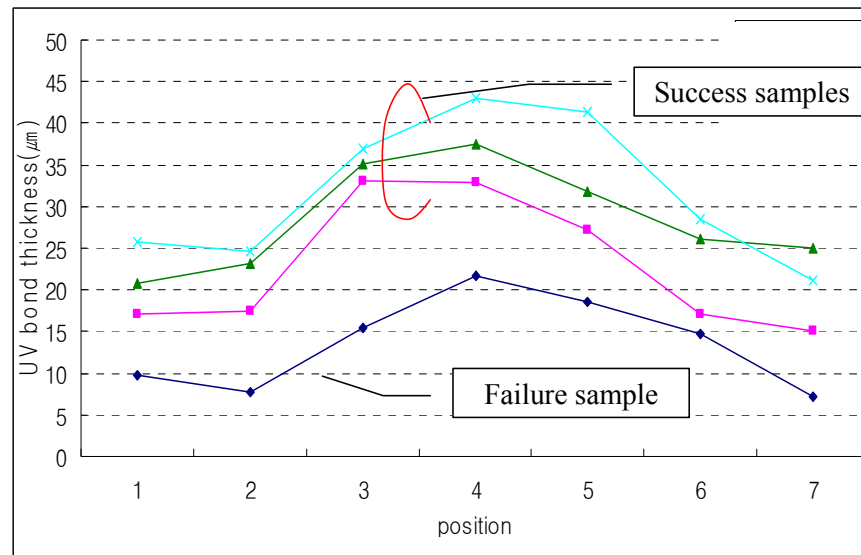


UV-bond thickness	Sample number	Success sample %
~0.015mm	12	0%
0.025~0.035mm	12	100%
0.035mm~	12	100%

SEM picture of cross section for IR-filter attached housing

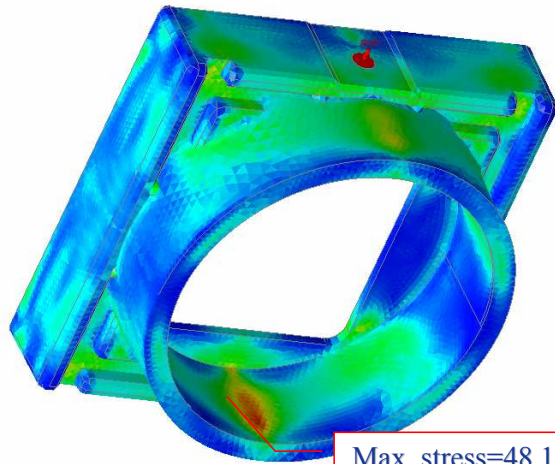


Measurement position of UV bond thickness

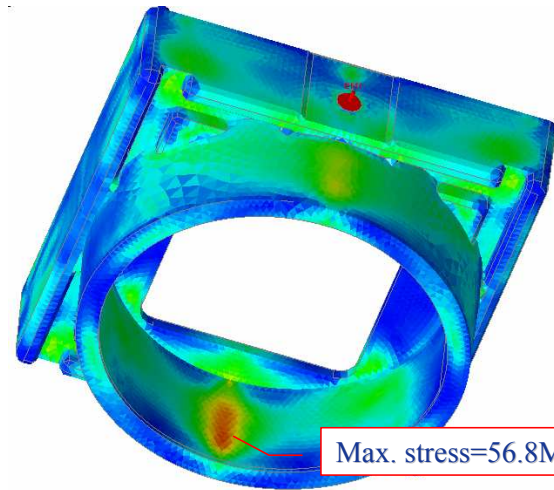


Graph of UV bond thickness according to position

Residual Stress & Failure Mode III

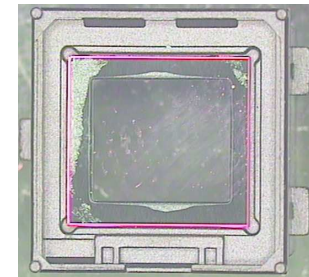


(a) Pressure 1000kg_f/cm², period=1.2sec



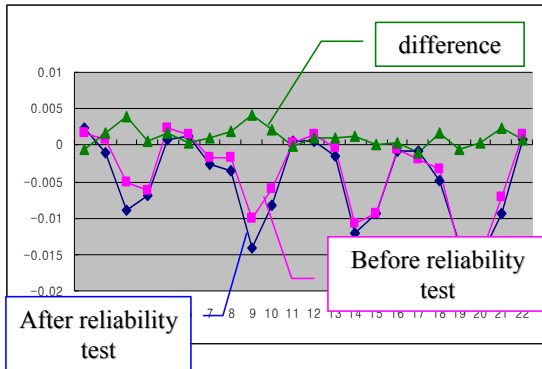
(b) Pressure 1400kg_f/cm², period=1.5sec

Stress distribution of housing after injection molding process
(Red: high stress, blue: low stress)

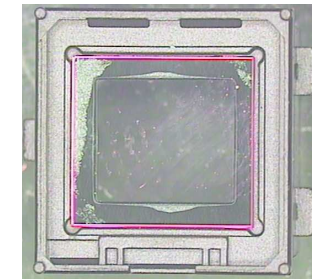
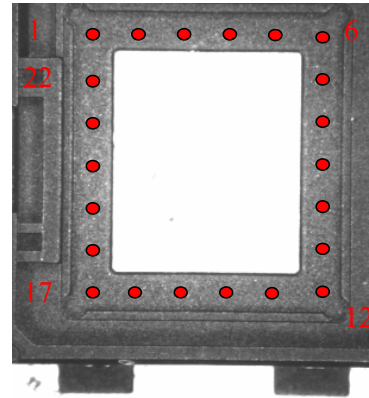


failure mode III

Bonding Surface Profile

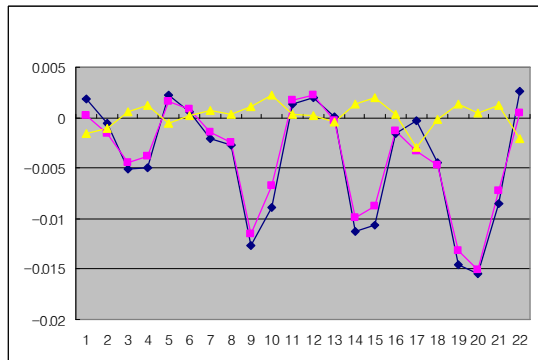


pressure 1000kg_f/cm², period=1.2sec

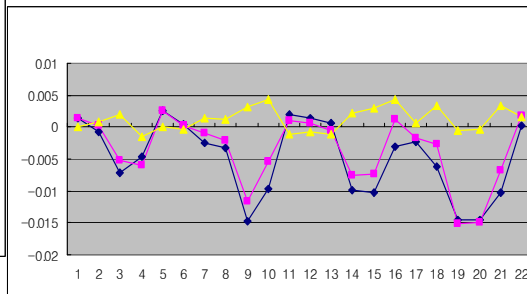


Failure mode III

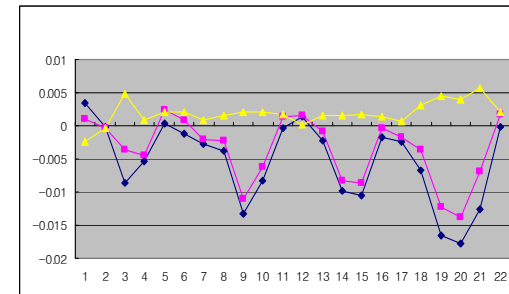
The point the height is measured on housing surface where IR filter is attached.



(b) Pressure 1200kg_f/cm², period=1.3sec



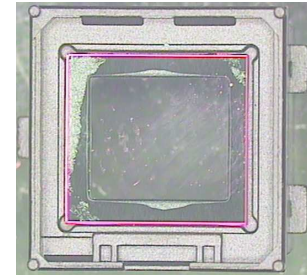
(c) Pressure 1300kg_f/cm², period=1.4sec



(d) Press 1400kg_f/cm², period=1.5sec

Housing surface profile that sticks to IR-filter by UV-bond
(measured, X-axis: position, Y-axis: height (mm))

Corrective Action for Failure Mode III

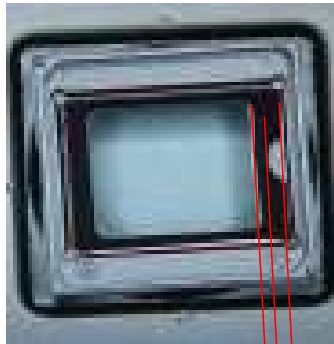


failure mode III

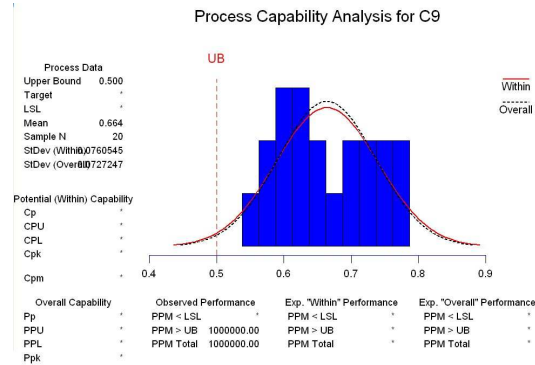
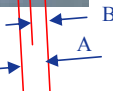
Failure sample number according to Injection pressure and time

Injection pressure (kg _f /cm ²)	800	900	1000	1200	1300	1400
Pressure time (sec)	0.9	1.1	1.2	1.3	1.4	1.5
Total sample	12	12	12	26	30	32
Failure samples	0	0	0	11	30	29

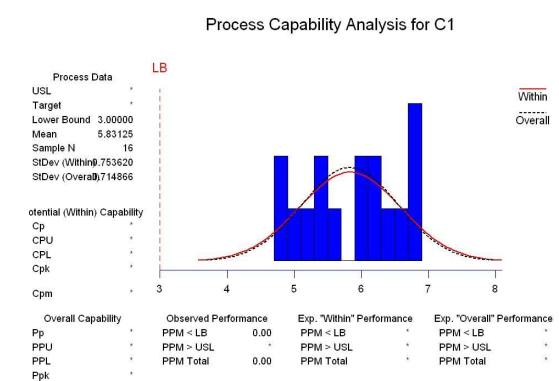
Capability Analysis



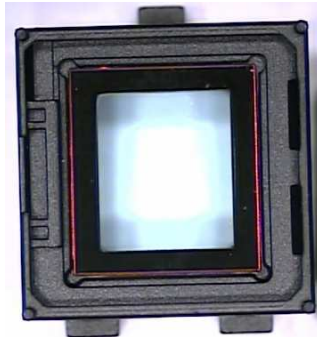
failure sample after the reliability test



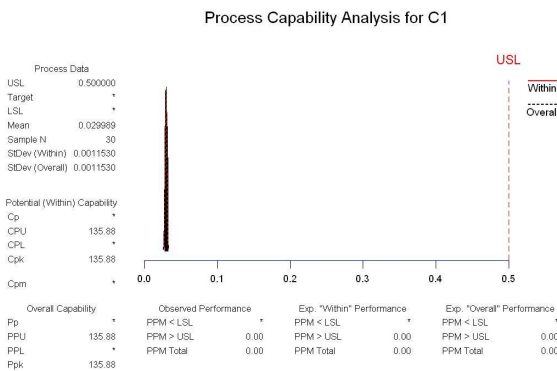
Process capability in detached width



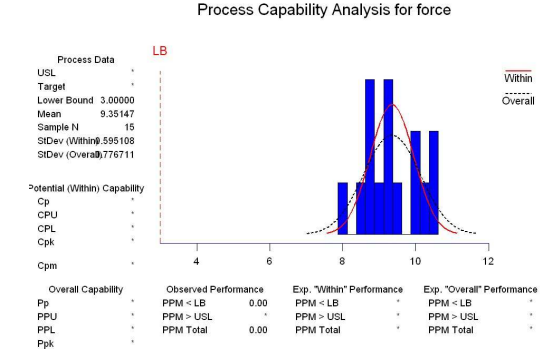
Process capability in detaching force



Improved Sample after reliability test





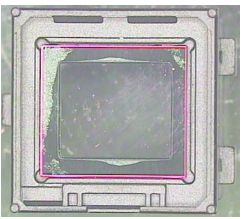
Process capability in detached width

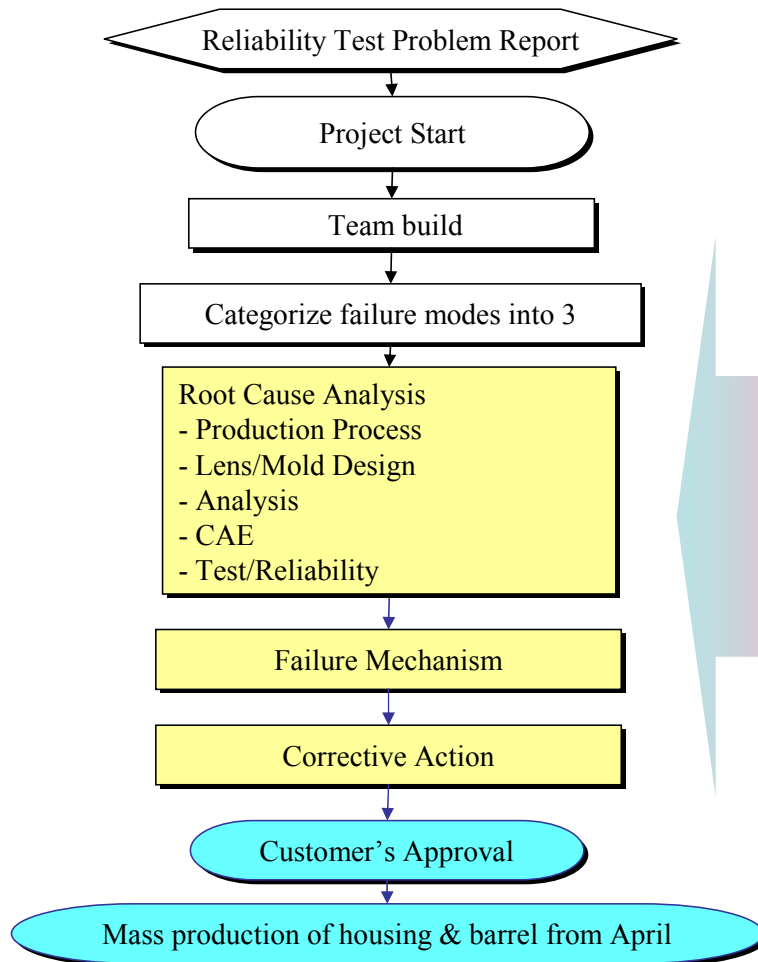


Process capability in detaching force



► Failure Modes, Failure Mechanism, and Corrective Action

Failure mode	Failure Mechanism	Corrective Action
<p>1</p> 	<p>1) <u>Over flow part</u> of 1 point gate injection mold for housing has <u>air trap</u> and <u>surface profile</u> is not straight 2) <u>Humidity</u> go through the over flow part 3) <u>thermal stress</u> applied 4) <u>RMS(surface roughness)</u> of housing surface is low, so <u>bonding strength</u> is low. 5) UV bond is detached</p>	<p>1) two point gate injection mold. 2) U shaped surface profile (Pt=7μm~17μm) 3) Make surface rougher (RMS 1.3μm \rightarrow 2.2μm)</p>
<p>2</p> 	<p>1) <u>thin</u> UV bond thickness 2) <u>thermal stress</u> is higher than bonding strength 3) UV bond is detached</p>	<p>UV-bond thickness > 0.023mm</p>
<p>3</p> 	<p>1) high <u>injection pressure</u> in injection molding process make <u>residual stress</u> of housing high 2) when the reliability test is performed, housing is <u>deformed</u> 3) UV bond is detached</p>	<p>Injection Pressure : 900kgf/cm² (800~1000) Pressure time : 1.1sec (1.0~1.2)</p>



Multi-Physics CAE

Injection Molding Process Simulation

Thermal Stress Simulation

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Material & Structure Analysis (EDS, SEM, 3D-NDT)

Test Result Analysis (6 sigma, Reliability)