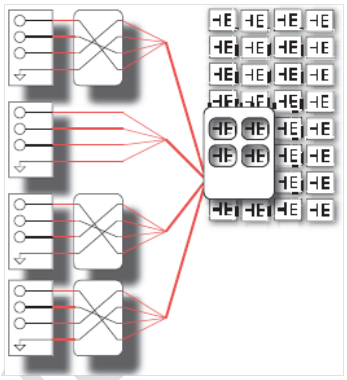
# Agilent ASUR Parallel Device Reliability

## A Component of the Solution Suite for Advanced Reliability



- Parallel Multi-site Multi-device Reliability
- Accelerated to Long-term Reliability Assessment
- JEDEC DC and AC WLR Library Modules
- Graphical Programless Testing
- Agilent WLR DNA Technology
- DSP Phenomena Detection
- Interactive to Automated Measurements
- Semi and Auto 200 & 300 mm Prober Control

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## Nanometer Era Parallel Reliability System

ASUR PDR (C1280A) is a modular and scalable high-performance accelerated reliability test system for parallel multi-site and multi-device studies that permits users for the first time the flexibility of tuning multiple stresses acceleration rates that are indicated for new and advanced deep nanometer technologies and still preserve correlation to the accelerated techniques of the worldwide standard PDQ-WLR using instrument-based solutions

Agilent's Advanced Scalable Unified Reliability (ASUR) family of reliability test products provides a range of solutions for different needs, budgets, experience levels and strategies for laboratories and production.

The Single Device Reliability (ASUR SDR) product provides a PC and instruments-based solution for accelerated stress reliability studies using proven JEDEC reliability test algorithms. ASUR PDR is part of the ASUR scalable family of solutions and is the parallel version of the proven reliability suite of solutions.

ASUR PDR provides parallel multi-site and multi-device, accelerated to long-term stress, for the reliability assessment of TDDB, BTS, [N|P] BTI, HCI, EM, etc. in DC and AC (pulsed). Innovative features allow for device conditioning, as in real circuits, avoid relaxation effects, and use DSP techniques for the detection of novel phenomena found in advanced materials such as high- and low-κ dielectrics, Cu and transition silicide barrier metallization, etc. PDR advanced features include the use of adaptive scanning and specialized failure detection methods to study relevant operating regimes, identify soft breakdowns, etc.

The Nanometer Era Industry Dilemma:

*Innovation has higher risk*

Worldwide technology development centers and manufacturing sites require reliability measurement solutions that are highly modular and scalable as technology evolves and new paradigms are encountered. New and correct test solutions become the barrier between accurate reliability data and incorrect lifetime predictions: Technology success or failure

Extensive and diverse reliability tests are now necessary to meet new significant data metrics introduced by the ever evolving technological needs. The future is data driven, and meaningful data can only be attained by the expert integration of a test cell: equipment, software and test techniques for correct reliability assessment.

Solution Suite for the Nanometer Era

The development of nanometer scale technologies and new materials has brought testing challenges into the mainstream. Technological projections, their road maps and analysts' reports concur that modern reliability testing's impact on the semiconductor industry is enormous for the nanometer era. Reliability data is indispensable in the process of selecting new materials; therefore, it is critical to have modular scalable and cost-effective reliability testing for modern manufacturing.

Successful manufacturing of current technology depends uniquely on accurate reliability data and becomes even more for deep nanometer scale.

Advanced Scalable Unified Reliability (A S U R)

Reliability data correlation with confidence from one instrument to systems

- ASUR provides reliability solutions from single- (SDR) to multi-site parallel (PDR) test
- Modular Precision Architecture and Scalable Test Cell Control
- PDQ-WLR Technology DNA in its sixth generation
- Superior phenomena detection beyond traditional methods now include DSP
- Reliability Data Analyzer (RDA) the only dedicated reliability analysis environment in the industry

ASUR is used in IDM, Foundries, Fabless and equipment companies, reducing development cycle time while helping control maturing processes. For fast identification and prediction of reliability problems at all phases of the IC life cycle — development, qualification, production — ASUR Single Device Reliability (SDR) with multi-device test provides effortless expansion to capacity, new test needs and test cell standardization across multiple instruments, while growth is assured by the test cell scalability and modularity.

ASUR PDR provides immediate view on stresses and devices behavior through the use of its real-time plotting tool. Moreover, sophisticated post-test analysis of results is direct through the optional suite's Reliability Data Analyzer, ASUR RDA.

The ASUR PDR supports from manual test to 200 and 300 mm semi and auto wafer prober environments.

## ASUR PDR - Nanometer Data Volume

The development of state-of-the-art deep nanometer technologies demands sophisticated software and hardware test capabilities and expert knowledge of device technology in order to gather statistically significant volumes of data for reliability studies.

New materials and structures, advanced fabrication nodes and their processes create new chip reliability exposure for existing and emergent device technology which demands those extraordinary amounts of reliability data.

ASUR PDR contributes to the proper testing and selection of suitable volumes of reliability data collection, accurately time-stamp data, modeling, simulation and variability determination and control of *known* and *new* failure mechanisms in the statistical population to successfully achieve the integration of new processes, materials, devices and their performance in modern circuit applications.

Traditional single-device tests do not generate essential information, at multiple different conditions in appropriate periods of time, as is required for the study of degradation mechanisms present in advanced IC design, Furthermore, the accelerated models that are used may not be appropriate for those device studies. Therefore the rapid collection of statistically significant data at proper, multiple, acceleration stresses is indispensable for the understanding and development of modern nanometer technology.

The advanced study of electrical and thermal degradation mechanisms in modern nanometer era technology can be successfully accomplished by using the powerful features of ASUR PDR in conjunction with Agilent Technologies superior instrumentation, and decade's long expertise in reliability. ASUR PDR assists users in capturing essential device degradation behavior, from accelerated to long-term, by measuring various simultaneous acceleration degrees of electrical and thermal stresses, in parallel, while testing multiple sites and multiple devices on-wafer.

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Although packaged reliability test is an established solution, modern technology manufacturers that require reducing longer test cycles associated with those techniques are turning to on-wafer test with ASUR PDR for immediate feedback of their reliability assessment at various phases of the device process and qualification.

To complement the reliability solution experience Agilent Technologies offers ASUR RDA, a focused reliability data analyzer, to extract device degradation parameter information, lifetime, acceleration factors, etc. contained in those large data volumes. ASUR RDA is designed to meet the needs of reliability and technology development engineers and scientists shifting their attention from mathematical techniques to interpreting data to provide a solid course of action toward process improvement.

This test and analysis approach frees precious human resources for *understanding* data as opposed to controlling complex equipment, writing intricate tests and manipulating enormous data volumes.

Reliability tests for current technology and newer such as those for 32 nm and beyond are no longer exclusive of the DC domain; AC reliability and other significant statistical data is vital thus requiring tools to be extensible into emerging paradigms. ASUR PDR improves over preceding WLR technology generations and includes parallel multi-site and multi-device algorithms in new domains required for advanced technology development and assessment and providing high volumes of statistically significant data.

ASUR PDR methods, including parallel on-the-fly techniques are provided for DC and AC reliability testing of: gate oxides, bias-temperature instability (BTI), hot-carrier injection (HCI), electromigration, etc.

Development and execution of pre and post test, including device conditioning, is supported via the programless PDR interface component.

## High Volume Reliability Test With Confidence

The JEDEC compliant ASUR suite of reliability assessment algorithms, now in their sixth generation, has over 12 years of in-field experience and validation and has become the de-facto worldwide standard in production and labs. In its high volume and parallel multi-site and multi-device form, it performs DC

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and AC tests without the need of programming using a module based approach

DC Modules

• Gate Oxide Integrity (GOI)
• Bias Temperature Stress (BTS)
• Bias Temperature Instability (NBTI and PBTI)
• Hot Carrier Injection (HCI)
• Electromigration (EM)

AC Modules

· AC Time Dependent Dielectric Breakdown (AC TDDB)
· AC Bias Temperature Instability (AC BTI)
· AC Hot Carrier Injection (AC HCI)
· Double Pulsed AC (AC HCI +NBTI)

General Parameter Test Module

- Device Conditioning
- Pre- and Post-stress Tests

By using those turn-key modules with the correct test cell wiring topology ASUR PDR ensures accurate data collection, and reducing measurement fluctuations, by supporting Kelvin, Pseudo-Kelvin and non-Kelvin wiring and probe card configurations for different operating conditions of devices, test techniques, instrumentation, etc. This flexibility in the topology permits users to scale their actual hardware test solutions and eliminate or reduce measurement variations and inaccuracies caused by residual parasitic components.

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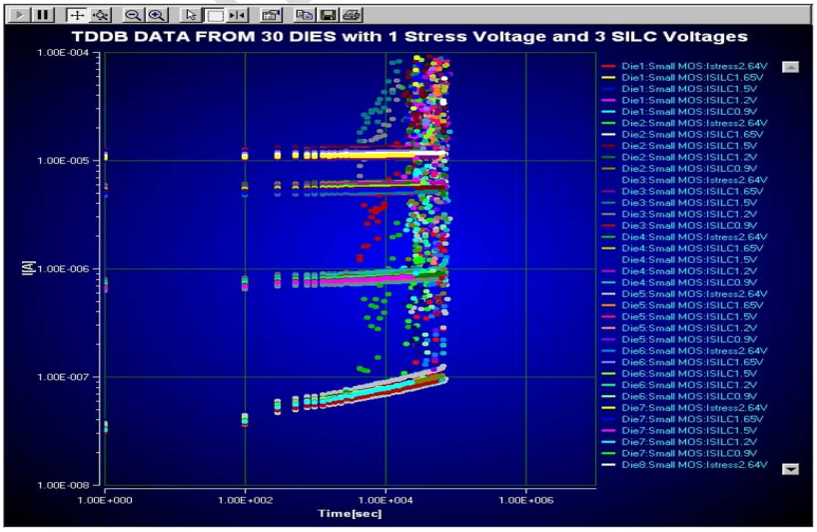
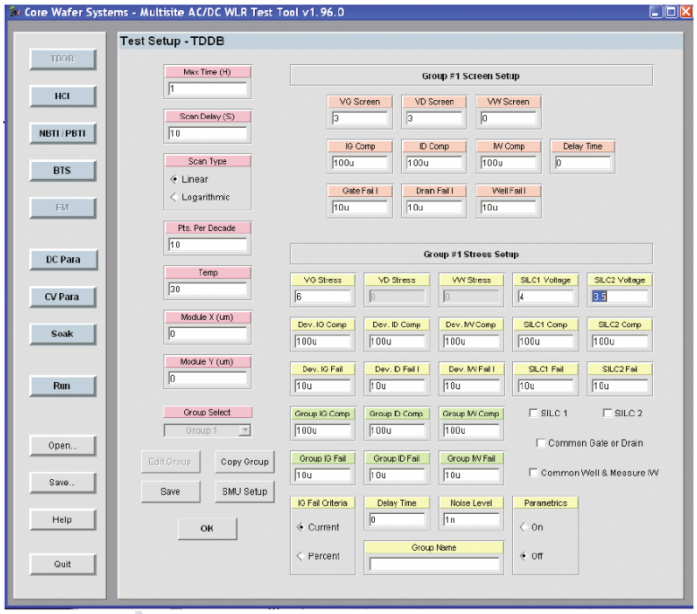
## Agilent ASUR PDR – Parallel Reliability Technology Evolution

ASUR PDR provides a lower risk way to invest in and manage high volume reliability testing required for the nanometer era. ASUR PDR is a scalable platform that lets users choose the degree of acceleration for each and all devices under test. ASUR PDR is a platform for advanced reliability test that grows with processes needs rather than locking users into a one-job one-box solution. Parallel, multi-site and multi-device test gives users a better return on assets by performing tests on multiple devices in the time it normally takes to test a single device, which is especially



valuable when making long-term stress tests and their analysis requiring statistically significant volumes of information. Scalability allows growth without throwing away an initial investment.

Customers can reap the benefits of ASUR PDR scalable, parallel architecture such that allows it to be traded against technology measurement needs. This flexible and scalable architecture permits you to control risk, generate significant statistical data, create budget leverage, maximize data collection in long test cycles and achieve critical business objectives of reliability test. Users can trade off between its per-pin to shared-pin architectures as test requirements, including test volume, change or budget allows. You can perform parallel multi-site probing with any combination with multiple accelerated to long-term running reliability tests taken in the time of a single test.




Optionally, users can add to PDR the Reliability Data Analyzer (RDA), a comprehensive reliability data analysis tool, and PDQ-Fab for test structure design.

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## For Accurate Electrical Acceleration Factors

Electrical acceleration factors can be measured in a single touchdown with no relaxation due to matrix resources switching-time, if present, from creating up to sixteen logical device groups, to unlimited per-pin connections. Each of the three topologies allows it to be configured with different stresses in any reliability test to quickly create complete electrical acceleration datasets required for lifetime extraction.
Except when SMUs change states, devices connected in any of the three supported topologies in ASUR PDR are never de-stressed, while each individual device is characterized assuring optimal use and accurate accounting of elapsed stress time for correct acceleration factor calculation.

ASUR PDR Configurable Topologies

ASUR PDR offers three configurable topologies, or devices connection modes: *Per-pin*, *Quasi-per-pin* and *Shared Groups*. Those topologies in any ASUR PDR test cell are extensible, provide test scalability and advanced phenomena detection– an all in one software solution for advanced reliability technology.

It is important to note that apart from the topology chosen for a particular reliability assesment, the instrumentation raw speed or the devices response may not be the predominant measurement factors, but often parasitics in the environment play a dominant role in data acquisition and quality.

While there are inherent parasitics in any test cell environment, ASUR PDR and SDR have features that uniquely enable users to have a superior degree of control on them and achieve superior quality and confidence in data acquisition. These features along with ASUR JEDEC compliant WLR modules excel in uniquely providing the semiconductor industry with a proven solution and solid experience of over 12 years of demonstrated reliability solutions. This considerable expertise and superior control makes PDR the most sought after and trusted solution for parallel reliability studies. The recognized success of PDQ-WLR makes PDR the ideal vehicle to ensure success for current and future deep nanometer technology.

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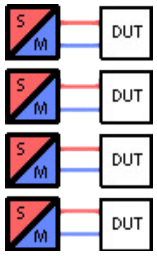
**Per-Pin**

Every device terminal is assigned a coresponding, particular, SMU. Therefore there is no inherent device relaxation due to switching. Measurements can occur as fast as hardware allows for transitions between force to measurement condition. The per-pin topology in ASUR provides the best time resolution since no switching time is spent scanning the DUTs.



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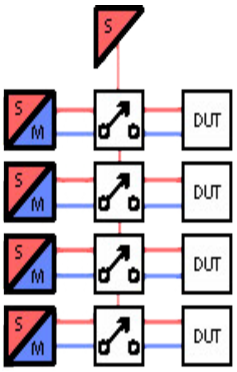
**Quasi-Per-Pin**

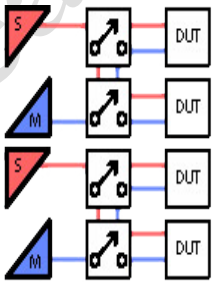
Quasi-per-pin topology allows to directly tie together individual terminals of one or more devices to a common resource such as voltage, current, or ground while the other terminals are connected in a per-pin fashion. For example, several well or source terminals can be connected together through a test execution via a switching matrix or other method. This is allowed for all sites and devices being simultaneously tested even when they may be stressed at different voltages. The use of the switching resources to connect those device terminals to ground or to other common resource is only done at the beginning of the test.
In the quasi-per-pin topology, all other device terminals that are required to continuosuly change state, or function during test, such as stressing or measuring, are connected to individual SMUs, in a per-pin fashion. The net result of using this topology is better tester utilization of its resources by concentrating those that are common to various devices and allowing more individual resources to be available during a test for additional devices to be connected if desired.



There is no device relaxation caused by switching and SMU's are dedicated for each device. *Performance is the same as Per-Pin but with resource cost savings.* Both topologies, per-pin and quasi-per-pin can obtain the same time resolution and no relaxation conditions.

**Shared Groups**

A group is a collection of devices that have the same stress and measurement conditions. The devices need not be physically close to each other. ASUR PDR allows sixteen groups where the number of devices per group is limited by the switching matrix resources. Also in this topology as in the others supported in ASUR PDR, there is no relaxation as the system software performes special switching for devices to sequentially transition between measurement and stress conditions. The shared groups topology allows the most number of devices to be connected to test resources, stress and measure, while trading-in time resolution due to the sequential scan nature of the topology. This is an excellent vehicle for those degradation studies that require large amounts of statistical data.

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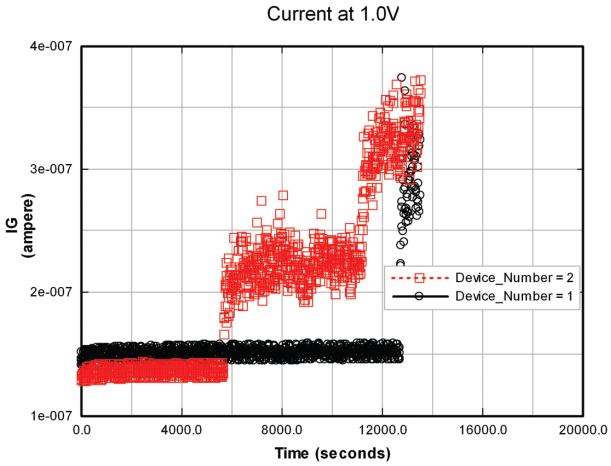
## DSP and Phenomena detection

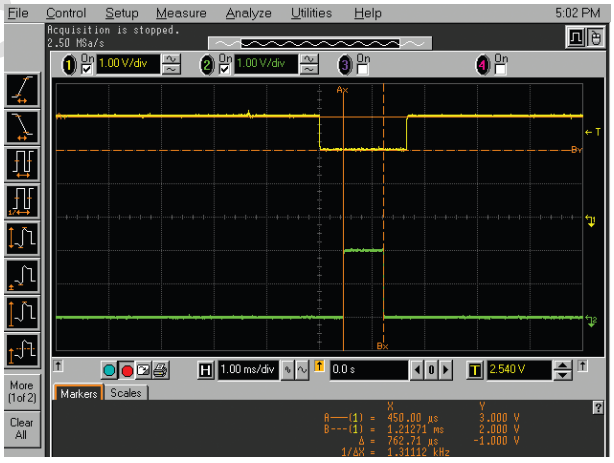
ASUR PDR superior phenomena detection enables the discovery of failures in advanced materials and processes that otherwise can optimistically skew lifetime predictions. ASUR PDR proprietary adaptive detection mechanisms allow the capture of soft breakdowns that may be missed by simple threshold or percent change detection definitions. The digital signal processing, DSP techniques, utilized in ASUR PDR execution engine carefully remove spurious components by mathematical analysis that otherwise conceal device behavior. PDR intelligent soft failure detection allows for quicker test termination on all-devices-failed to maximize resource utilization.




DSP Processed Data
AC and DC Measurements

## On-the-fly BTI measurement speed

ASUR PDR is ahead of the most complex testing challenges that often hinder accurate reliability assessment of today's advanced CMOS technologies with ease. This includes industry leading "on-the-fly" BTI measurements techniques that significantly reduce the device relaxation effects by avoiding those caused by the switching of matrix resources in any of the three topologies. The actual measurement speed is only dependent now in the sampling capability of the instrument used, and its intrinsic internal speed for changing states, the software does the rest.




On-the-fly BTI Measurements

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## ASUR PDR Hardware Features

Agilent ASUR PDR supports a vast range of instruments for solutions required in modern reliability. Those test cell components give various degrees of flexibility depending on the application sought and include

## Standard

- Agilent E5260A, E5270B
- Agilent E5250A, B2200A, B2201A and third party switching matrices
- Agilent 81110A, 8114A pulse generators
- Agilent 4284A and E4980A CV meters
- Agilent 4294A impedance analyzer
- Agilent 41000-100 to -400 series systems
- Agilent power supplies, oscilloscopes, etc.
- Agilent proprietary Pseudo-Kelvin (Triax 2-to-1) Adapter C1280-61001

Agilent E5270B

Agilent B2201A

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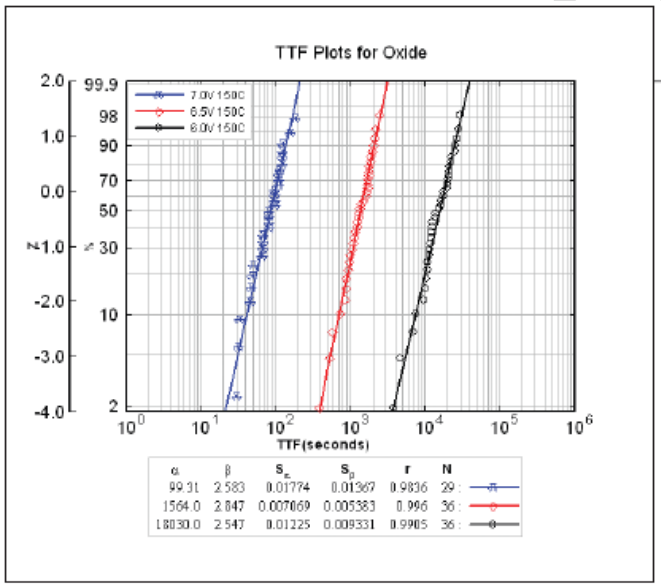
## Specialized

In addition to the standard instruments, Agilent provides specialized reliability components such as the Pseudo Kelvin adapter, shown below, to meet advanced needs.

### Pseudomorphic Kelvin and full Kelvin wiring

Pseudomorphic Kelvin provides Kelvin-like compensated measurements with fewer switch matrix and cabling requirements. ASUR SDR and PDR support both traditional full-Kelvin and pseudomorphic Kelvin wiring topologies automatically.


Pseudo Kelvin Adapter (C1280-61001)




Weibull TTF plots for oxide

### Upgradeability and compatibility

When the performance of parallel, multi-site testing is required, ASUR SDR customers can upgrade to ASUR PDR with partial or even complete reuse of test instruments.

Compatible with PDQ-WLR on SPECS – includes test plan import and export of SPECS test plans from 4070 SPECS and algorithm compatibility through common TIS instrument library.

## Windows System Controller

**Supported Computer**
HP **xw8400** Workstation
**Operating System**
Windows XP Professional
**Required Memory**
2 GB
**Required Disk**
4 GB Executable
250 GB minimum data

## System Software

Standard ASUR PDR software configuration
Provides the following capabilities:
ASUR Parallel System Core
Off-line debugging
JEDEC Compliant WLR Modules
Real-time plot
Interactive, Algorithm and Test Plan Control
OS Shell Control Commands
OS Remote X Display Supported
Automatic Data Formatting Data Output
Manual, Semi and Auto Prober Server for 200mm and 300mm

## Agilent ASUR PDR

Agilent ASUR PDR is an end-to-end instrument based reliability test cell environment for instrument based solutions, hardware and software.
Users have complete access to the JEDEC WLR library modules and instrument control via a standardized library that has same command syntax structure for all supported instruments.

## Agilent ASUR PDR Modules and Test Development Customization

Users can modify the test sequence of the standard PDR modules and introduce custom pre- and post-stress built-in tests through the programless panels' functions.

## Data Analysis and Output Formats

All ASUR PDR data is directly compatible with ASUR RDA. Data can be also be output into flat ASCII files and then imported into other tools. Users can choose to directly export the data to excel by using built-in tools such as Atomizer. Furthermore, data can be

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processed and configured such that it can then be directly imported into corporate databases.

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