

- Adhesives
 - » Structural bonding agents
 - Types:
 - Epoxies
 - Urethanes
 - Acrylics
 - Silicone elastomers
 - One or two part formulations
 - Must consider:
 - Cure, outgassing characteristics and shrinkage
- Optical Cements
 - » Types
 - Thermoplastics
 - Thermosets
 - Photosets
 - » Must be transparent and homogeneous

For a detailed discussion of optical cements, structural adhesives and elastomeric sealants see:

Yoder, *Opto-Mechanical Systems Design, 2nd ed.*, Marcel Dekker (1993) pp. 133-150 and *Engineered Materials Handbook, Vol.3, Adhesives and Sealants*, ASM International (1990).

The table on the next two pages is taken from John Daly's SPIE course notes: SC015, "Structural Adhesives for Optical Bonding", given at Photonics West 2000, San Jose, CA (Jan. 27, 2000).

A more extensive discussion is given in Jamil Baghdachi's course notes: SC 16, "Structural Adhesives and Optical Cements", given at Photonics East 1998, Boston, MA (Nov. 2, 1998)

From Roger Paquin

ADHESIVE APPLICATION SUMMARY

Name	Manufacturer	Type	Applications /Advantages
2216B/A	3M Adhesives Div. 800-362-3550	2 part epoxy	<i>Aerospace optics bonding</i> High Strength / Low outgassing Common use started '80s High viscosity = easy to use Room temp cure option
100 B/A	3M Adhesives Div. 800-362-3550	2 part epoxy	<i>Improved faster curing 2216 replacement</i> Offered in Duo-Pak (DP-100) dispenser Sets-up in 5 minutes @ room temperature Properties slightly degraded vs. 2216B/A More outgassing than 2216
Mil-Bond	Summers Optical 215-646-1477	2 part epoxy	<i>Aerospace/Military optics bonding</i> High Strength Low outgassing Glass to Metal bonding Excellent adhesion with use of primer Temperature cure required
A-12	Armstrong Products 800-233-3823	2 part epoxy	<i>Aerospace/Military optics bonding</i> High Strength Low outgassing Hughes choice in '80s Developed as a wood adhesive Glass to Metal bonding Excellent adhesion with use of primer Flexibility/strength varied by mix ratio changes Temperature cure required
ECCOBOND LV 45 / 15LV	Emerson and Cumings 800-225-9936	2 part resin / catalyst	<i>Easy to use & control</i> High strength / High Viscosity Room temperature cure Low outgassing
ECCOBOND 285/catalyst 11	Emerson and Cumings 800-225-9936	2 part resin / catalyst	<i>Suggested replacement for LV45</i> High strength Lower outgassing 65 C temperature cure Wide temperature range (-55 to 155 C)
Hysol 1C Torr seal	Dexter Specialty Resins 925-458-8000	2 part epoxy	<i>Vacuum sealing and tack bonding</i> White / High viscosity Low outgassing
Hysol 0151	Dexter Specialty Resins 925-458-8000	2 part epoxy	<i>Suggested as replacement for 1C</i> More flexible than 1C Clear / high viscosity
ABLEFILM	Ablestik Electronic	Premixed/ frozen	<i>Larger Optics to Metal</i>

506	Materials & Adhesives 310-764-4600	glass-fiber epoxy film	Flexible to accommodate CTE mismatches Easily removed by heating Requires heat and pressure for proper cure
Ablebond 724-14	Ablestik Electronic Materials & Adhesives 310-764-4600	Premixed/ frozen polyurethane	<i>Production product = well controlled</i> 14C has cabosil filler = higher viscosity Resilient / flexible = low stress Cures @ room temperature Short (1 month) shelf life @ -40 C
RTV 142	GE 800-255-8886	One part	<i>Low volatile silicone</i> One-component Room temperature cure Low outgassing
Slygard 186	Dow Corning 517-496-6000	2 part silicone	<i>Potted bonding of fragile optics</i> Very flexible resin High strength Bad for contamination and out-gassing Low viscosity Room temperature cure
93-500	Dow Corning 517-496-6000	2 part silicone	<i>Space - Grade Encapsulant</i> Very flexible. very low viscosity Wide temperature range (-65 to 200 C) Soft: durometer = shore A 46
Norland 65	Norland Products 732-545-7828	1 part UV cure	<i>Ideal for small pieces and quick setup</i> Glass to metal or glass to glass Higher viscosity = easier to use Quick with UV cure Flexible for low strain
E-20NS	Loctite Corp. 800-323-5106	2 part epoxy	<i>Glass to Metal</i> medium viscosity High Peel & Shear Strength Durobond applicator packaging
E-30CL	Loctite Corp. 800-323-5106	2 part epoxy	<i>Glass to Metal</i> Clear / Low viscosity High Peel & Shear Strength Durobond applicator packaging
U-05FL	Loctite Corp. 800-323-5106	2 part epoxy urethane	<i>Glass to Metal</i> Low viscosity 5 minute work life High Peel & Shear Strength Durobond applicator packaging

- **Desirable Properties:**
 - » **Optical:**
 - High transmission, colorless, low fluorescence
 - Homogeneous and strain free after curing
 - » **Mechanical:**
 - Moisture, and mechanical and thermal shock resistance
 - Temperature stability, UV and radiation resistance
 - Minimum shrinkage, adhesion in thin layers
 - » **Other:**
 - Non-toxic, chemically stable
 - Capable of decementing

- **Thermoplastic Cements**
 - » Cellulose caprate:
 - liquifies at 120°C
 - slow cooling essential
- **Thermosetting Cements**
 - » Primarily 2-part, room temperature extended cure
 - » More rapid cure with accelerator or higher temp.
 - » Index 1.54 - 1.55
 - » Decementing with solvents or hot oil
- **Photosetting Cements**
 - » Colorless, one-part RT cure by UV exposure
 - Maximum absorption at 0.254 to 0.378 μ m
 - Bond strength lower than thermosets
 - Debonding difficult

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Additional properties and discussion are given in Yoder's *Opto-Mechanical Systems Design*, but for more details, always consult the manufacturer.

Major manufacturers of optical cements include: Summers Labs (Lens Bond), Norland and Eastman.

TABLE 8. Representative Elastomeric Sealants

Material	Mfr. code ^a	Suggested cure time at °C	Elastomer tensile strength, 10 ⁶ N/m ² (psi)	Temperature range of use, °C (°F)	Thermal expansion coeff., ppm/°C	Density at 25°C g/cm ³	Shrinkage after 3 days at 25°C (%)
732	DC	24 hr at 25	2.2 (325)	-55 to 200	310	1.04	
RTV112	GE	3 days at 2	2.2 (325)	<204 (400)	270 293	1.05	1.0
NUVA-SIL	L	UV cure 1 min or 7 days at 25	3.8 (550)	-70 to 260	167	1.35	0.4
3112	DC		4.5 (650)	-55 to 250	300	1.02	0.25
93-500	DC	7 days at 25 4 hr at 65	69 (100)	-55 to 155			
RTV88	GE	<24 hr at 25	5.9 (850)	-54 to 260	210	1.48	0.6
RTV8111	GE	<24 hr at 25	2.4 (350)	-54 to 204	250	1.18	0.6
RTV8262	GE	<24 hr at 25	5.2 (750)	-54 to 260	210	1.47	0.6

^aMfr. code: 3M = 3M Company; DC = Dow Corning; GE = General Electric; L = Loctite.
Source: Adapted from Yoder (1993).

Table 9. Structural Adhesives

Adhesive Name	Temperature Range °C	Mixed Viscosity relative	Work Lifetime minutes	Tensile Strength psi @ RT	Lap Shear Strength psi @ RT	Cured Flexibility relative	Total Mass Loss %TML	Condensable Volatiles %CVCM
3M 2216 B/A	-55 to 90	High	90	-	2500	Moderate	1.01	0.05
3M 100 B/A	-55 to 90	Medium	5	-	1500	Moderate	5.0	-
Milbond	-60 to 100	High	30	2100	-	Moderate	0.98	0.03
A-12	-55 to 90	High	180	-	2500		0.9	0.0
45LV/15LV	-55 to 121		90	-	3200	Low	1.98	0.02
285/11	-55 to 155	High	240	-	2100		0.28	0.01
724-14C	-55 to 125	Med- high	30	-	1900		1.11	0.12
Ablefilm 506	-55 to 150	-	24 hrs.	-	1400		0.9	0.32
Hysol 1C	-55 to 100	High	30	2000	-		0.81	0.02
Hysol 0151	-55 to 100	Medium	30	-	-		1.51	0.01
E-20NS	-55 to 100	Medium	20	5600	2500		-	-
E-30CL	-55 to 100	Low	30	8000	4200		-	-
U-05FL	-55 to 100	Medium	5	1300	2100		-	-
RTV 142	-55 to 200	Medium	60	550	300		0.24	0.0
Sylgard 186	-55 to 200	Low	120	700	-	Excellent	2.19	0.94
Dow 93-500	-55 to 200	Low	60			Excellent		
NOA 65	-55 to 100	Med- low	-					