Microelectronics Reliability 49 (2009) 1196–1199

Contents lists available at ScienceDirect

Microelectronics Reliability

journal homepage: www.elsevier.com/locate/microrel

Lot reliability issues in commercial off the shelf (COTS) microelectronic devices

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ARTICLE INFO

Article history:
Received 26 June 2009
Available online 11 August 2009

ABSTRACT

Three cases will point out as entire lots of unreliable microelectronic devices may reach the final user, without any warning. The conclusion is a warning against the many risks introduced for more and more small and medium end users of microelectronic devices by the lack of reliability culture.

1. Introduction

In an old [1] and in a recent paper [2] the authors considered the reliability of the failure analysis reports themselves, and tried to highlight the many logical flaws that very often affect the "explanation" of an observed failure mode in terms of some physical failure mechanism. The cultural purpose of that paper was to bring some relief to the final customer of microelectronic devices, that, in the near totality of cases of failure analyses ordered to the device manufacturer or to external labs, is charged with any crime (EOS or ESD, usually) to explain why perfect devices failed in his hands. The practical aim, on the other hand, was much more cogent: a wrong failure analysis addresses the final user towards erroneous corrective actions, wasting time and money and not solving the root problem.

The present paper continues on the road of criticism, moving from the wrong failure analyses to the quality and reliability of the consumer electronics purchased off the shelf. Three cases will point out as entire lots of unreliable microelectronic devices may reach the final user, without any warning.

In one case, a nominally equivalent device of an obsolete and no more available component, produced by a different manufacturer, is shown to carry fatal packaging defects worth of the pioneer era of solid state electronics.

In the second, more subtle case, the last lot of a certain kind of obsolescent integrated circuits found on the market (and bought to complete the production of a set of equipments) resulted affected by extremely severe adhesion problems of the metal layers over the silicon.

In the final example, the formation of silver sulphide inside the package of a popular plastic packaged white LED opens the door to different scenarios, all critical from the reliability point of view.

The first, obvious conclusion of the paper is, once again, a warning against the many risks introduced for more and more small and medium end users of microelectronic devices by the lack of reliability culture: giving up with the incoming inspection and screenings, neglecting even simple tests, as the good old burn-in, renouncing to perform independent failure analysis to only trust in data sheets and commercial documents, all contribute to allow bad products to massively reach the production lines.

But the recent experience of the authors in the field of Reliability of Optoelectronics for Space applications forced the conclusions to include other hazard levels: extremely harsh environment and small commercial volume, typical of Space, jointly call for very well assessed commercial technologies, and then for the extensive use of COTS. In this case, the evidence for unscreened lots in the market foresees even the crash of a whole mission if a unjustified confidence is allowed, because of their assessed history, to any kind of COTS.

1.1. Case history 1

The production line of a multi-junction diode for high voltage application in the automotive field was concluded. The customer tried to find a proper substitute. The first choice was on a new product, of similar nominal performances, but it showed some early sudden failures upon few testing cycles. Failure Analysis demonstrated some surface discharges (Fig. 1), consistent with the corona effect, known as one of the typical failure mechanisms for such devices. Looking for better technologies (that for the specific device means smooth lateral surfaces, and perfectly aligned identical chips), another kind of devices was purchased, nominally equivalent to the previous ones.

The astonishing result, systematic over several specimens, is reported in Fig. 2: a completely uncontrolled stacking and packaging process led to a deeply misaligned column of silicon chips that even fractured during the soldering step of the metal contacts.

The focal point in this analysis is the simultaneous availability on the market of nominally equivalent devices, suitable to substitute the obsolete one, with such a difference in their quality. While the first choice (Fig. 1) showed a rather subtle failure mechanism,

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doi:10.1016/j.microrel.2009.06.042

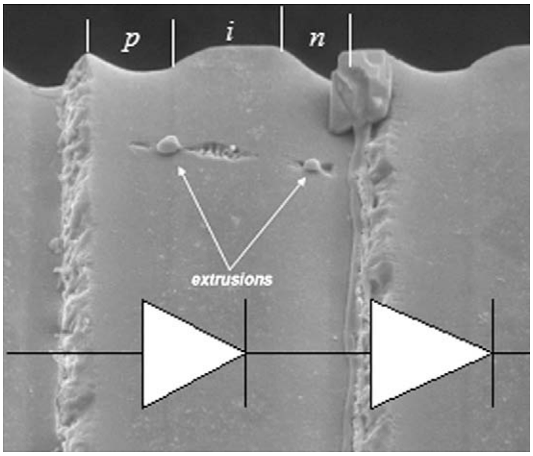

Fig. 1. SEM image of one element of the silicon diode stack, after removing the sealing glass by HF dip. A surface discharge occurred, coherent with the corona effect.

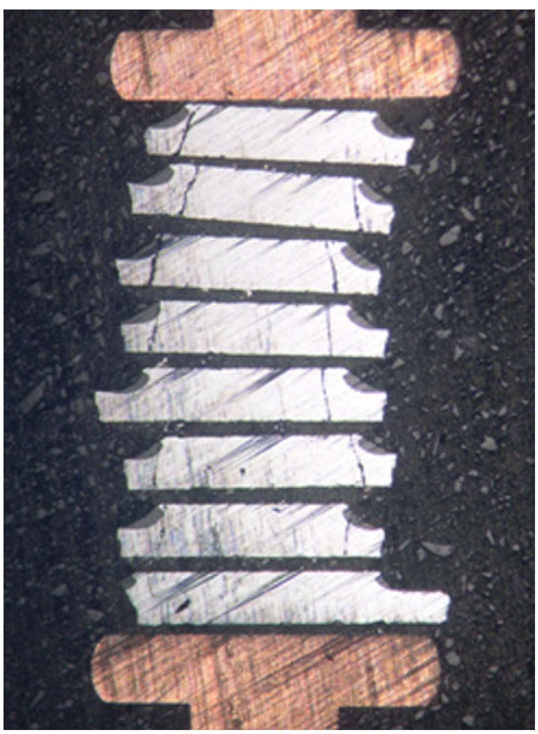

Fig. 2. Optical image of the cross-section of one of the diodes of the last choice. The misalignment and the cracked chips are evident.

not to be neglected even in well controlled technologies, the second family displayed so many troubles to lead to conclude that the lot has never been controlled.

1.2. Case history 2

Few years ago the physical mechanism, which leads to low and noisy signal (on board) of some RF amplifiers was investigated [3]. Some high performance laser scanner boards for sorting system applications failed after some regular life. Other boards of the same equipment did not pass the final electrical test (Fig. 3). The occurrence of board failures only when using specific devices purchased by a different supplier (hereby named B) than the usual one (A), but manufactured by the same company, suggested to investigate the possible weakness of the B type devices.

The detected instability on one side justifies the bad device performances, leading to the overall board failure. On the other side, it addresses the investigation towards contact interfaces (wire/chip, metal layers, metal/semiconductor), and calls for physical inspection (Fig. 4).

Lot weakness, handling or storage problems may be considered under suspicion.

It was the SEM inspection that showed the bad adhesion of the top metal layer (gold) over the barrier layer (tungsten), caused by imperfect deposition and patterning, as successively demonstrated by cross-sectioning some devices (Fig. 5).

Also for this case, even the most basic wafer-level lot qualification would have put into evidence the marginality of that product. Once again, it is its presence on the shelves that warns against the uncontrolled use of COTS.

Fig. 4. SEM images of a B type device: details show a very bad adhesion between gold and tungsten layers.

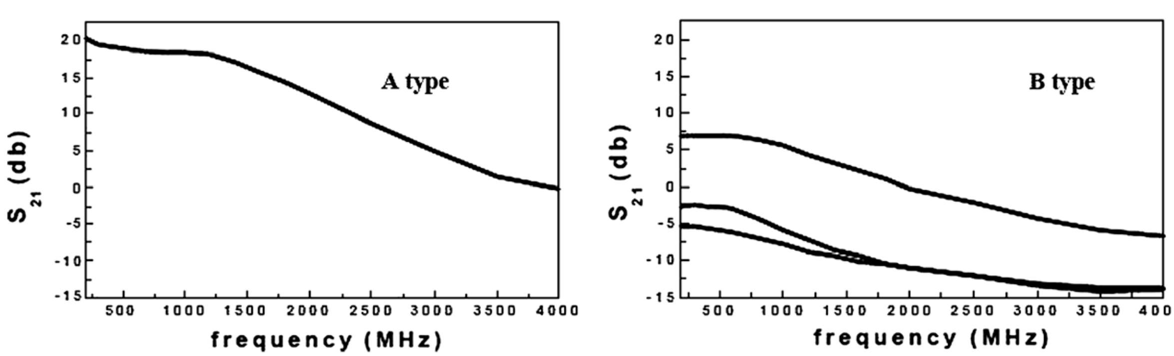

Fig. 3. Scattering parameter measurements on A and B devices.