ICAM2009
11th International Conference
on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25

Reliability of Ag Ink Jet Printed Traces on Polyimide Substrate

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Abstract – Printable electronics is a new emerging technology with capabilities of producing high volumes, low price and flexible electronic devices. Reliability is an important topic for the new technologies evaluation in order to enable the devices to the market. Printed samples were submitted to accelerated tests in order to evaluate traces reliability. It was possible to observe that samples with 1 and 5 layers have similar reliability in the 85/85 tests. Moreover, it was not possible to observe delamination in the samples submitted to cycling tests. Probably, the porous traces microstructure has a key influence in the reliability.

Printed electronics technology is an emerging technology. However, a number of questions, mainly related reliability of such devices are still pending. Reliability of electronic devices can be accessed through the use of accelerated life testing and degradation analysis [1]. In this sense, conductive traces printed through in ink jet method on flexible substrates can have its reliability estimated. Such analysis provides valuable information in order to allow the production of devices which utilized this technology [2].

In this paper, Ag conductive traces were printed on polyimide flexible substrate. After curing, the microstructure was analyzed through scanning electron microscope (SEM). Printed traces were submitted to two different environmental tests: 85/85 test (85ºC and RH 85%) and Thermal Cycling (-40ºC to 125ºC dwell time of 30 min and ramp time of 1h). The number of conductive layers printed was modified and these samples were grouped. A variation of 20% in the trace resistance was considered as a failure. In each group 36 samples were tested. Suspended samples were also considered in calculations.

For printed circuit boards the acceleration mechanism for reliability is a function of the thermal coefficient of expansion of the materials used in the device under test. The difference between the temperature extremes (ΔT) of the environment determines the stress introduced in the testes sample and the reliability that is exhibited. In figure 1 is possible to observe that samples with 1 and 5 layers have similar reliability after 85/85 tests. However, samples with 10 layers are much more reliable. Since there is no variation in the temperature the resistance variation might be connected to the trace degradation. It can be related to the porous microstructure of the printed and cured trace (figure 2). After the curing process, due to the liberation of gases a large number of porous were created. These porous could facilitate the corrosion process. Moreover, the variation in the reliability due to the number of layers probably is related to the induced oxidation of the surface and the depth of the oxidation effect since it is more significant in traces of 1 and 5 layers when compared to the 10 layers sample.

Figure 3 shows the reliability curve of samples which were submitted to thermal cycling tests. Since a variation in the temperature is induced, failures as delamination could be expected. After the performed tests, no visible delamination could be observed. However, it was observed a direct relation between the number of layers and the sample reliability. In this case, small cracks could be induced in the samples due to the induced thermal stress. These cracks can continually prejudice the trace conductivity, thus, inducing the electrical resistance increase and the sample failure.

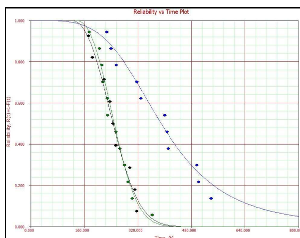

Figure 1: Reliability vs Time – 85/85 Tests- Blue, green and black lines, 10, 5 and 1 layer respectively.

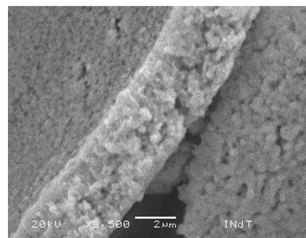

Figure 2: Trace microstructure after curing process.

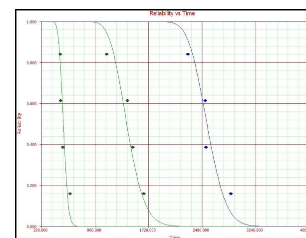

Figure 3: Reliability vs Time – Thermal Cycling Tests- Blue, green and black lines, 10, 5 and 1 layer respectively.

References

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