Optimizing the Incoming Inspection of Semiconductor Devices

Application Note 4156-6

Agilent 4155C/4156C Semiconductor Parameter Analyzer

Introduction

At present, incoming inspection and quality assurance inspection of semiconductor devices is extremely time consuming due to the need to inspect a large number of different devices. It is therefore desirable that the process be automated to save time. Moreover, the results are often different depending on the individual conducting the tests and it is desirable that these differences be eliminated to raise the reliability of the results and increase their consistency. This application note describes the inspection of a MOSFET and shows how use of the Agilent 4155C/4156C semiconductor parameter analyzer allows the user to conduct incoming inspections with greater efficiency and productivity than when using conventional methods.

Conventional Testing Methods

Conventionally, incoming tests of semiconductor devices have been conducted using one of the following methods:

• The characteristic curve of the device is measured and the operator conducting the test decides by a visual inspection whether part of the curve lies within the acceptable range, or

• The characteristic curve of the device is measured, markers are moved manually to read current and voltage values or a line is drawn on the curve, then major parameters such as threshold voltage are extracted and compared with specifications, or

• The above operations are programmed into a computer and the process from parameter determination to judgements is automated.

However, with visual inspection and manual operations, parameter extraction and go/no-go evaluations take time, and the results of inspection vary depending on the operator conducting the test. To improve the reliability of results and shorten testing time, there is a tendency to rely on experienced operators. Where computers are used, creating a program that will extract parameters, taking measurements, and subsequently changing the setup is a time consuming and troublesome process. So, there is a need for a testing environment that is easily operated and facilitates the creation of test programs and changing of settings.

Where large volumes of test data must be subjected to statistical analysis, it is common to use a PC. But with conventional testing environments, a special conversion program is required to convert the data into a format that can be read by the PC. The creation of this conversion program is one factor in improving the efficiency of inspection processes.

Agilent 4155C/4156C Improves Inspection Efficiency

The following features of the 4155C/4156C allow you to automate and raise the reliability of the inspection process:

• "Auto Analysis Function"[1] allows automatic extraction of a full range of parameters. The system eliminates the manual moving of markers and drawing of lines, allowing significant reductions in testing time and eliminating differences due to the operator conducting the test.

• A graphical user interface lets the operator set up measurements and enter automatic analysis settings. Setup files can be saved on diskette or in internal memory and recalled using an Agilent Instrument BASIC program running on the built-in

controller. This greatly facilitates the creation of test programs and changing of settings in comparison with conventional computer-based systems. Tests can also be conducted fully automatically using only the 4155C/4156C, without the need for an external controller.

• The drive built into the 4155C/4156C makes it easy to store test results on DOS format diskettes. Data stored in this way can be read directly by statistical analysis software for PCs such as Microsoft® Excel and Lotus® 1-2-3®, allowing the user to perform complex statistical analysis of test results.

Example of Automatic Go/No-Go Test for Incoming Inspection

We will now describe an example of automatic go/no-go test for an incoming inspection test. Using an Instrument BASIC program running on the Agilent 4155C/4156C, it is possible to create various test screens as well as a measurement screen. The example in Figure 1 shows a selection screen used to select the device to be tested. The operator uses a softkey to select the device to be tested.

Here we will use softkey (1) to select MOSFET. The next screen, as in Figure 2, shows the prerecorded measurement parameters for the MOSFET (Vth, BETA, Rdson and Gm) and the upper and lower limit values for each of these parameters. In this example, once the device is connected, you need only press the NEXT softkey to extract the above parameters using the "Auto Analysis Function" and
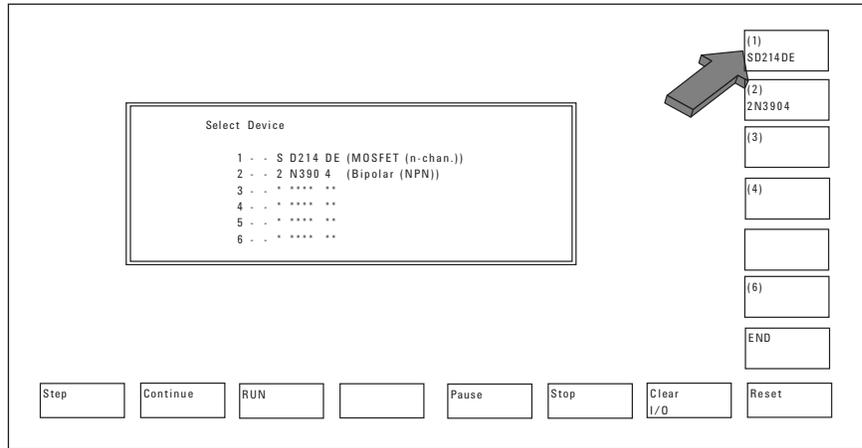

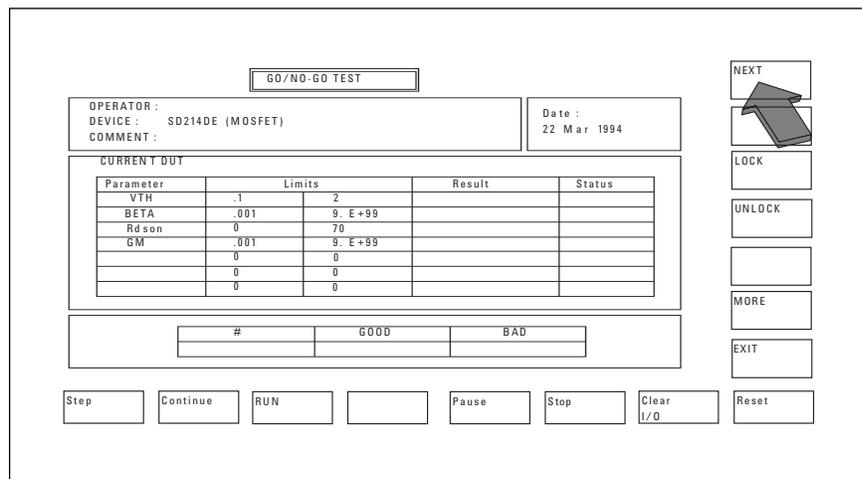**Figure 1. Example of a Test Device Selection Display**
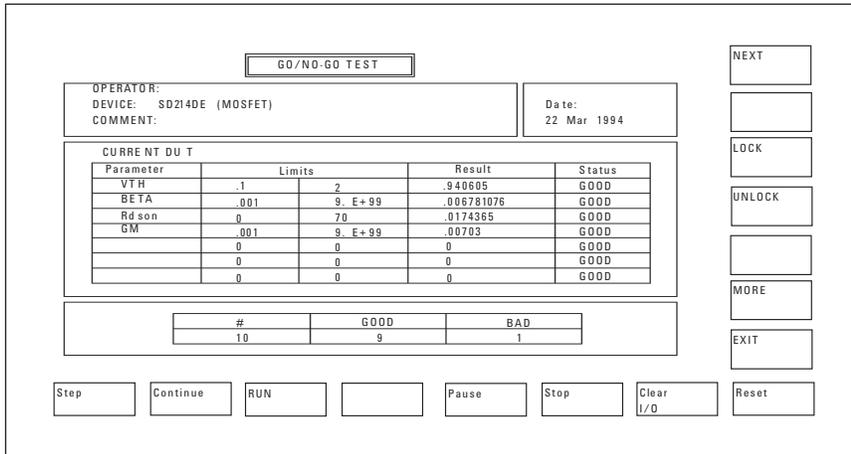

Figure 2. Example of a Go/No-Go Evaluation Test Display

Figure 3. Test Results

Figure 4. Example of Threshold Voltage Measurement

display the values in the Result column as shown in Figure 3. Moreover, the program automatically determines whether these values are within the upper and lower limits of the relevant parameter and displays the result of its evaluation in the Status column.

The test is performed using a setup file which already contains the relevant settings, and the go/no-go test is performed at the touch of a softkey, relieving the operator of all decisions based on manual and visual operations.

While the test is in progress, it is possible to verify not only parameter values and decision results but also the characteristic curves and the analytical process itself. To do this, you need only call up the measurement screen shown in Figure 4. This example shows the characteristic curve plotted to extract the threshold value. If the results of the go/no-go test are consistently "BAD," this screen allows you to display the characteristics in graph form and guess the cause of the problem. In this way, the 4155C/4156C allows you to perform efficient incoming inspections via simple softkey operations.

Finally, after the test is completed, the data can be saved to a DOS format diskette in the built-in drive. The data can then be read directly by a PC and processed using statistical analysis software without any need for format conversion. Figure 5 shows one example of data read directly in this way and subjected to statistical analysis using Microsoft Excel on a PC.
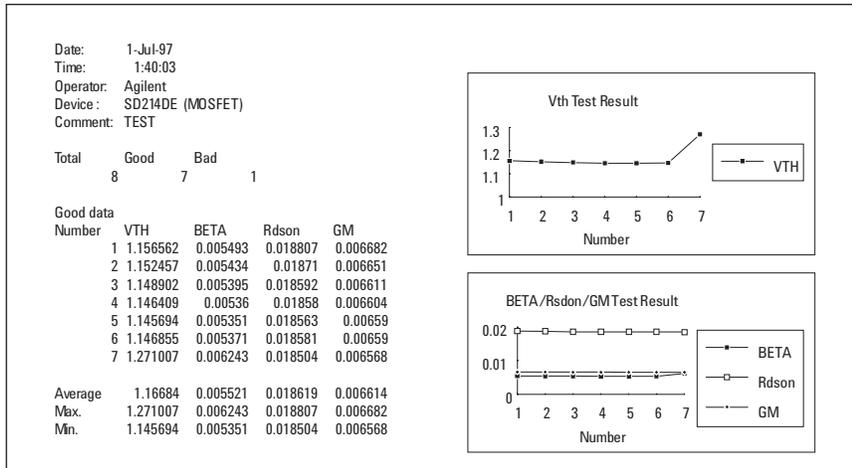
```
Date:       1-Jul-97
Time:       1:40:03
Operator:   Agilent
Device :    SD214DE (MOSFET)
Comment:    TEST

Total       Good        Bad
    8           7           1

Good data
Number  VTH         BETA        Rdson       GM
    1   1.156562    0.005493    0.018807    0.006682
    2   1.152457    0.005434    0.01871     0.006651
    3   1.148902    0.005395    0.018592    0.006611
    4   1.146409    0.00536     0.01858     0.006604
    5   1.145694    0.005351    0.018563    0.00659
    6   1.146855    0.005371    0.018581    0.00659
    7   1.271007    0.006243    0.018504    0.006568

Average     1.16684     0.005521    0.018619    0.006614
Max.        1.271007    0.006243    0.018807    0.006682
Min.        1.145694    0.005351    0.018504    0.006568
```

Figure 5. Example of Data Processed Using Microsoft Excel

Conclusion

As described above, the Agilent 4155C/ 4156C allows the operator to conduct incoming inspections of semiconductor devices entirely by simple softkey operations and removes the need for experienced operators and for complex programming of external controllers. It not only allows major savings in testing time but also eliminates differences due to the operator conducting the test and improves the reliability of test results dramatically. An Instrument BASIC program running on the built-in controller also allows you to control external instruments via Instrument BASIC. So, you can automatically test large numbers of devices by using handlers with 4155C/4156C.

Note: The information contained in this application note is also applicable to the Agilent 4155A/4156A and Agilent 4155B/4156B.

1. For a detailed explanation of "Auto Analysis Function," see *Application Note 4156-2, Automated Extraction of Semiconductor Parameters Using the Agilent 4155C/4156C* (Agilent pub number 5963-1249E).

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