CASE STUDY

Radar IC Manufacturer Cuts Testing Time in Half, Regardless of Elevated Temperatures, Using InfinityQuad Probes

Overview

Probing high pad count integrated circuits (ICs) in order to verify functionality has always been a challenge. As the number of on-chip connections increases and pad size gets smaller, this is becoming increasingly difficult, and nowhere is the challenge harder than when testing complex consumer RF devices. There, the need to minimize cost drives die size, and along with it, pad size, as small as possible, and functional tests need to be done reliably and with repeatable accuracy, as quickly as possible. To meet these needs requires a rethinking of how device probing is accomplished and the development of a fundamentally new component probing technology.

"We now have confidence that all the probes will make excellent contact each time a device is probed and at all temperature points," said Stefan Matzinger, Manager of the Components Verification Group at DICE.

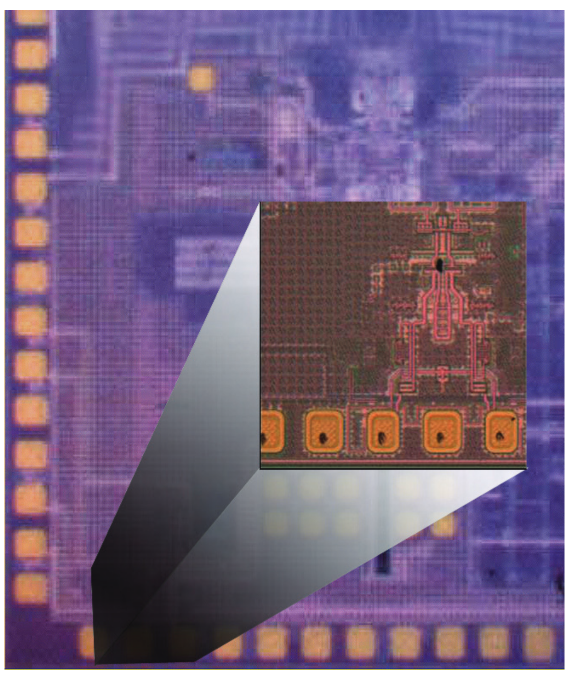

FIGURE 1. The automotive radar IC manufactured by DICE of Linz, Austria is 80 x 80 µm with up to 100 pads.

Danube Integrated Circuit Engineering (DICE) GmbH & Co KG of Linz, Austria provides a case in point. This company makes mmW receiver/transmitter ICs for automotive collision avoidance radar applications. Unlike cell phone RF front-end chips which typically have relatively few connections to the outside world, the circuits that DICE makes can have close to 100 connections surrounding a 5 mm^2 die, with up to 25 mixed-signal contacts per side. Chip cost constraints limit the size of the pads to just 80 µm x 80 µm as shown in the die photo (Figure 1).

Problems with conventional needle probes

The small pad size and high operating frequencies of these devices pose difficult challenges for test managers and the designers of probe solutions. Conventional probes using needles and coaxial probe tips (Figure 2) don't have the accuracy to land on ultra-small pads exactly the same way each time. Needle probes can be bent or misaligned, causing issues with the planarity and positional accuracy of the probe tips.

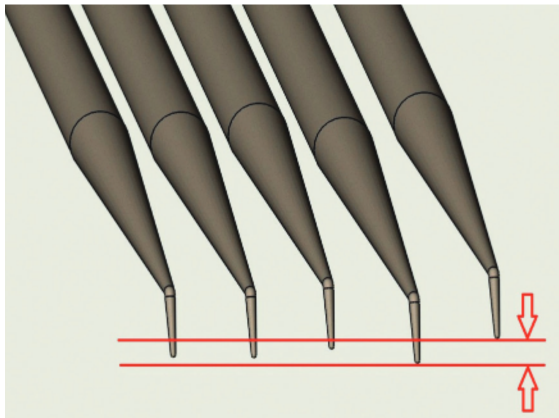

Figure 2. *Conventional probe needles have planarity errors which cause excessive skate on the first probe to contact the pads.*

Needle probes don't contact the circuits in an identical way from die to die and hence the test results can vary. Probes also expand and contract as the temperature changes (the automotive radar circuits that DICE manufactures are tested up to 125° C). The lack of precision and repeatability in probing can impact yields as good devices can get wrongly rejected.

Needle probes also pose testing problems in working with complex RF circuitry due to lack of impedance control. Probes with poor impedance control and shielding can have unwanted loss and act like antennas, generating interference on the signals on adjacent probes, affecting the accuracy of the testing process. In fact, older multi-contact probe technologies, even when using coaxial probes, are typically limited to handling signals up to a few GHz. The radar ICs that DICE manufactures operate at significantly higher frequencies (77 GHz).

The InfinityQuad probe is manufactured with a thin-film photolithographic process where a nickel alloy is deposited in pad patterns as small as 8 µm long by 12 µm wide (see Figure 3), with positional accuracy to within 1 µm and excellent planarity across all probe tips.

The ability to probe small pads using conventional probes can also be affected by the inability to penetrate the layer of oxidation that forms on aluminum pads. Most consumer products use aluminum pads. To break through the oxide, probe tips are commonly “scrubbed” on the pad surfaces and the resultant damage to the pad allows for good contact between the probe tip and the pad metal. If the probe tips are large in size compared to the pads that they are probing (it is common for a tungsten needle probe to have a tip diameter of 20 µm and for an RF probe tip to have a diameter of 40 µm) the pads can receive excessive damage during the probing operation. In addition, if a lot of scrub is required to achieve a good probe connection, the chance of the probe tip skating off the pad is increased.

An additional problem with conventional probes with multiple needles is that the needles have to “fan out” in order to get many contacts into a small area. This fanout creates a tendency for the probe needles to skate at an angle at the extremities of the probe array in respect to the forward skate in the center of the probe. This also limits how small the pads can be and still be probed reliably without excessive damage.

Because of the problems with conventional needle-probing technologies, manufacturing engineers at DICE were initially forced to test their radar ICs manually in order to ensure that the pads were contacted correctly. This process was time consuming and, because the process wasn't automated, there was the possibility of errors being made that could impact product yield (good ICs might be damaged or judged to be bad due to imprecise testing). So, DICE manufacturing engineers looked for a better solution.

Solving the RF probing problem

DICE found a better alternative to conventional probes in the InfinityQuad™ probe technology developed by FormFactor. InfinityQuad probes have monolithically fabricated tips that can be precisely and reliably brought into contact with the pads on a die to improve test yields and speed up the testing process.

> *The InfinityQuad probe system can handle frequencies up to 110 GHz and since all probe tips are monolithic, the side skate problems that come with using discrete probe needles are eliminated. InfinityQuad probes are designed with the durability to handle more than 250,000 touchdowns without degrading in performance.*

The InfinityQuad probe is manufactured with a thin-film photolithographic process where a nickel alloy material is deposited in pad patterns as small as 8 µm long by 12 µm wide (see Figure 3), with positional accuracy to within 1 µm and excellent planarity across all probe tips. As a result, InfinityQuad probes can be used with pads as small as 30 µm wide and 50 µm long –in automated over-temperature testing - and provide plenty of pad area margin in the case of the 80 µm x 80 µm pads used in the DICE ICs.

InfinityQuad probes use microstrip transmission lines to the probe tip (Figure 4), which helps minimize probe-to-probe electrical interference and enables high signal density. This is due in part to the electromagnetic field that surrounds the probe tips being better defined than is possible with high-density discrete needle probes. The InfinityQuad probe system can handle frequencies up to 110 GHz and since all the probe tips are monolithic, the side skate problems that come with using discrete probe needles are eliminated. InfinityQuad probes are designed with the durability to handle more than 250,000 touchdowns without degrading in performance.

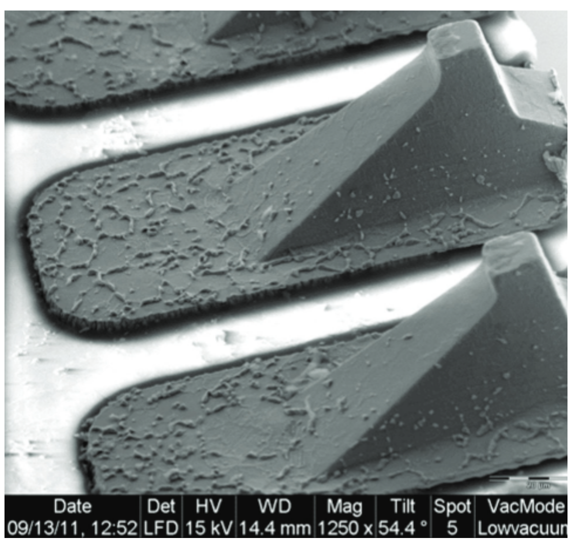

Figure 3. InfinityQuad probe tips manufactured by FormFactor are formed with a photolithography process and can be as small as 8 µm long and 12 µm wide.

InfinityQuad probes are constructed from pre-fabricated polyimide coupons containing the probe tips which are configured to a customer's unique application. Probes with up to 25 contacts, with pitches down to 75 µm, can be built with a lead time of two to three weeks.

DICE reduces test time, improves repeatability

The superior mechanical and electrical performance of InfinityQuad probes enabled DICE to test its ICs in half the time compared to the use of conventional probes. In addition, temperature sensitivity, which previously impacted probe accuracy, has been eliminated. "We now have confidence that all the probes will make excellent contact each time a device is probed and at all temperature points," said Stefan Matzinger, Manager of the Components Verification Group at DICE.

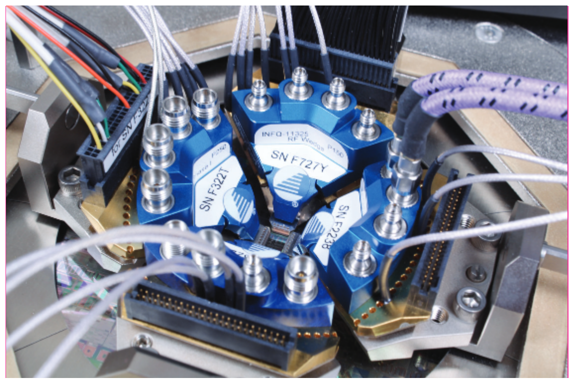

Figure 4. InfinityQuad probes have a common set of tips that can be configured by FormFactor to meet the needs of many probing applications, and with a short delivery time.

With the continued drive to smaller wireless devices and the push to develop more automated consumer systems that use radar, the usage of RF circuitry will continue to grow. In addition, the functionality of ICs will continue to increase as companies combine RF, digital logic, and power control on the same components to produce "systems on a chip." These trends will drive the need to further reduce the cost of manufacturing RF and hybrid components while maintaining high reliability.

InfinityQuad was designed to meet today's testing challenges, and as IC designers are driven to provide advanced circuitry in even smaller packages (already some are designing using 50 µm X 50 µm pads), probe technologies need to advance to meet their needs.

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