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Y-FLEX

The Future of Fast Data Transmission

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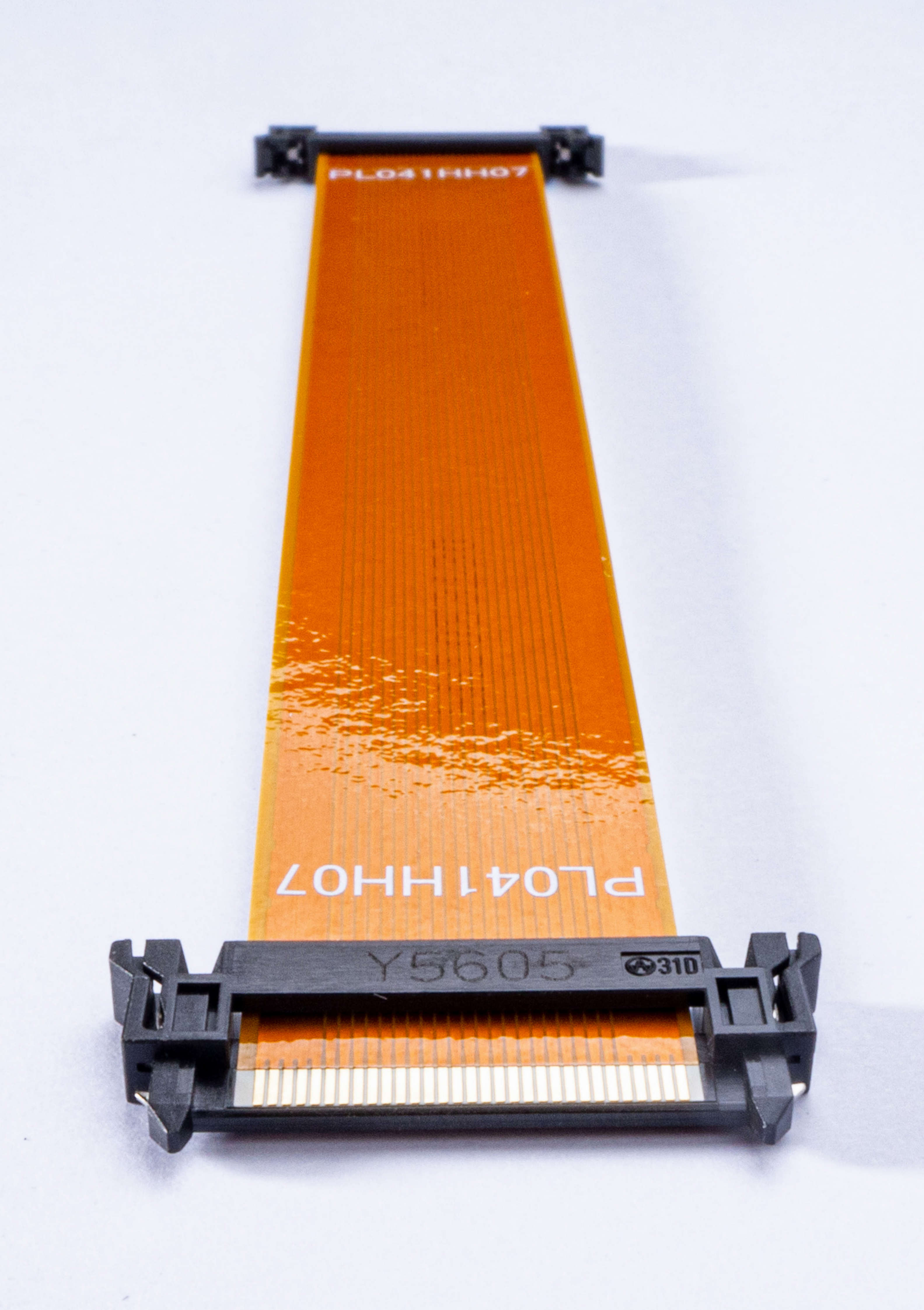

Y-FLEX

The Future of Fast Data Transmission

Conventional technologies such as FFC (flexible flat cable) / FPC (flexible printed circuit) or micro-coaxial cables cannot cope with requirements for extremely high reliability and continuously increasing data transmission rates between internal printed circuit boards.
The Y-FLEX technology offers an innovative yet established approach that unites the advantages of the classic methods but better meets the requirements of technically demanding products and will therefore see much more use in the future.

Already in 1997, Yamaichi Electronics established the first Y-FLEX cables on the market. Nearly 25 years ago, the product was way ahead of its time and was hence only reluctantly accepted by the market. Nevertheless, the manufacturer of connectors, test sockets and flat cables believed in the technology and has developed it continuously right up to the present. This faith is now paying off.

The Y-FLEX cable is a special high-speed FPC which is ideal for high data transmission rates. It is realised with characteristics such as an LCP (liquid crystal polymer) base material, contacting of various layers with so-called silver bumps and a special, completely reproducible production process.

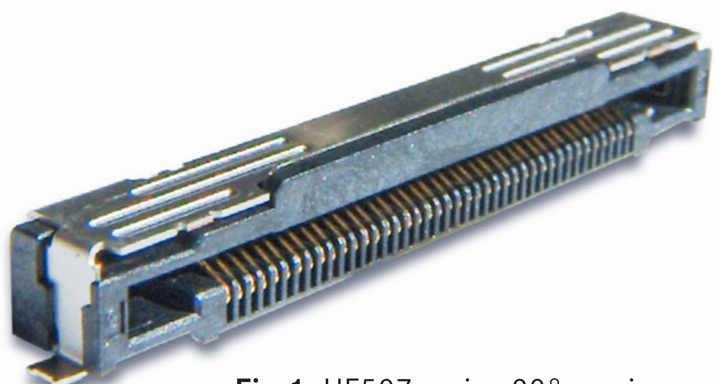

Fig. 1: HF507 series 90° version

It must be matched specifically to the respective FFC/FPC connector for especially high transfer rates to be achieved. In principle, the Y-FLEX mating face can be adapted to any standard ZIF, non-ZIF or LIF connector. However, specially developed high-speed ZIF or non-ZIF connectors such as those in the HF507 series (see Figure 1) from Yamaichi are the most suitable for achieving optimal performance.

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Regional Sales Manager
with over ten years of development experience in fields including FFC/FPC cables and connectors at Yamaichi Electronics

The manufacturing process described below is decisive for the high reliability and the remarkable data transmission characteristics of the Y-FLEX. In step 1 (see Figure 2a), the silver paste is applied in the form of a pyramid-like cone (silver bump) to a copper foil. Then a film made of the LCP insulation material and another copper layer are laminated under vacuum and heat (see Figure 2b). These two steps assume key roles in the production process. Use of a specific silver bump height and defined lamination conditions result in optimal contacting and the required mechanical strength of the various copper layers. In steps 3 to 5 (see Figure 2c), the Y-FLEX is prepared for precision etching through the application and development of a photoresist coating and then etched. The extremely precise removal of the unneeded copper allows for maximum accuracy and freedom of design of the conductive traces. Cleaning and application of a protective layer in steps 6 to 8 (see Figure 2c) give the Y-FLEX stability and insulating protection.

Y-FLEX Manufacturing process

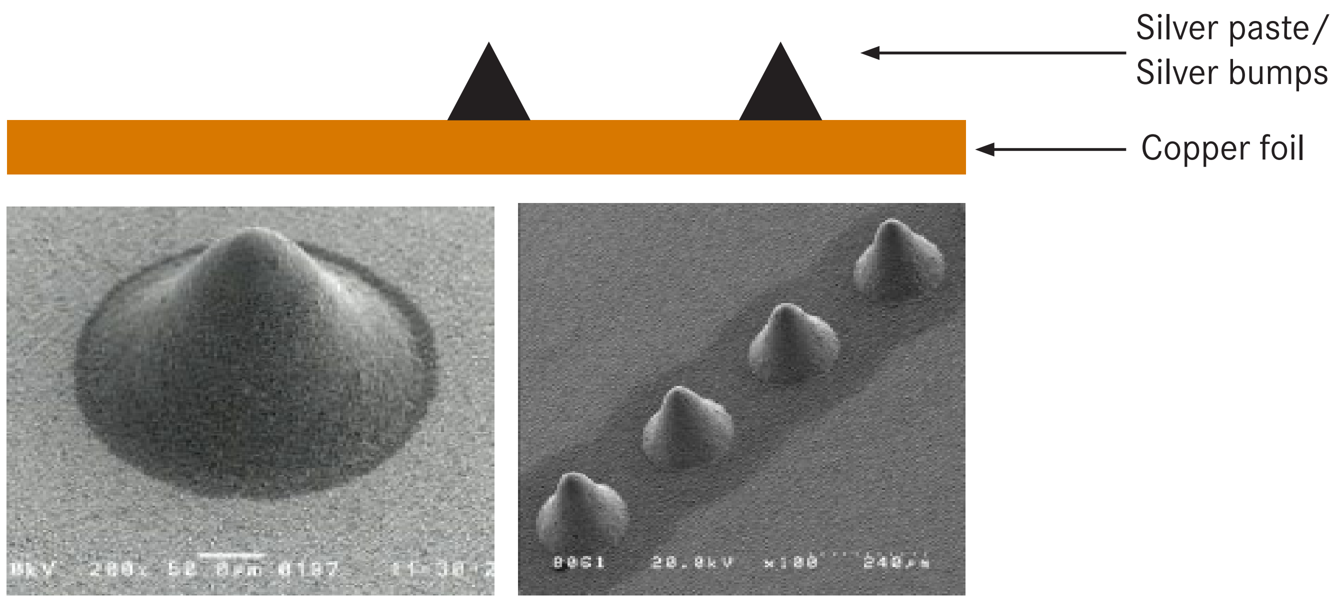

Fig. 2a: Step 1: Application of the silver paste to the copper foil (100X and 200X magnification)

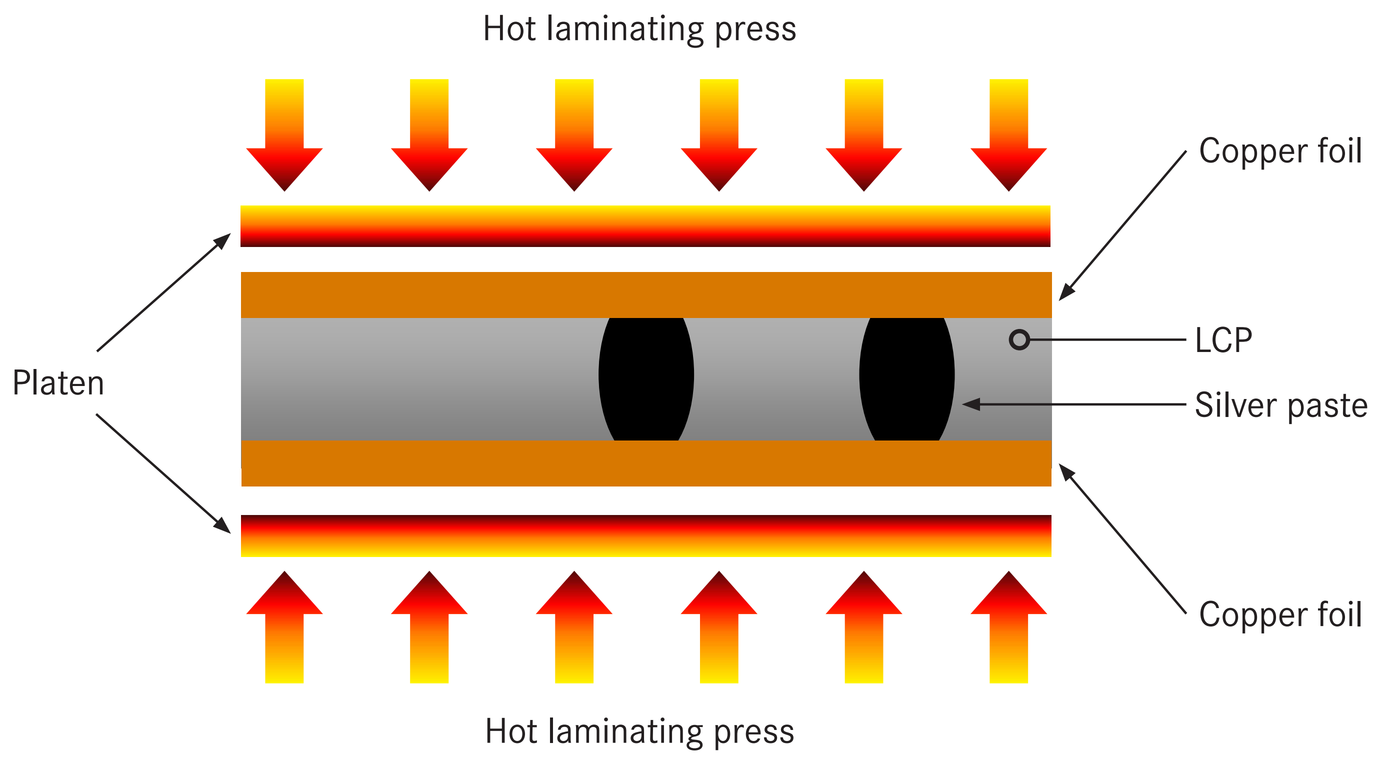

Fig. 2b: Step 2: Thermal lamination of the different layers

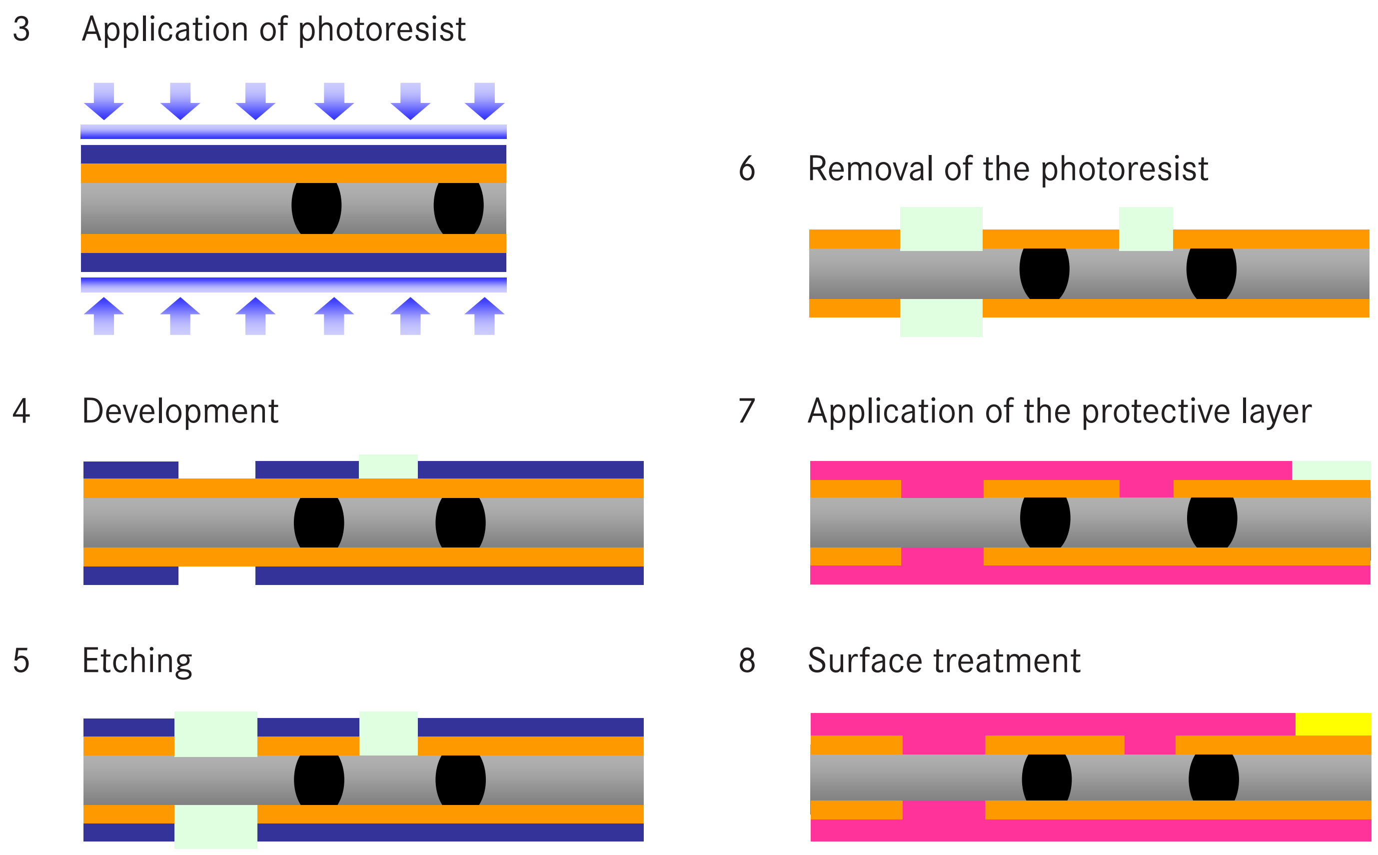

Fig. 2c: Steps 3–8: Precision etching and coating

FFC is the most widely used flexible flat cable, beating out Y-FLEX, micro-coax and FPC. FFCs will continue to be used in many applications in the future for good reason, particularly when relatively long cables (> 0.5 m) or not especially high signal transmission rates (< 3 Gbps) are required. With FFCs the trace widths and spaces can be designed with a certain amount of variability to yield higher data rates. However, the associated manufacturing costs are high. Much higher data transfer rates can be achieved with Y-FLEX technology due to its greater design flexibility. For example, where FFCs have to be bent, the Y-FLEX can be used without folding thanks to the special shaping capabilities and thus has significantly better reflection properties. Also, components can be placed on the Y-FLEX, for example, to additionally improve the attenuation properties (see Figure 3).

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Y-FLEX compared with FFC and FPC

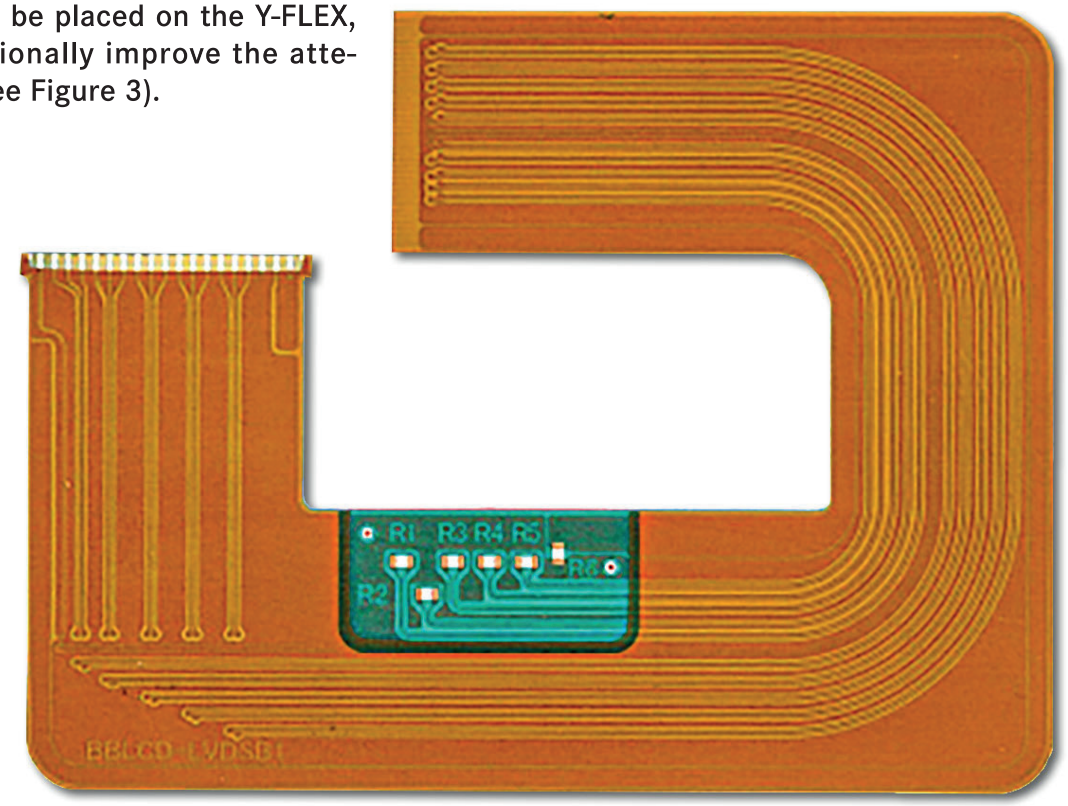


Fig. 3: Y-FLEX with homogeneous conductive traces and resistors

In standard FPCs the electrical connection between the individual copper layers is established via through-hole plating using THT (through-hole technology). As mentioned above for the manufacturing process, this is accomplished in the Y-FLEX in a special process in which the conductive silver paste is pressed through the LCP material to establish a conductive connection between the individual copper traces. Because the silver bumps only penetrate the insulation material between the copper layers – not the copper layers themselves – a more homogeneous structure can be achieved than with THT through-hole plating, and no additional surface treatment or material fillers in the drill holes are required (see Figure 4).

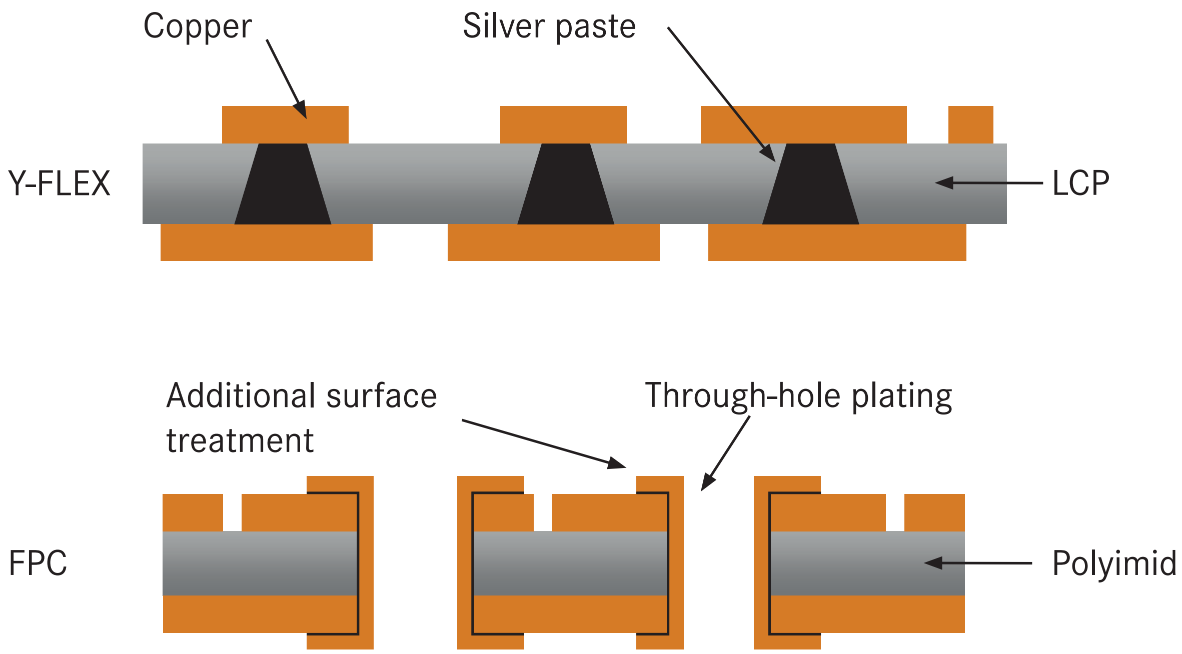


Fig. 4: Comparison of Y-FLEX and FPC designs

The standard Y-FLEX is made up of two layers. However, the technology permits many more copper layers. Ten layers have already been realised in trials and up to four copper layers have been used in practice.

The biggest difference between this and FPCs, however, lies in the insulation material. Compared with the standard polyimides used in conventional FPCs, the LCP insulation material in the Y-FLEX exhibits a much lower dielectric constant ε and a much lower dissipation factor tan δ at high frequencies (see Figure 5). As a result, attenuation is much lower and the data transmission rates are much higher than in standard FPCs.

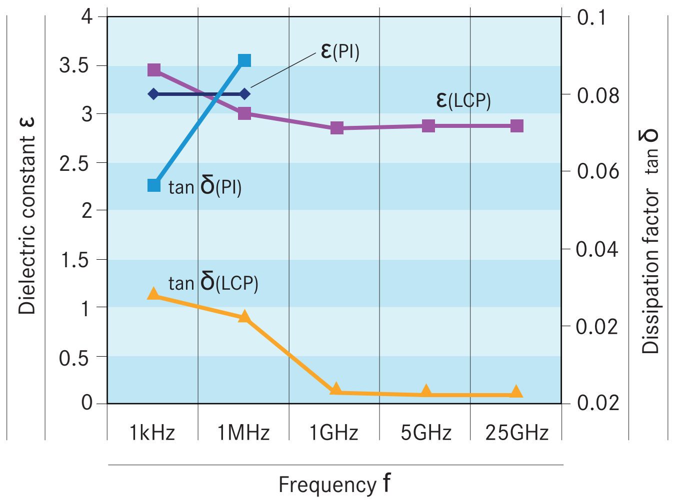
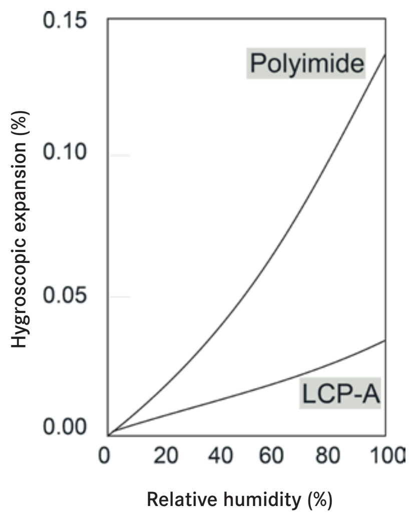


Fig. 5: Dielectric constant and dissipation factor for LCP and PI

Fig. 6: Hygroscopic properties of LCP and standard polyimide

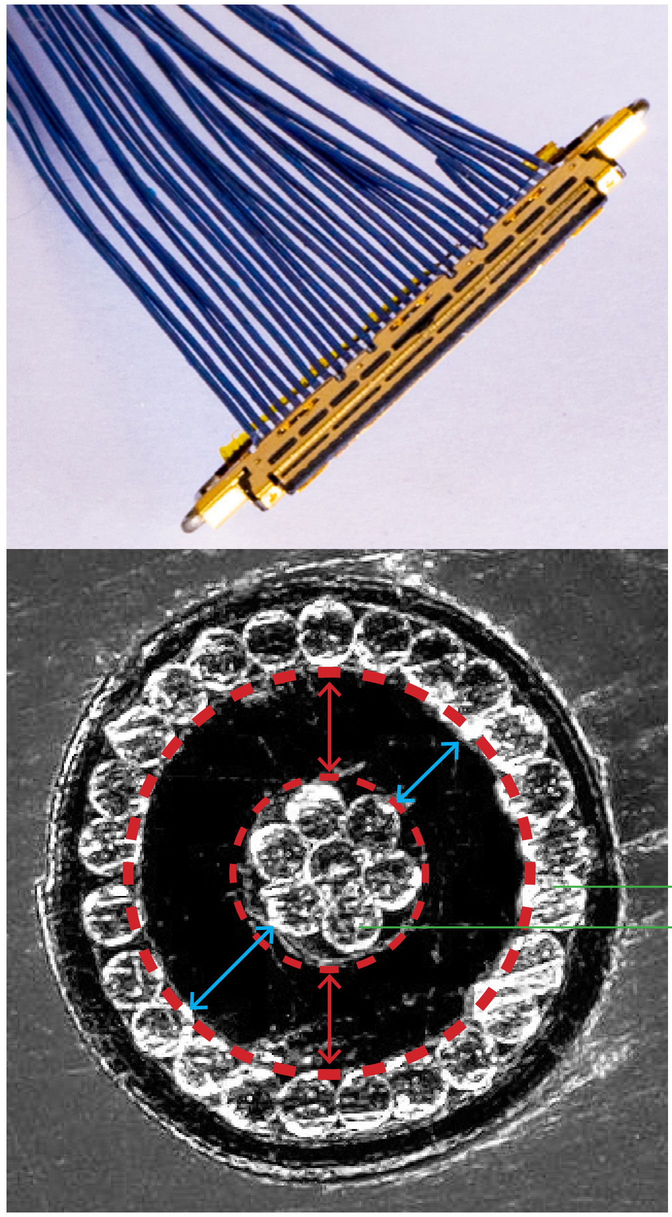


LCP's superior hygroscopic properties compared with those of standard polyimide (see Figure 6) make processing easier and allow trace spaces and widths of less than 30 µm to be realised with exceptionally high accuracy. Use in high relative humidity conditions is also much more stable. Shielding foils as are usual in FFCs and FPCs can also be used in the Y-FLEX to improve the electromagnetic compatibility (EMC).

Y-FLEX compared with micro-coaxial cables

Because of the mentioned disadvantages of FPC cables in the high frequency range, micro-coaxial cables are often used in applications with high data transmission rates. In this comparison as well, the Y-FLEX represents a reliable alternative due to the above mentioned properties. Transfer standards such as PCIe Gen 4 (16 GT/s), USB 3.2 Gen 2 (10 Gbps) or eDP HBR 3 (8.1 Gbps) can be reached without any problems with Y-FLEX. In the latest measurements performed on the current Y-FLEX generation in combination with HF507 series FFC/FPC connectors (see Figure 1), data rates of 56 Gbps (PAM4) were even realised over a cable length of 100 mm.
Owing to the described manufacturing process (above all the precision etching and use of the LCP material as an insulator), the Y-FLEX has one very decisive advantage: it is 100% reproducible. This means that all conductive traces are completely identical and thus achieve unprecedented constant transmission characteristics over their entire lengths. In contrast, in a coaxial cable, the relationship between inner and outer conductors (see Figure 7: Micro-coaxial cable) differs along the cable due to the braid structure.

An even more decisive influencing factor is the assembly of the individual coaxial conductors on the connector at the end of the line. There may be length and thus signal runtime differences in individual lines here. The homogeneity is also negatively affected at the contact transition to the connector. Impedance fluctuations result. Exactly the same performance in each individual conductor is therefore not possible with micro-coaxial cables. The manufacturing process is also elaborate, for which reason the Y-FLEX technology especially has a cost advantage at relatively high volumes.



Actual spacing between inner and outer conductors. Clear difference in spacing visible

}X

Delta outer conductor to inner conductor = X

Outer conductor
Inner conductor

Ideal, constant spacing between inner and outer conductors

Delta outer conductor to inner conductor = O

Fig. 7. Multi-core micro-coaxial cable and cross section of single line

The development of highly reliable components with increasing complexity is – as already mentioned – steadily progressing. With new generations of electronic devices always having more extensive performance features, conventional technologies and manufacturing methods often run up against their limits. That's why the tried and tested Y-FLEX technology, based on the aforementioned advantages, is awakening ever more interest in many future-oriented companies in the electronics sector.
The company Rohde & Schwarz – technology market leader in fields including mobile radio and high-frequency measurement technology – recognised these advantages and uses Y-FLEX cables in numerous different products to bring their reliability and performance up to the highest possible level. Besides being used in the new 5G radio communication tester and different measuring devices, the Y-FLEX can be found in the R&S®QPS (Quick Personnel Security Scanner) from Rohde & Schwarz.

R&S®QPS Quick Personnel Security Scanner
The R&S®QPS is a security scanner that meets the need for a security check that is unobtrusive and uncomplicated for the person being scanned, but at the same time extremely precise and efficient. It consists of flat detection panels with several thousand transmitter antennas that emit extremely low-power millimetre waves one after another in rapid succession and the same number of receiver antennas that record information. The test person stands briefly between the detection panels with arms stretched out slightly to the sides (see Figure 8) [1].

Fig. 8: R&S®QPS Quick Personnel Security Scanner [1]

Use of the Y-FLEX

by EMC measurement technology market leader Rohde & Schwarz

The operator starts the scanning process via a touch screen and quickly receives the result for all types of potentially threatening objects displayed on it. Apart from advantages such as ease of operation, an open scanner with no chamber, outstanding body coverage and many more, minimal process times for maximum throughput was prioritised by Rohde & Schwarz. The extremely short scanning operation necessary for this requires fast data transmission.

Andreas Schießl, Security Scanner Hardware Development Manager at Rohde & Schwarz, explains the function as follows:

‘The QPS consists of two large detection walls, so-called panels. Each panel in turn contains 32 modules (clusters) with 96 transmitter and receiver antennas each. Behind each receiver is an analogue-to-digital converter that converts the analogue signals to digital signals. During the scan, the cluster buffers the digital signals. The fast digital data transmission between the modules and the central computer occurs via Y-FLEX cables, which connect the modules in series. After the scan, the modules transmit the data via the Y-FLEX chain to the central computer, which starts the data evaluation after less than 100 milliseconds and quickly transfers the result of the scan to the operator.’

Several gigabytes of data in total are transferred by the over 3,000 receivers in each panel per scan. To bring the data transmission rate and reliability at this extremely important point up to the maximum level with optimised manufacturing costs, Andreas Schießl’s development team considered several possible solutions. Richard Rasch, chief design engineer for the mechanics of the QPS, welcomes the flexibility of the Y-FLEX:

‘Through the use of the Y-FLEX, we can easily avoid mechanical tolerance problems that occur with the use of FPC or PCB solutions. Initial concerns as to the workability in manufacturing were also quickly dispelled. The manufacturing process is by no means more complex than for comparable flat cables.’

‘However, the electrical properties together with the competitiveness of the Y-FLEX made the difference in the end,’ Richard Rasch and Andreas Schießl agree.

‘With the Y-FLEX we achieve a data transmission rate of 12.5 Gbps per line pair over a length of nearly 400 mm in an electromagnetically challenging environment. Through the use of multiple Y-FLEX lines, we can solidly meet our extremely high demands on the transfer rate. In addition, the stable manufacturing process and the maximum reliability resulting from that – as well as much lower costs than with a micro-coaxial conductor solution – persuaded us to use the Y-FLEX,’ says Andreas Schießl.

Further markets for use of the Y-FLEX

Y-FLEX manufacturer Yamaichi Electronics sees the products in many other future markets apart from measurement technology. Autonomous vehicles stopped being a vision long ago. The installation spaces in the ECUs (electronic control units) are becoming tighter all the time. Where board-to-board connector solutions are not possible, the extremely flexible and reliable Y-FLEX can be used to ensure the best transmission characteristics.

Very high data transmission rates are needed in data networking, e.g. in the hardware for 5G radio network infrastructures. Specifically, the Y-FLEX is used in the so-called RRU (remote radio unit) between the main board and the antenna assembly. Because the RRU has to be suitable for outdoor use and able to withstand all weather conditions, the Y-FLEX offers a much higher stability and thus better electrical properties here than any conventional FPC with polyimide substrate as an insulating layer due to its hygroscopic properties.

In image processing, ever higher resolutions are placing ever increasing demands on data transmission. Moreover, specifically in the medical field, maximum stability during image transmission is essential and potentially life-saving. The Y-FLEX is already used here between the main boards and monitors of various image processing systems.

Christoph Prem, Sales and Marketing Director at Yamaichi Electronics, sees a bright future for the Y-FLEX technology:
‘We have been on the market since 1997 with the basic technology of the Y-FLEX. Market entry in Germany proved to be more difficult at first as the demands on the data rates in the first few years were by no means as high yet. So we are all the more pleased that the measurement technology market leader Rohde & Schwarz already recognised the outstanding technology of the Y-FLEX a few years ago and is now using them in a multitude of projects. Major companies and industry market leaders in markets other than measurement technology are also expressing great interest in the Y-FLEX. The product is attracting more and more attention due to its outstanding electrical properties, and the higher demands on data transmission in a wide variety of applications. We are certain that the Y-FLEX will find application in many different industries in the future.’

	Cable impedance control	Signal transmission and shielding	Mechanical loadability	Reliability	Costs
Y-FLEX	Impedance matching relatively easy Constant at high relative humidity	Very good attenuation at high frequencies Very high data rates Very good EMC shielding	Good bending properties Robust	Very stable production process 100% reproducible Simple installation into end product	Very inexpensive for high volumes Initial costs for special designs
Micro-Coax	Impedance matching very complicated for special values	Good attenuation at high frequencies Very high data rates Very good EMC shielding	Good bending properties Sensitive transition region to necessary cable connector	Sensitive production process Not 100% reproducible Simple installation	Expensive for high volumes Possibly low initial costs
FFC	Impedance matching very complicated and associated with high manufacturing costs	Poor attenuation at high frequencies Low data rates Very good EMC shielding	Good bending properties Robust	Sensitive production process Not 100% reproducible Simple installation into end product	Very inexpensive Possibly low initial costs Initial costs for special designs
FPC	Impedance matching relatively easy, not constant at high relative humidity because of moisture absorption by PI	Less good attenuation at high frequencies Medium data rates Very good EMC shielding	Good bending properties Robust	Very stable production process Reproducibility possible Simple installation into end product	Inexpensive for high volumes Initial costs for special designs

Fig. 9: Summary: Comparison of flat cables

List of sources: [1]: https://bit.ly/3n1M3Sn

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