ULTRA-THIN, HIGHLY FLEXIBLE RF CABLES

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Abstract – HiCoFlex is a technology for producing flexible multilayer substrates, resulting in foil-like circuits. The extension into high frequency applications, loss measurements on coplanar waveguides, extensions with LCP foils and benzocyclobutene (BCB) are described. Applications are very thin, highly flexible RF cables e.g. between submodules for telecommunication and opto-electronics.

1. HICOFLEX TECHNOLOGY

HiCoFlex is a new technology for producing flexible multilayer substrates [1]. The field has now been extended into high frequency applications. This opens the way to realize very thin, highly flexible RF cables and interconnections.
The HiCoFlex multilayer technology starts with rigid substrates, alumina or glass plates, which are used as a carrier during the multilayer build-up process and the assembly of components. First a thin 'release layer' is applied on these substrates. The multilayer is built up by repetitive application of polyimide layers by a spin-on process from the liquid solution and curing and metal layers by a sputtering and if needed enforced by galvanic deposition. Vias between conductor levels are opened by laser or plasma processing. Assembling and bonding of the components and tests of the circuits are possible while the film is still sticking on the rigid carrier substrate, avoiding handling problems. After that, the flex multilayer can be released from the carrier. This technology allows narrow and well defined lines and gaps (down to 10 … 20 µm) and vias of 30 µm. Actually circuits with up to 4 metal layers are realized. The total thickness of such a foil is around 50 µm. The minimum bending radius is smaller than 0.5 mm. It is even possible to fold the material without effect to the electrical properties. The results are highly flexible foil-like circuits with excellent mechanical and electrical properties.

2. RF CABLES AND INTERCONNECTIONS

In RF applications the narrow and well defined lines and gaps enabled by the thin film technology ensure a perfect high frequency performance. The aim of this work was to evaluate and qualify different polymers for RF applications. In this paper HiCoFlex coplanar waveguides based on polyimide and structures based on Liquid Crystalline Polymer (LCP) foils were compared. Losses were measured to verify the performance 20 GHz. Further tests with benzocyclobutene (BCB) are under test.

2.1. REALIZED RF TEST STRUCTURES AND POLYMER MATERIALS

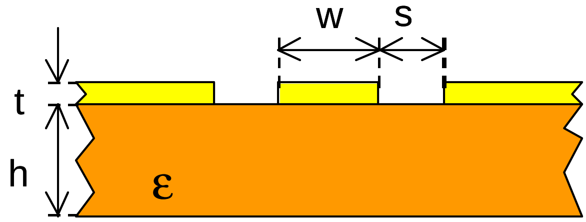

Fig. 1. Coplanar waveguide structure

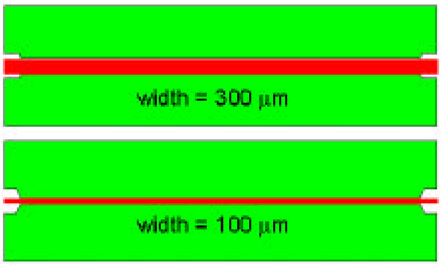

Fig. 2. Section of photomask for CPW

For the analysis coplanar waveguide (CWG) test patterns were use. Figures 1 and 2 show the profile and the layout of these patterns.

The polyimide PI 9161-15, a product of ALTANA (Beck Insulation), is applied by spin-on, drying and curing. The final layers have a low frequency dielectric constant of 3.1. The LCP foils, R/flex 3600, supplied by ROGERS Corporation, have a dielectric constant of 2.65 over a wide frequency range.
Dielectric thickness used in the samples were 20 µm for the polyimide and 50 µm for the LCP. The test patterns had conductor widths of w = 100 µm and 300 µm, the space between conductor and ground s is 20 µm. The conductor and ground metallisations were by 7 µm plated layer of Cu / Ni / Au. Figures 3 and 4 show pictures of the final flexible coplanar waveguide test samples.

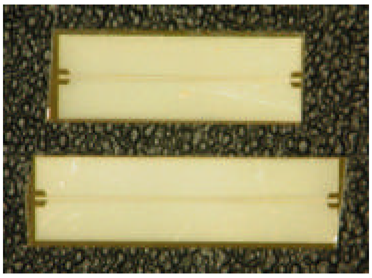

Fig. 3. Realized flexible coplanar waveguide test samples

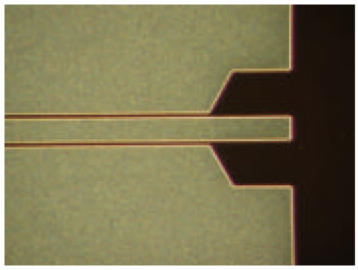

Fig. 4. Contact part of a realized coplanar waveguide with 100 µm conductor width.

2.2 RESULTS OF RF MEASUREMENTS

The measurements of the RF properties (losses, etc) of the test samples were performed in the RF laboratories of AVANEX. The terminations of the cables had to be cut to avoid harmful impedance changes. For serious results a careful contacting of the test structures needed much attention.
The measured S-Parameters are plotted in Figures 5 and 6 for the each kind of polymers.
The RF performance of PI 9161-15 (Fig. 5) is acceptable at least to 20 GHz with a bandwidth ≥ 20 dB. The results for LCP Rogers R/flex 3600 (Fig. 6) are similar.

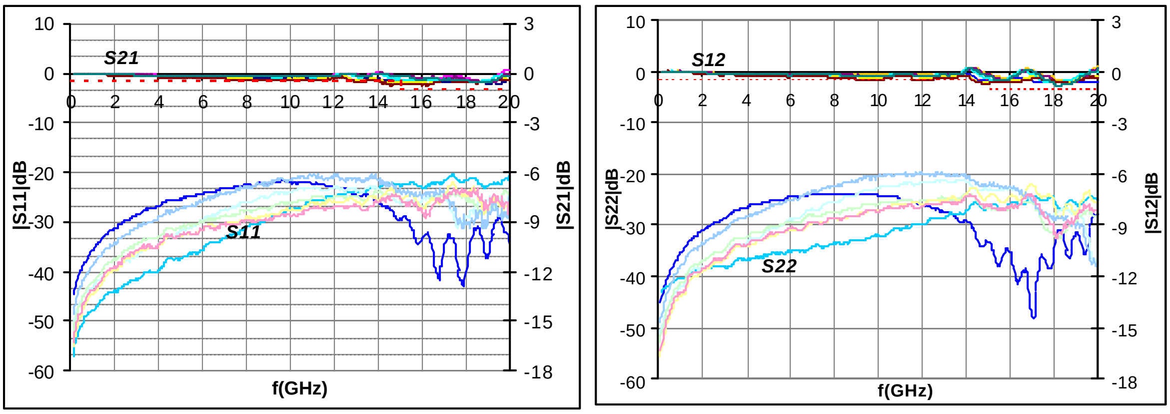

Fig. 5. S-Parameters measured for waveguides with the polyimide PI 9161-15, 14 samples of different length 4 … 7.5 mm, measured at 25°C

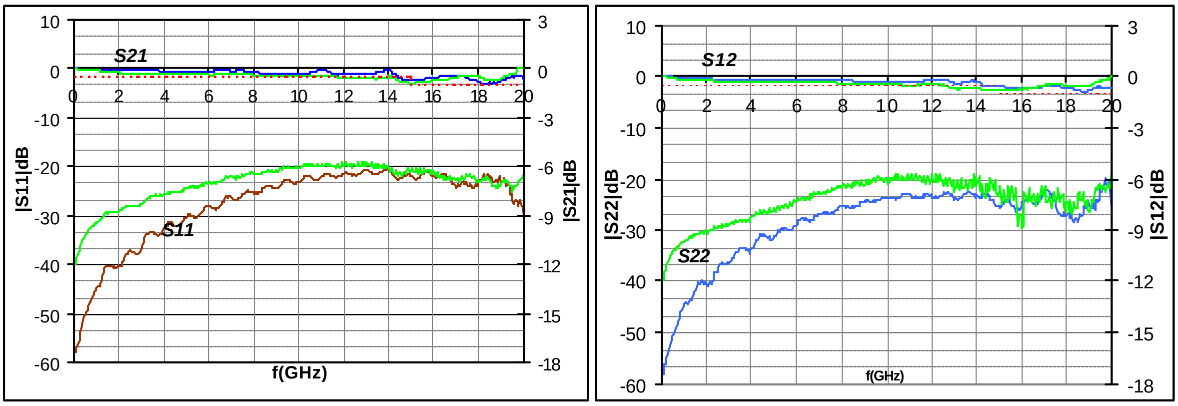

Fig. 6. S-Parameters measured for waveguides with LCP Rogers R/flex 3600, 10 samples of different length 4 … 7.5 mm, measured at 25°C. To get reasonable results the backside Cu of LCP foil had to be removed.

3. APPLICATIONS

Applications are in the fields of high density interconnect (HDI) technologies for sensors, industrial and medical microsystems, and newly also for high frequency interconnections e.g. between submodules for telecommunication and optoelectronics.

4. CONCLUSION

The RF measurements show clearly that the materials tested, the polyimide PI 9161-15 and the Liquid Crystal Polymer LCP Rogers R/flex 3600 are appropriate to RF applications until at least to 20 GHz. Loss measurements on coplanar waveguides show good performance at least to 20 GHz with a bandwidth > 20 dB, i.e. S11, S22 < -20 dB and S12, S21 > -1 dB.
RF structures with the polyimide PI 2611, with BCB and PI-BCB sandwich structures as dielectric material will follow later.

5. REFERENCES

[1] A. Fach, Y. Athanassov, U. Brunner, D. Hablützel, B. Ketterer, J. Link, „Multilayer polyimide film substrate for interconnections in microsystems“, Microsystem Technologies, Volume 5, pp. 166-168, 1999