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SILICONE OPTICAL BONDING

Frequently Asked Questions

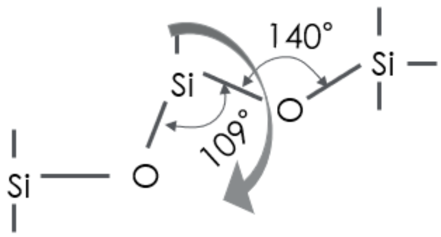
Overview

High quality displays are in ever-increasing demand. Users spend significant amounts of time with electronic devices under many different conditions each day. Devices must function well and be easy to view whether the user is indoors or outdoors. At a time when having information at one's fingertips translates into competitiveness, high quality displays that enhance user experience are critical. Displays bonded with Optical Bonding silicones can help improve readability in bright light, enhance display responsiveness, and enable higher resolution screens.

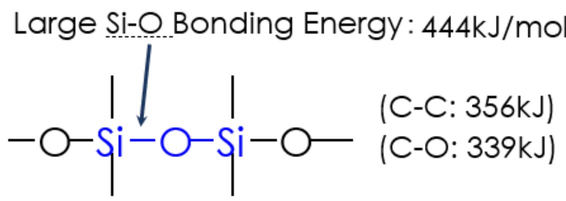
Before choosing an optical bonding product and corresponding application process, there are many questions that should be considered. As a step toward your selections, here are answers to some of the most asked questions pertaining to a variety optical bonding topics.

Q1: To what can the high reliability of Silicone OCR (Optically Clear Resin) be most attributed? Why does Si-OCR have higher reliability?

A. The high reliability of Si-OCR is rooted in the unique silicone structure.



Flexible Bonding
Small Rotation Barrier



It has high thermal stability:

Bond	Energy (kJ/mol)	Bond	Energy(kJ/mol)
C-C	356	C-S	259
C-H	413	Si-C	360
C-O	339	Si-O	**444**

Average data; not to be used as or to develop specifications.

High UV stability: The solar spectrum is divided into three bands. These are Ultra-violet light (UV) – 290nm–380nm, Visible light – 380nm–780nm, and Infra-red light – 780nm - 2500nm. Only the visible light band is seen by the human eye. The shorter the wavelength, the higher the energy associated with the radiation. This is highlighted by the fact that it is the shorter-wavelength, high-energy UV light which causes fabrics to fade and plastics to deteriorate.

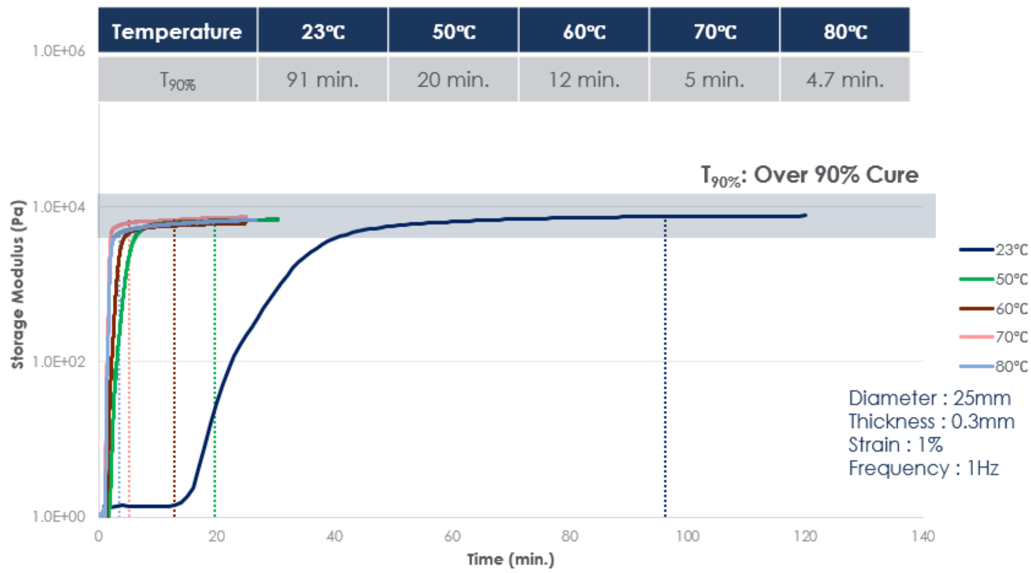
Type of Radiation	Wavelength (nm)	Energy (kJ/ mol)
UV	290-380	315-413
Visible	380-780	154-315
Near-Infrared (NIR)	780-2500	48-154

It can help with stress relief: Basically, Si-OCR is soft and has a low and stable modulus, allowing it to provide excellent protection for displays from assembly stress, mechanical shock, and vibration.

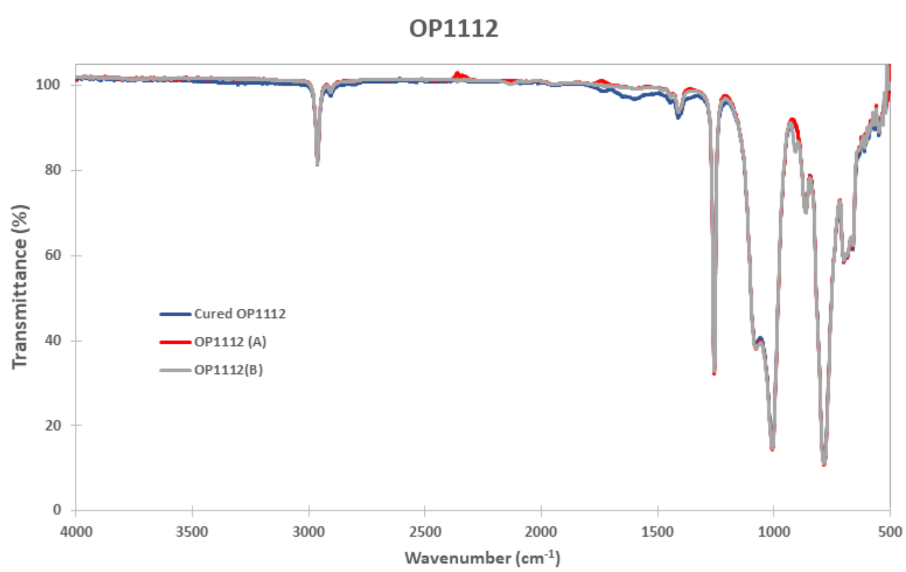
Q2 How do we determine the cure rate to a solid state for Si-OCR (FTIR, Rheology, etc)?

A. In general, we can use a rheometer to monitor the curing profile of Si-OCR from a liquid to a solid state. Take SN3001 gel curing at different temperatures as an example. Note: The selected data points in the table below are merely illustrative of the curing profile and should not be equated to gel or handling time.

Temperature	23℃	50℃	60℃	70℃	80℃
$T_{90\%}$	91 min.	20 min.	12 min.	5 min.	4.7 min.



However, it is impractical to show the difference between the cured and uncured Si-OCR by FTIR. The following shows the FTIR curves for cured/solid state Si-OCR OP1112, and the uncured liquid state of OP1112(A) and OP1112(B).



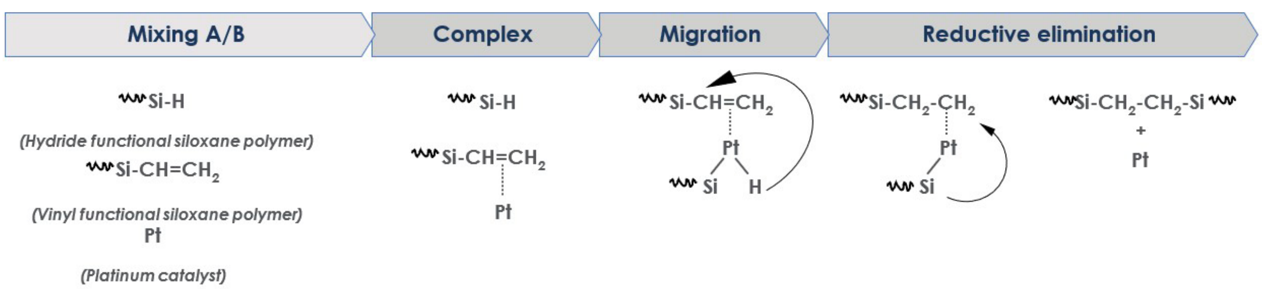
Q3: How do we determine the cure rate of Si-OCR? And how do we know whether Si-OCR is properly cured at the lamination line?

A. The answer to this question is strongly related to the real/actual application at user side, and therefore will vary. In practical terms, it is impossible for users to test the rheology of Si-OCR at their production line each time before they initiate lamination. Therefore, the recommended curing conditions for Si-OCR are based on our rheology, hardness, and lap shear data.

Q4: What is the mechanism of cure-inhibition for addition cure Si-OCR?

A. Checking for any cure inhibition effects is necessary in order to help avoid an "un-curing" phenomena from occurring, such as:

Curing mechanism for addition cure type products



Curing inhibition from the reaction side:

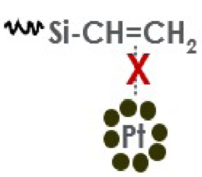
- Bonding with Pt catalyst
- Impossible to make complex structures
- Finally, uncured surface or oily surface
- Cure inhibitor (amine, sulfur, etc)

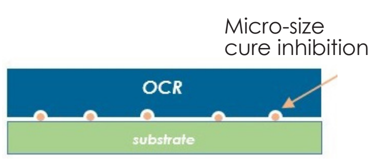
Curing inhibition from the substrate side:

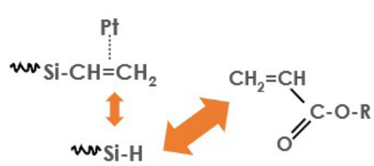
- Localized cure inhibition
- Micro-size cure inhibition effect
- Finally, weak adhesion issue
- Cure inhibitor (Plasticizer, amine, sulfur, etc)

Curing inhibition due to chemicals:

- Good reactivity with hydride-siloxane
- Slow to no reactivity between hydride- and vinyl-siloxane
- Higher reactivity with acrylic group





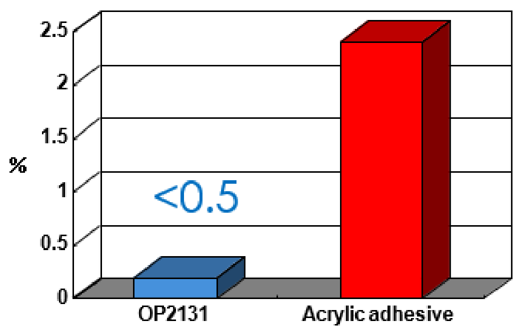


Potential inhibitors of addition cure products:

- Compounds containing nitrogen: Amine, amide compounds, Natural amine, Ethanol amine, N-methyl methanol amine, Triethanol amine, N,N-dimethyl ethanol amine, n-butyl amine, Diethyl amine, Tri-ethyl amine, tetra-methylene diamine, cyclohexyl amine, melamine di-methyl formamide, Nitrile, Cyanate, Oximo, Nitroso, Hidrazo, Azo compounds, adiponitrile, 2-Butoxime, α —nitroso—-β—-naphthol, Chelate compounds, EDTA(ethylene diamine tetra acidic acid), NTA(Nitrilo acidic acid)
- Compounds containing sulfur: Sulfur compounds, Thio compounds, Dibenzyl disulfide, Thioacetic acid, Aryl thiourea
- Compounds containing tin: Organic tin, etc
- Compounds containing phosphorus: Phosphine, Triphenyl phosphine, phosphite, Triphenyl phosphite
- Compounds containing arsenic, antimony, selenium, tellurium: Arsines, Stibines, Selenidem, Tellurium compounds, Triphenyl arsine, Triphenyl stibine, p-chloro phenyl carboxy methyl selenide
- Fatty acid or esters: Fatty acid, Acrylic acid, Methacrylic acid, Esters, Ethyl acetate, Vinyl acetate

Q5: What is the cure shrinkage level of Si-OCR?

A. The cure shrinkage rate is typically lower than 0.5%, and this is one of advantages of silicone as an optical bonding material. A low cure shrinkage level offers many benefits for optical bonding, as little inner stress is generated during the curing process. Consider the cure shrinkage level of OP2131 optical bonding silicone, below, as an example.



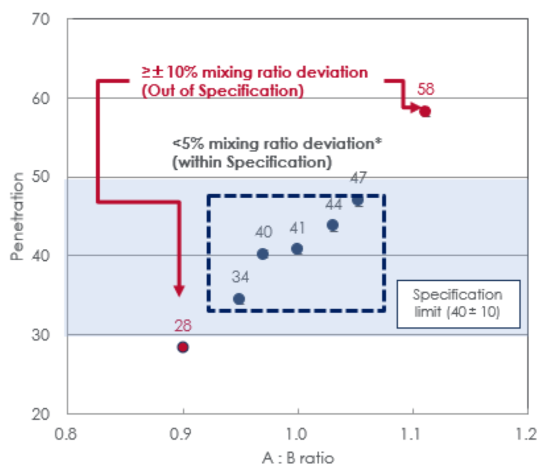
Low cure shrinkage

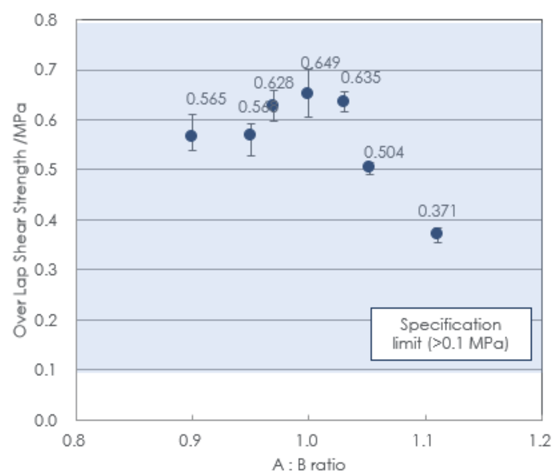
Q6: For material with a 1:1 ratio, what's the maximum mis-match rate that can typically be tolerated? 3 percent? 5 percent?

A. We have tested the penetration and lap shear of SN3001 gel at different off-ratios for the A and B components, as follows:

Q6 cont'd:

In short, below 5% deviation for SN3001 showed the spec-in properties.





Q7: What are the recommended conditions for degassing Si-LOCA (Liquid Optically Clear Adhesive) in a tank at the user's production line?

A. 3000Pa for at least 2hrs.

Q8: Once thawed, how long afterwards can it still be used?

A. For two-part, refer to the shelf life of the product. For one-part, use within 12 hours is recommended.

Q9: Besides snap cure, will all thermal materials cure eventually at room temperature (23-25°C)? If yes, how long can that be expected to take?

A. Yes. Room temperature cure will typically occur within 3 days

Q10: What should the surface tension of the substrate be for Si-LOCA to bond well?

A. Surface tension over 46 dyn/cm is recommended.

Q11: After reliability testing, how will lap shear or modulus change?

Note that every material will vary, but as an illustrative example, we can consider the following example of SN1001 optical bonding silicone:

Reliability condition		Initial	500	1000
85°C	Lap Shear	0.6	0.6	0.5
	Modulus	0.02	0.07	0.08
85°C/85%RH	Lap Shear	0.6	0.4	0.3
	Modulus	0.02	0.08	0.08

Unit: MPa; Substrate: Soda lime Glass; Bond thickness: 150um;

Product: SN1001; Batch: 17NJPA019

Q12: What are the recommended storage conditions for 2-part addition-cure silicone materials?

The recommended storage temperature range is 10°C – 23°C, however, a broader storage range of 0°C - 43°C for 2-part addition cure silicone materials is generally acceptable.

Q13: If the suggested curing temperature is 60°C for thermally cured material, is it ok to accelerate curing at 80°C? Would there be any disadvantage to that approach?

A. We are not aware of any downside to this approach in terms of the Si-OCR itself. However, the potential does exist for issues to develop with the related module parts, therefore warranting a complete evaluation prior to implementation.

Q14: What is the most common cause of bubble generation after bonding?

A. The bonding material and process should be considered/tracked simultaneously.

Bonding material issues could arise when:

- There is not the proper mixing ratio
- Portions of the material is not cured

Bonding process issues could arise when:

- Vacuum degassing is not applied on the mixing tank
- Bubbles exist in the pipeline
- The dispenser generates bubble during the mixing of Part A and Part B
- Over-degassing after bonding

Q15: What is the most common cause of delamination after bonding?

A. The bonding material and process should be considered/tracked simultaneously. Bonding material issues could arise when:

- There is not enough adhesion strength
- Cure inhibition occurs

Bonding process issues could arise when:

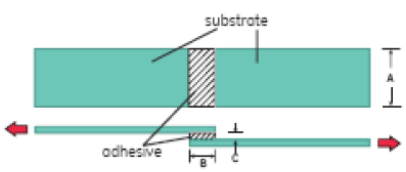
- Lamination is applied after the gel point
- Parts are touched/moved before properly cured
- Over-degassing after bonding

Q16: How can slippage be controlled during the optical bonding process?

A. Generally, slippage occurs when the Si-OCR is in uncured state or in the early stage of the curing process. First, jigs can be utilized to fix the modules. Second, for UV-Pt material, we need to find the process window, which is strongly related to UV intensity, dosage and temperature, in order to avoid slippage issues.

Q17: What is cohesive failure and adhesive failure? Which one should be targeted in optical bonding?

A. The differences in various failure modes are illustrated below. 100% cohesive failure is the goal in optical bonding to make sure the display that has been bonded can endure the high specifications of reliability testing.

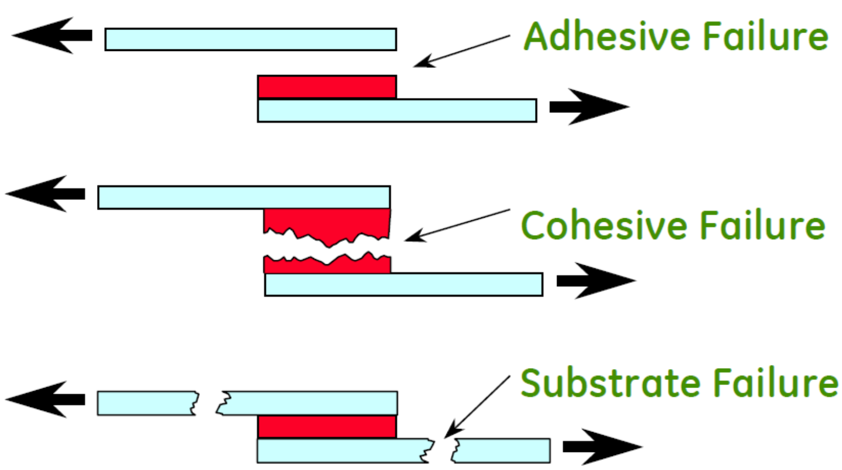


	JIS Method	ASTM Method
A:	25mm	1"
B:	10mm	0.5"
C:	1mm	-
Pull Rate:	10mm/min.	1"/min.

Units

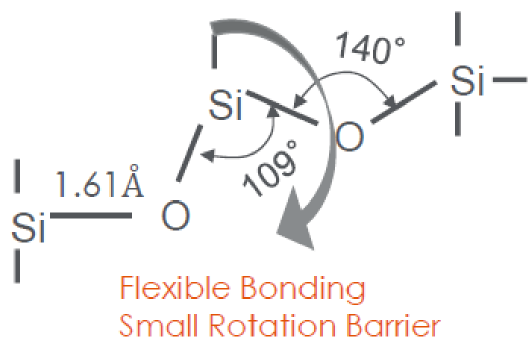
$1\ Pa = 1\ N/m^2 = 1\ kgf/cm^2$

$1\ MPa \sim 145\ lbf/in^2$ (psi)



Q18: Why does Silicone OCR exhibit hazing after high temperature and high humidity testing?

A. Silicone structures are very flexible due to the longer bond length (Si-O: 1.61 Å) and lower rotation barrier (< 0.2 kcal), and thus silicone structures show greater gas permeability. According to gas permeability simulations, silicone's free volume diameter is approximately equal to 7 ~ 11 Å and typical gas molecule diameter is approximately equal to 2.8 ~ 3.8 Å (e.g. N2 : 3.78 Å, O2 : 3.64 Å, H2O : 2.86 Å) which means moisture can diffuse easily through silicone structures before solidification when silicone is exposed to high humid/high temperature conditions. That said, after several days, haze will typically disappear gradually.



[Silicone structure]

[Gas permeability]

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