An ultra-thin, highly flexible Multilayer

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Abstract – HiCoFlex is a technology for producing flexible multilayer substrates, resulting in foil-like circuits. This technology has recently been extended into the fields of high frequency applications and the integration of components, as thin film resistors, RF lines and structures and embedding of active chips. The advantages are higher miniaturizations, new ways of 3D packaging, more design possibilities and possible combinations with PCB. Additional solutions for foil-like circuits are by applying thin film techniques on commercial foils with suitable RF properties. Small foil elements with integrated passive thin film components or embedded active chips can be laminated into conventional printed flex-boards as local high-resolution part and connected to the wiring of the print. By this method expensive high-resolution features such as precision resistor arrays or RF structures in high frequency circuits, can be limited to the areas where they are needed. Other applications are very thin, highly flexible RF cables e.g. between telecommunication or opto-electronics sub modules.

1 HiCoFlex Technology and Properties

The HiCoFlex technology [1] 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 using a spin-on process from the liquid solution and curing and metal layers by a sputtering and if needed enforced by electroplating. 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 the handling problems. After that, the flex multilayer can be released from the substrate. The structuring technique allows line widths of 15 µm, spacing of 10 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, resulting in highly flexible foil-like circuits with excellent mechanical and electrical properties. The minimum bending radius is smaller than 0.5 mm. It is even possible to fold the material without effect to the electrical properties.

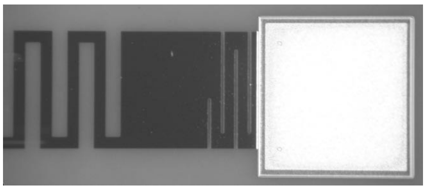
Highly flexible Multilayer assembled with SMD

2 Integration of passive components

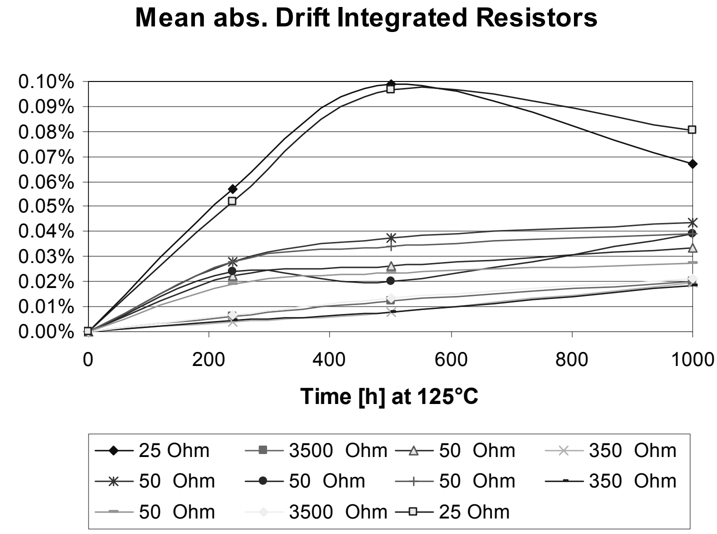
Integration of passive components, mainly thin film resistors, and embedding of active chips into HiCoFlex multilayers have recently been investigated. The advantages are higher miniaturizations, new ways of 3D packaging and more design possibilities.

Thin film resistors – Integrated resistor on polyimide (PI) were produced by standard thin film methods: Sputtering NiCr, photolithography, Ti/Cu/Ni contacts, annealing, laser trimming, protection by a further PI, release from the carrier substrate [2]. Test structures were analyzed by measurement of the resistance drift during PI curing (380°C peak temp), the temperature coefficient of resistance TCR, by a temperature life test for 1000h at 125°C, a humidity test for 1000h at 85% r.H. / 85°C and a bias of 18 VDC and a simple bending test.

Resistor foil elements



3500 Ω thin film resistor

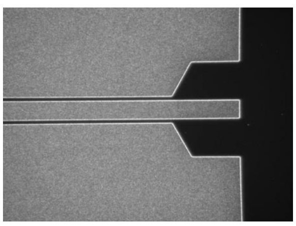


Temperature life test 1000 h at 125°C

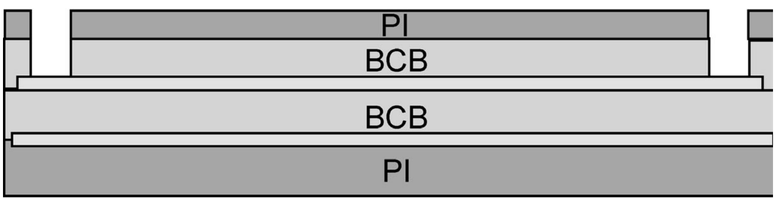
The evaluation showed that NiCr thin film resistors in a range of 10 Ω to 100 kΩ can be integrated into HiCoFlex, that laser trimming is possible and that the properties are nearly as on rigid alumina substrates. The test results are: TCR: -18 ± 8 ppm/°C; the temperature life test at 125°C, 1000h showed a drift < 0.1%; drift in the humidity tests after 1000h with 18 VDC is typically < 1%; the bending effect is typically < 1% for bending radius of 1.25 mm.

RF lines and RF structures - Narrow and well-defined lines and gaps enabled by the thin film technology ensure a perfect high frequency performance. This allows the realization of very thin, highly flexible microstrips, stripeline and waveguide structures for RF cables and interconnections.

One aim of this work was to evaluate and qualify different polymers for RF applications, e.g. Spin-on polyimides, BCB, Kapton, LCP and HyRelex (fibreglass fabric with PTFE coating). The handling of the foil-type polymers is described in the next chapter. BCB, well-known for its excellent RF properties, but due to the brittleness was not of use for detachable films. Only PI-BCB multilayers and PI-BCB-PI sandwiches make flexible films possible. LCP and BCB have the advantage of a low water uptake, an important point for high frequencies. Losses of coplanar waveguides were measured to verify the performance until 20 GHz. Polyimides and LCP showed to be acceptable, at least to 20 GHz with a bandwidth ≥ 20 dB.



Contact part of a flexible co-planar waveguide test samples



Multilayer sandwich PI-BCB-BCB-PI (Section along transmission line)

PI-BCB, PI-BCB-BCB and PI-BCB-BCB-PI multilayer sandwiches were analysed with a microstrip test pattern up to 40 GHz. The results indicate a good RF performance for this material combinations which is not susceptible to moisture and still very flexible [3].

Embedding active chips - First attempts to embed chips into HiCoFlex were encouraging. Embedding technique has been published by IMEC [4].

Thin Film on Foils - Alternative solutions are by applying thin film techniques on commercial foils, e.g. Kapton, Liquid Crystalline Polymer (LCP) or other polymers with suitable RF properties. Methods for temporary attachment of the foils on rigid carriers during the thin film coating and their detachment afterwards have been studied.

3 Lamination of foils with integrated thin film components into PCB

Small foil elements with integrated thin film components like resistors, RF lines and RF structures can be laminated into conventional printed flex-boards as local high-resolution part and connected to the wiring of the print. By this method expensive high-resolution features such as precision resistor arrays or RF structures in high frequency circuits, can be limited to the areas where they are needed. The concept has been proven by lamination of integrated chip foils into PCB [5]. Further test samples are under way.

4 Applications and Conclusions

Applications of HiCoFlex multilayers are in the fields of high-density interconnect (HDI) technologies for sensors, industrial and medical micro systems, 3D packaging, and recently also for flexible RF cables and high-frequency connections, e.g. between optoelectronics submodules.

The integration of passive components, as thin film resistors, RF structures, and embedding of active chips into HiCoFlex multilayers has been demonstrated. The resulting very thin and flexible Multilayer foils can be laminated into conventional rigid and flexible PCB as a local high-resolution part.

This work has been supported by the EU 6th framework program under contract 507352 SHIFT and funded by the Swiss State Secretariat for Education and Research SER, under project 03.0233.

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