Attaching Fiber Optic Modules

Optical fibers transmit information in the form of pulses of light. The advantages of optical fibers over traditional copper wires include: higher throughput, greater signal distance and speed, smaller cable mass and diameter, greater pull tension limit, and resistance to electromagnetic interference (EMI) and radio frequency interference (RFI). The disadvantages of fiber optics when compared to copper wires include: end-face defects, cleanliness, and the ease of attaching connectors to electronics assemblies (Figure 1).

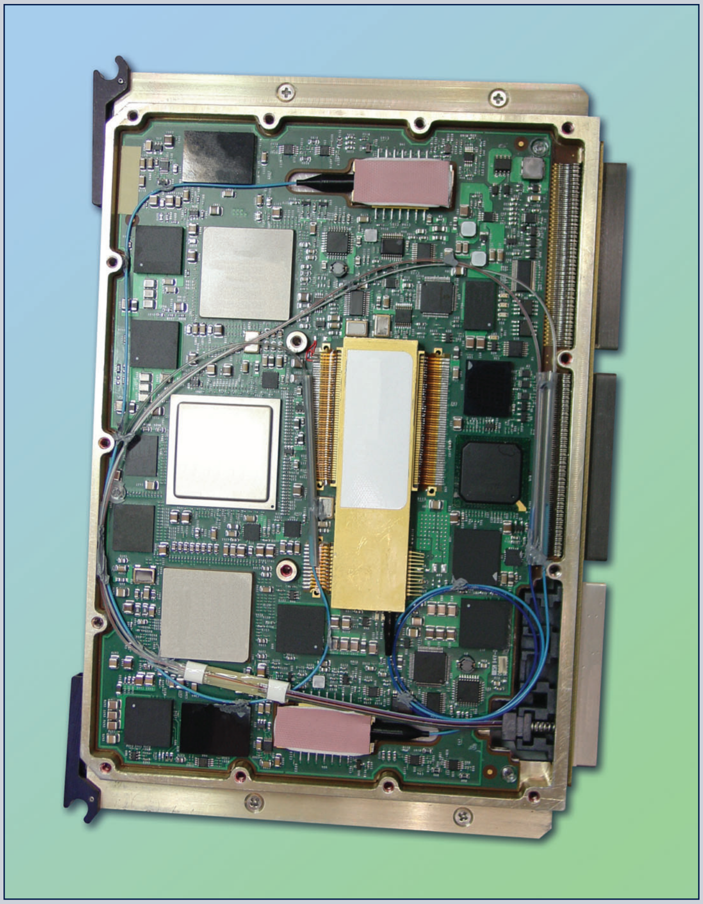

Figure 1: Circuit card assembly combining fiber optic components with electronics.

End-Face Defects

End-face defects adversely affect the optical performance by creating air gaps and blockages in the light path that prevent direct physical contact during mating. The types of end-face defects include: loose contamination or dirt; oil contamination; scratches; and pits, chips, or other defects. Loose contamination can include dust or debris that can be removed with proper cleaning. Oil contamination is typically introduced via fingerprints and can also be removed with proper cleaning. Scratches are features that are typically caused by the cleaning or polishing processes and require re-polishing of the fiber. Pits, chips, and other defects may require cutting off the damaged section and re-polishing.

Cleanliness

Dust in the optical path is a concern, because the contamination can increase the insertion loss (IL) and decrease the return loss (RL), both of which are undesirable. IL is the loss of signal power resulting from the insertion of a device in an optical fiber and is usually expressed in decibels (dB). RL is the loss of signal power resulting from the reflection caused at a discontinuity in an optical fiber and is usually expressed as a ratio in decibels (dB). The return loss is high if two optical fibers are well matched. A high return loss is therefore desirable as it results in a lower insertion loss.

A recent study by iNEMI [1] showed that dust particles can accumulate and redistribute at the connector end face during repetitive connector mating and de-mating cycles. In the study, they found that electrostatic charge force was one of the mechanisms responsible for the particle accumulation, redistribution, and their movement in and towards the core area.

The effect of dust accumulation at the core of the fiber was reduced by application of ionized air or use of a fluid cleaning process, with both methods neutralizing the electrostatic charge at the connector end face. Applying ionized air or using cleaning fluids were good techniques for minimizing movement of particles during the service life of connectors in optical systems.

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Attachment Techniques

There are multiple methods to use for attaching fiber optic modules to an electro-optics assembly, and may include: soldering, conductive adhesives, or mechanical assembly. The main concerns for the fiber optic module connector are its sensitivity to cleanliness and heat. In a standard reflow process, flux, surfactant, and water residues could damage or reduce the performance of the optical components. Low temperature alloys can be used with any of the soldering techniques to attach fiber optic modules, especially when the conventional soldering temperatures may damage the component.

To reduce the likelihood of heat damage, the fiber optic module is added after the other components are processed. To increase reliability and reproducibility, automated soldering process, such as selective soldering, robotic soldering, or selective laser soldering are favored over hand placement and soldering. Other attachment techniques are available, including anisotropic conductive films and conductive epoxies.

Pick-and-place systems use vacuum heads with x-y positioning control to pick up and hold the components. Cameras are used to verify alignment of the components, boards or panels of boards using fiducials. Cameras also aid in the placement of the components in the appropriate board locations to which solder paste has been applied.

Selective laser soldering is a technique where a 2 to 80 W average powered laser is used. The parameters depend on the solder joint dimensions and the required speed. Solder mask coatings are more damage resistant to lasers emitting in the 940 to 980 nm range. Some of the parameters to consider in selective laser soldering are: average power (watts), pulse time/length (ms), pulse duty cycle (% on/off), power density (intensity, watts/cm^2), and laser focus position. Each of these variables can be optimized for minimizing the soldering time, the amount of energy delivered to solder joint, the rate of heat delivery to solder joint, the rate of the soldering process, and ensuring good solder joint quality. The laser system is mounted to a precision x-y positioning table or robotic arm coupled with a camera and imaging system that allows for coaxial viewing of the laser beam in real time. [2]

Robotic soldering is similar to selective laser soldering in that a soldering iron is mounted to a precision x-y positioning table and robotic arm with a camera and imaging system that allows for viewing of the soldering process in real time. The actual soldering process is much like hand soldering, only that higher precision and reproducibility is gained by using a robotic system to form each solder joint.

Selective soldering is similar to wave soldering except only a small area of the board is contacted at a time. The assembly is attached to a precision x-y positioning control system and is selectively moved over a small solder fountain and carefully lowered into and out of the molten solder. Alternate selective soldering machines can precisely move a small solder pot under a stationary circuit card assembly.

Whenever one uses automated placement and soldering processes, it is important to remember that each system requires programming of the component variables and bare board coordinates, as well as the soldering parameters necessary to form quality assemblies. The up-front time spent on programming the systems pays off with fewer soldering errors, a more reliable manufacturing process, and a more reliable product.

Anisotropic conductive films (ACFs) allow for the interconnection of circuit lines through the adhesive thickness (in the Z-axis), but are electrically insulating along the plane of the adhesive (in the X-Y plane). The film is a heat-bondable, electrically conductive adhesive film, composed of thermoplastic and thermosetting epoxy/acrylic matrix with conductive particles. Application of heat and pressure, using a thermo-compression (hot bar) bonder, causes the adhesive to initially flow and to bring the circuit pads into contact, trapping the conductive particles between the component and circuit pads. [3]

Screen printed conductive epoxy can be used to attached fiber optic modules. Conductive epoxy can have a coefficient of thermal expansion (CTE) that more closely matches that of the epoxy used in the circuit board, minimizing failures due to cracking of solder joints due to thermal cycling. Non-conductive epoxy can be used to provide additional mechanical strength. Another advantage to using conductive epoxy rather than solder is that the manufacturing process has fewer steps, eliminating the pre-tinning, prebake and flux removal steps of the typical electronics manufacturing process. The terminals of the components may need a AgPd surface finish to reduce the likelihood of increased resistance due to tin oxide formation and diffusion within the adhesive joints when using pre-tinned components. [4]

Rework Considerations

To rework a soldered connection, standard techniques can be used, such as hot air or infrared radiation equipment to heat the location above the reflow temperature. The part is removed, the site prepared for a new component, and a new part is re-soldered.

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To rework an ACF, one heats the bond-line area to above 100°C with an appropriate rework tool and peels the circuits apart. The bond site requires cleaning with a solvent, such as acetone, and the circuits can be re-bonded with a new piece of ACF.

To rework conductive epoxy, one heats the epoxy above its glass transition temperature (Tg), removes the defective component, and attaches a new one, with no additional steps. [5]

Summary

There are a variety of technologies to attach fiber optic modules or other heat sensitive components. Localized soldering technologies such as selective laser, robotic, and selective soldering provide joints familiar to the conventional electronics manufacturing industry. Anisotropic conductive films and screen printed conductive epoxy provide alternatives with fewer steps for attachment as well as rework.

For more information about the incorporation of fiber optic modules into a circuit card assembly, contact the ACI Technologies Helpline at 610.362.1320, email helpline@aciusa.org or visit www.aciusa.org.

References

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ACI Technologies

ACI Technologies, Inc. 1 International Plaza, Suite 600 Philadelphia, PA 19113 *phone:* 610.362.1200 *web:* www.aciusa.org

Training Center *phone:* 610.362.1295 *email:* registrar@aciusa.org

Helpline *phone:* 610.362.1320 *email:* helpline@aciusa.org