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IC-CAP WaferPro: A New Software Environment for Automated DC/CV and RF Measurements in IC-CAP

White Paper by
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Introduction

Accurate DC/CV (and RF) statistical modeling of CMOS devices requires collecting a significant amount of measured data from different wafers across several temperatures. DC and RF device modeling teams must adopt a modeling flow that includes a sophisticated automated measurement solution and efficient data handling capabilities to support advanced statistical analysis and modeling (Figure 1). Automated measurement software must combine the ability to drive probers, switching matrixes and thermal chucks according to a predefined wafer map, with the ability to run complex DC/CV and RF measurements using a variety of instruments—from parametric testers to single box instruments. Furthermore, measured data must be processed upon measurement to calculate Electrical Test (ET) data, such as V_{th}, I_{dmax}, or f_T.

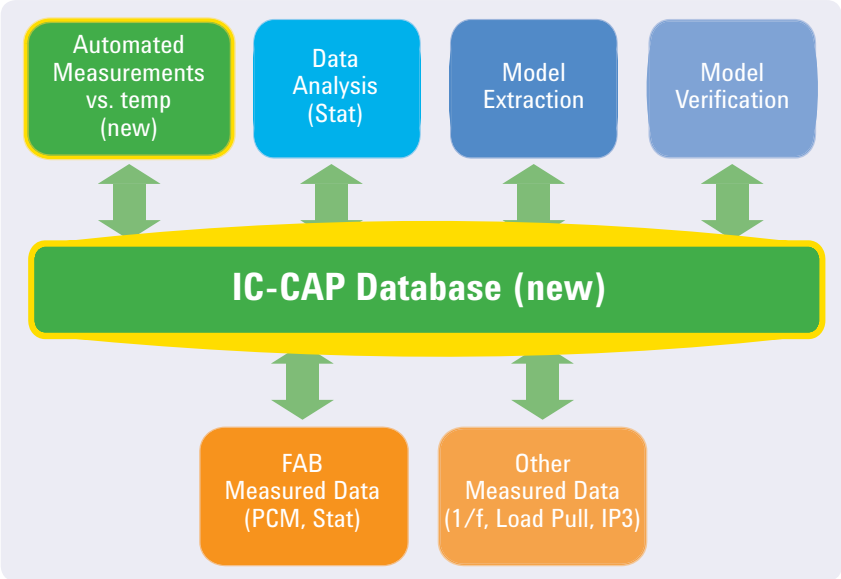

Figure 1. Typical device modeling flow

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Background

Modern software prober solutions can handle prober positioning, alignment and temperature control very efficiently, but lack the flexibility to support a customizable measurement library and complex post process data calculation and analysis.

Agilent Technologies is introducing a new turn-key DC/CV and RF automated characterization solution to help modeling and device engineers achieve more efficient on-wafer measurements across temperature. This breakthrough solution is based on the Integrated Circuit Characterization and Analysis Program (IC-CAP) modeling software and efficiently controls DC/CV analyzers, network analyzers, probers, switching matrixes, and temperature chucks, as well as the powerful 407x and 408x Series of Agilent parametric testers. The newly designed solution is called IC-CAP Wafer Professional (IC-CAP WaferPro).

IC-CAP WaferPro is integrated into the IC-CAP platform and takes advantage of its powerful measurement and programming environment to enable a custom library of efficient measurement routines (e.g., adaptive measurement algorithms) that can greatly reduce the overall measurement time. Since the measurement routines are in the IC-CAP environment, either simple or complex post processing (such as calculation of spot measurements or figures of merit, RF deembedding and direct extraction), can be applied to measured data before data is saved. This paper shows a preview of the capabilities provided by this innovative solution that will be released with IC-CAP 2010.08.

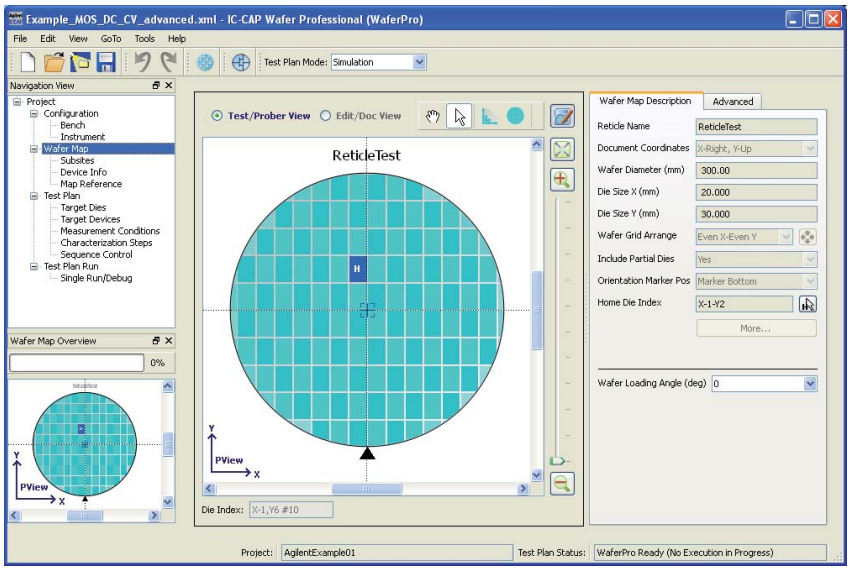

Figure 2: The WaferPro Project Window (wafer map definition)

Device Modeling Measurement Challenges

Measurements for device modeling are generally more accurate, extensive and therefore more time consuming than production-like measurements. Where it may be sufficient for production tests to probe process control monitors and do single point spot measurements, in order to characterize how the device model varies versus temperature, both swept and spot measurement tests must be done for several temperatures (typically 3). For a typical MOS process, acquiring data across a wafer lot at each temperature requires measuring several geometries, capacitance and diode structures, and may take several hours. The wafer/prober re-alignment after a change of temperature is particularly challenging due to wafer thermal expansion in all directions (including z). Unless sophisticated algorithms using pattern recognition technology can be applied to automate the proper re-alignment, manual intervention is usually required to re-align the prober at each temperature.

With measurement taking several hours, or even days, it is important to be as efficient as possible, without compromising measurement accuracy. Measurement control software must work in conjunction with the prober native control software, as well as each instrument, to allow automated measurements across temperature. To maximize efficiency and avoid measuring bad devices or die, the software should also be able to run check tests verifying device and die integrity, and then based on the test results, decide whether to continue, skip the current device or die, or stop the measurement completely. Additionally, it is important to have the ability to monitor results during test plan execution, to spot any failure conditions that are reported.
Since this extensive collection of data is then analyzed to statistically identify the "typical" set of devices that will be used for modeling extraction, it is necessary to efficiently manage and analyze large quantities of data.

IC-CAP WaferPro Benefits

The W8510 IC-CAP WaferPro was designed in partnership with the device modeling team at ST Microelectronics and represents a solution to real characterization needs. WaferPro runs on the IC-CAP platform as add-on product. The newly designed WaferPro project window, as shown in Figure 2, lets users define and manage the test plan which includes wafer map and device information. WaferPro links to the core IC-CAP program and utilizes built-in IC-CAP measurement drivers, as well as its simulation, programming and graphics engines.

IC-CAP WaferPro runs fully automated measurements on semi- and fully automated probers, and includes drivers for several popular probers.

As previously mentioned, parametric testers such as the Agilent 407x Series coupled with automatic prober re-alignment supported by major prober vendors are key to efficient automated measurements across temperature. IC-CAP WaferPro provides the ultimate flexibility to support direct control of Agilent parametric testers, as well as simpler single instrument bench setups (e.g., B1500A + B2200A). Unlike other software, which may be limited to a specific test station or type of prober, once the WaferPro test plan or project file is defined, the program can drive different test stations composed of different DC and RF instruments. This allows engineers to optimize lab equipment usage.

IC-CAP WaferPro is a turn-key solution that includes a variety of DC/CV and RF measurement routines built into the IC-CAP environment. Thanks to IC-CAP's open and powerful environment, it is easy to add custom routines or user-defined calculations of figures of merit (e.g., V_{th} for MOS DC or f_T for RF measurements).

While executing the test plan, IC-CAP WaferPro conveniently saves calculated values or spot measurements to .csv files along with device information (Figure 3). Swept measurement data, such as I-V, CV or S-parameter curves, are saved to IC-CAP MDM data. Furthermore, WaferPro can be used to monitor the actual measurement, to analyze and verify the so far obtained measurement results, while it continues measuring. Measured data can be loaded back into the WaferPro environment for further post-processing (e.g., applying capacitance calibration, etc.).

WaferPro will also be IC-CAP Database enabled. When the new IC-CAP Database link is available, it will allow saving measured data directly to a specified SQL relational database. This represents a powerful and versatile data handling solution for further post-processing and statistical analysis, as it enables the efficient data query necessary for data analysis and other modeling activities (e.g., target modeling).

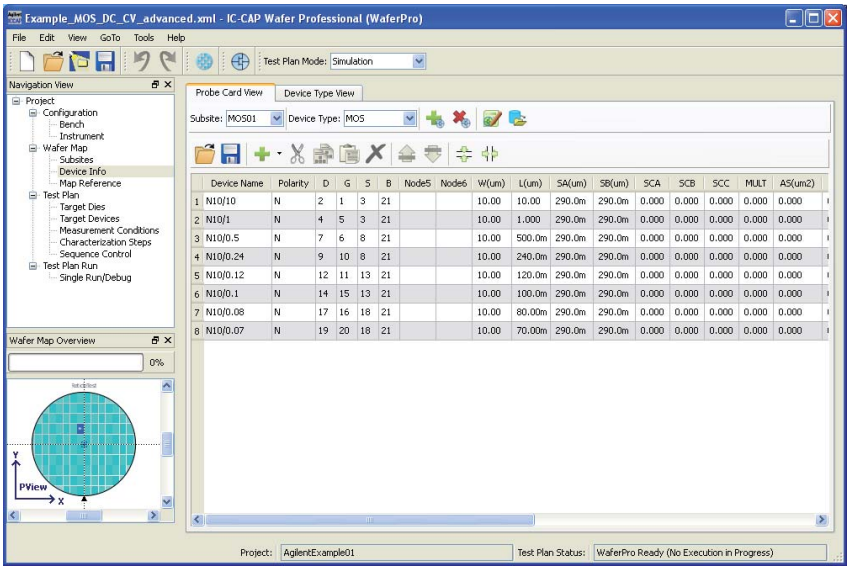

Figure 3: WaferPro Device Info Table (probe card view)

How IC-CAP WaferPro Works

The new measurement environment includes two IC-CAP model files (Routine and Driver) and the new WaferPro test plan manager (Figure 4). The Routine model includes the routine measurement library; each routine is represented by one DUT and its setups. The Driver model file includes the drivers for supported probers, switching matrixes and thermal chucks.

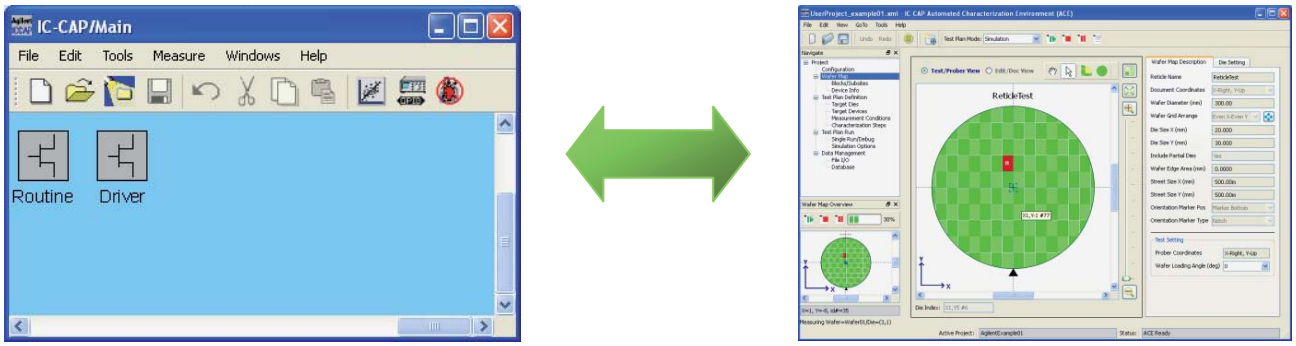

Figure 4: WaferPro communicates with IC-CAP through an internal link

The second part of the WaferPro solution is the new WaferPro Project Window. This window environment manages the wafer map information (Figure 2), the device tables (Figure 3), and the test plan definition and execution (Figure 5).

A test plan is defined by first specifying the wafer, dies and subsites. The second step is to build lists of "target devices" by selecting devices that are suitable to be measured by the same routine algorithm (e.g., DC devices, capacitance structures, open devices, etc.).

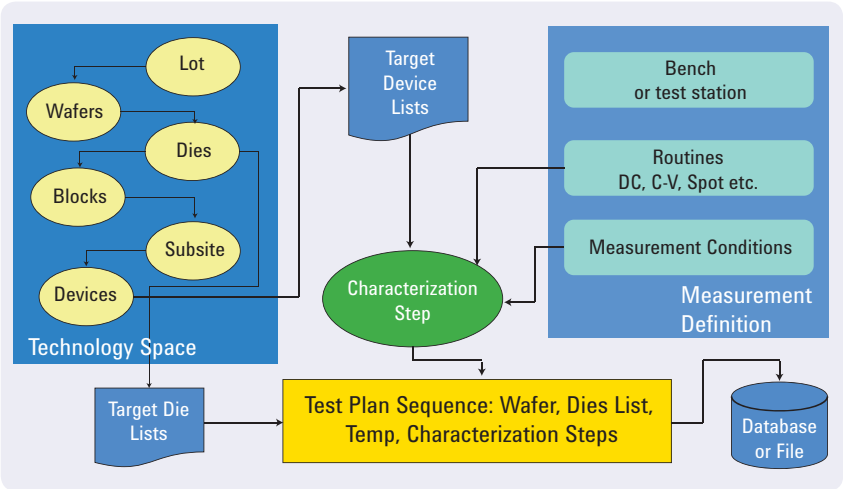

Figure 5: The WaferPro wafer map and test plan definition nomenclature

The next step is building the “characterization steps” by associating a routine and its measurement conditions (e.g., bias information, integration time, etc.) to each target device list. The final step is specifying the test plan to define the sequence of characterization steps applied to specified wafers, die lists and temperature.

When the test plan is run, a second IC-CAP process is launched, to execute the test plan as a background process. At any time during the execution, the user can monitor a comprehensive log that shows the current test plan status and each single test result, including any failures, or warning conditions and related comments (Figure 6). It is also possible to view the results of a particular test by simply selecting the specific test and opening the related multiplot display.

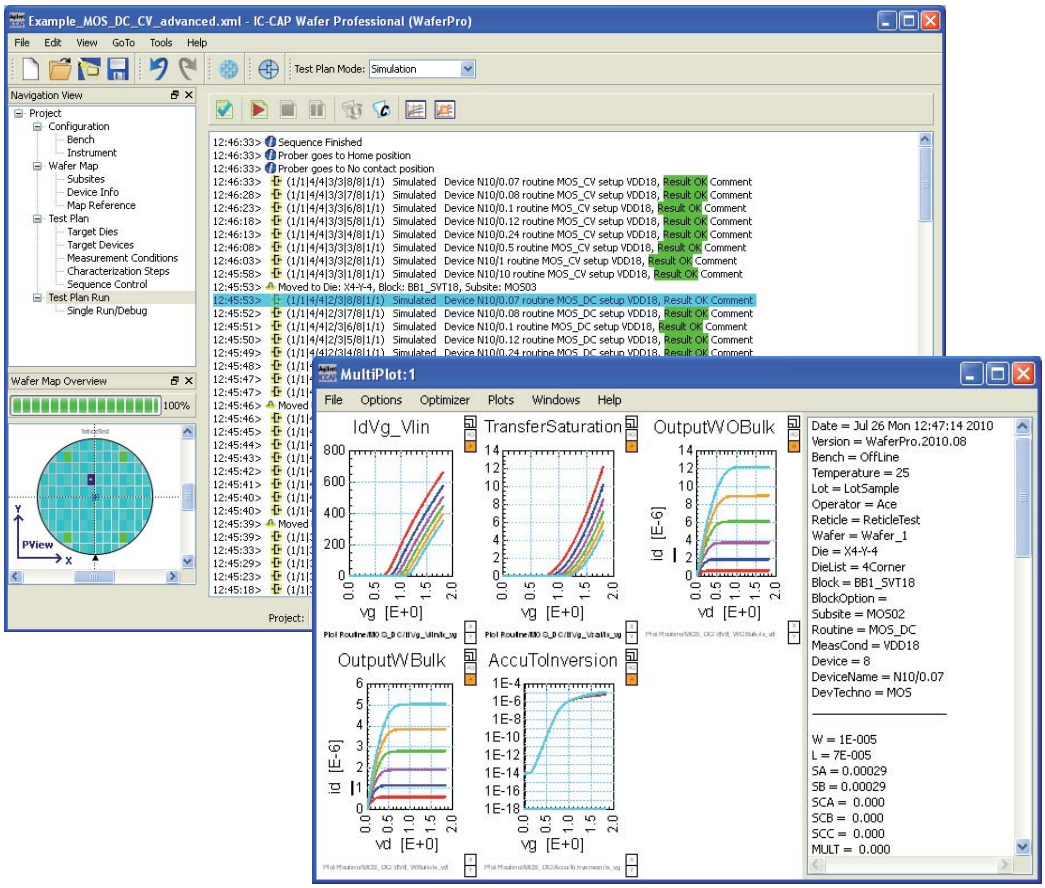

Figure 6: Test plan run page and its log information with display capabilities. The display also shows the DUT information, as well as all the calculated data (or spot data) included in this routine.

Summary

IC-CAP WaferPro is the most powerful test plan suite ever built that is specifically designed for on-wafer DC/CV and RF measurements for device modeling.

- It works out of the box with a variety of test stations, probers and instruments, including the Agilent parametric testers.
- It includes several built-in measurement routines, yet is flexible enough for users to customize the measurement and calculation of post-process data.
- It will be compatible with a new IC-CAP Database feature and provide the foundation for advanced statistical analysis and modeling.

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Revised: April 28, 2010

Product specifications and descriptions in this document subject to change without notice.

Printed in USA, September 15, 2010
5990-6494EN

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