Microelectronics Reliability 88–90 (2018) 26–30

Contents lists available at ScienceDirect

Microelectronics Reliability

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

Reliability concerns from the gray market

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ARTICLE INFO

Keywords:
Counterfeit electronics
Scrapped devices
gray market

ABSTRACT

With the term "counterfeit electronic components", we refer to electronic devices that are misrepresented as to their origin or quality. The greatest risks of using counterfeit parts are personal injury, mission failure and dramatic reduction of the reliability of a system and apparatus.

Reliability issues concerning counterfeit electronics will be considered because the severity of this problem is likely to increase in the near future.

We will highlight several examples as entire lots of unreliable microelectronic devices have reached the end user and only incoming lot inspection and screening procedures could have avoided a large number of field failures.

The conclusion is a warning against the lack of reliability culture for end users of microelectronic devices under-evaluating the higher risks due to the low quality and poor reliability of the consumer electronics purchased in the open market sources rather than from authorized markets.

1. Introduction

Some concerns over planned electronics obsolescence are related to the correspondent high production of e-waste. It represents an ethical and environmental issue specifically when it reaches the most impoverished areas of the world. It is a major source of human exploitation, pollution and counterfeit electronics [1].

The origin of the counterfeit electronics problem has been exemplarily explained in [2, 3], and how it is jeopardizing health, safety, security and why it is causing significant harm to the economy has been reported in [4]. Its risk priority arouse when some counterfeit devices were discovered on time in military systems, medical devices, radiation detectors, high-speed trains brakes and airport landing light system with a high risk to the safety of the people involved [5, 6].

In this context, the top cause of customer – attributable integrated circuit failures has been indicated in [6] as buying ICs from non - authorized sources basically because the origin and the history of components on the grey market are often unknown or at least unclear.

A wealth of information about visually inspecting components and some requirements and practices to mitigate the risks of purchasing fake electronic parts have been provided in [1, 7–11] because it is imperative that some processes are put into place to detect counterfeit before they get into the manufacturing [12].

Improperly testing, inaccurate handling, uncontrolled storing and counterfeiting manipulation (such as re-marking/re-topping, re-furnishing, re-packaging) significantly increase the risks of introducing reliability issues in terms of latent failures in electronics devices.

At the manufacturing level, a further aspect of the electronics obsolescence is that the production cycle of today's components could be very short, so many of the electronic devices could have a life cycle significantly shorter than the finished product, in that scenario the electron devices sold in the grey market with a low prices and immediate availability become very attractive even without real assurances about their quality and reliability.

Their past history is unknown, so there is no way to predict how long they are going to last, and their intrinsically weak presence could have an extremely negative effect on the system reliability.

It represents a serious problem for medical, military and aerospace industries that is likely to increase in the near future which poses a serious risk to public health and security.

Counterfeit components can be produced and distributed in several different ways. Apart from re-labelled and re-packaged devices, a rich source of material for counterfeiters is excess inventories and scrapped parts.

The quality of excess parts that reach the grey market, even if it was originally high, depends on storage conditions and handling procedures.

The scrap electronics is due to original component manufacturers (OCM) or distributors that discard huge amounts of scrap or obsolete products and test failures, that instead to be physically destroyed, reach the market. The scrapped parts include:

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https://doi.org/10.1016/j.microrel.2018.06.098
Received 31 May 2018; Accepted 27 June 2018

a) manufacturing defects such as e.g. absence of the die, lifted wire bonds, missing or no bond wires, damaged terminations.
b) devices which failed quality checks and other screening tests.

Unlike the majority of literature written about counterfeit electronics which are more focused on counterfeiting manipulation, this paper talks about over-production or rejected devices not destroyed but re-introduced and sold “as is” in the market through the broker chains.

2. Case histories

The proposed examples point out as entire lots of unreliable microelectronic devices may reach the end user, without any warning nor control.

In these cases where visual inspection method, marking permanency tests and x rays analysis are useless, the common user fault is that incoming lot inspection, technology characterization validation or at least screening procedures (possibly followed by physical analysis of the failed items) could have avoided a large amount of field failure returns. In some cases even only an electrical measurement could have recognized the fake component.

Many factors contributed to these field returns: obsolescence, lead time, costly inspection/testing procedures, lower prices, the absence of origin verification tools.

2.1. RF amplifiers

The occurrence of laser scanner board failures only when using specific devices purchased by a broker (hereby named B) than the usual supplier (A), but manufactured by the same firm, suggested investigating the possible weakness of B type devices [13].

Regular measurements were obtained on A devices. When B devices were tested, the measurements showed totally unstable, sometimes even attaining negative gain values (Fig. 1).

The detected instability on one side justifies the bad device performances, leading to the overall board failure. On the other side, it addressed the investigation towards contact interfaces (wire/chip, metal layers, metal/semiconductor), and calls for physical inspection Lot weakness, handling or storage problems were considered as possibly responsible.

A cross- section was performed in order to investigate the device structure.

The SEM inspection showed the bad adhesion of the top gold layer over the barrier tungsten layer, caused by imperfect deposition and patterning.

The bad metal adhesion in the thin transistor metal fingers is reported in Fig. 2 and can easily explain the noisy performance.

Many indications point towards the weakness of the Ti/W/Au triple metal system, focused on the quality of the W/Au interface.

The root cause for the observed degradations has been identified in bad processing, and then in a weak lot, brought into evidence also for a different plastic package. Long-term storage under uncontrolled conditions possibly worsened the situation, anticipating the unavoidable failure even before the beginning of the operational life of the devices.

These salvaged scrap RF amplifiers were able to reach the field without any electrical measurement.

2.2. Red LEDs

Some GaP/GaAsP LEDs in standard transparent plastic package failed after some accelerated life tests. The Failure Analysis started with the technological characterization of a virgin device. In Figs. 3 and 4, optical images of a cross-sectioned LED show a very bad adhesion of the upper metal contact. This is the cause responsible for the open circuit showed at the end of the life test. The SEM picture (Fig. 5) shows the gold bond lifted-off after the plastic package removal in a failed device.

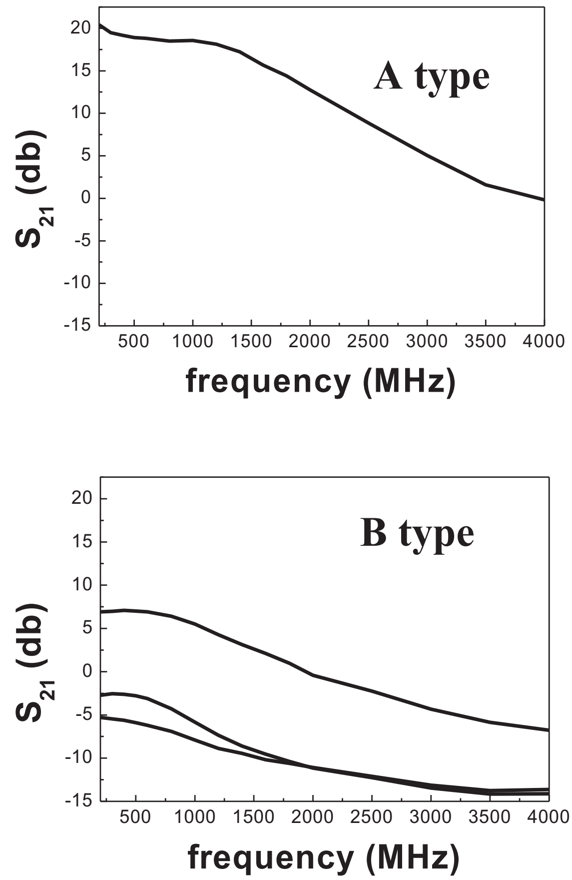

Fig. 1. S21 Scattering parameter measurements on A (good) and B (bad) RF amplifier. The measurements performed on B type devices showed high instability and negative gain.

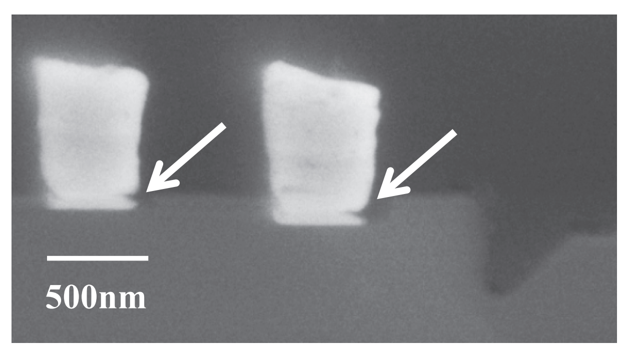

Fig. 2. SEM cross-sectional view of a detail of the metal fingers. Arrows point at the incomplete metal coverage responsible for the observed failure mode.

A lot qualification would have put in evidence the marginality of that product avoiding is availability in the market [13].

2.3. GaAs power amplifiers

A FIB cross-sectional view of the gate of a GaAs power amplifier is proposed in Fig. 6. The SEM picture shows such fatal technological defects worth of the pioneer era of solid-state electronics.

Improper adherence, catastrophic alignment and unusual voids are evident. The device reached the market and failed immediately in a field application.