Wafer Level Reliability Test Application
Agenda

- Introduction
- ProChek & Test Structures
- ProChek WLR Application
- ProChek Test Considerations & Test Results
- ProChek Plus
- Summary
- Q&A.
Why ProChek

**Obtaining Data**

- **End-User Perspective**
  - Incomplete data for reliability analysis
  - May not provide detailed data
  - Does not provide radiation data

- **Fab Perspective**
  - Expensive and lengthy process to obtain test result data
  - Data Management
    - Several types of data need to be collected accurately
    - Several devices under test (DUTs) are tested at the time

**Long & Resource Intensive**

- Defining and characterizing semiconductor reliability attributes takes a lot of time and resources.

**Expensive Equipment**

- Modern test equipment requires a large capital investment, is complicated to use, and may be focused on a single purpose.

**Comparative Data**

- Selecting the foundry that provides the best performance devices for your products.
- Tracking long term performance and product quality.
What is ProChek?

An innovative low-cost concept serving to rapidly characterize intrinsic process reliability and monitor process quality.

ProChek...

- Is a flexible & dedicated semiconductor qualification and reliability characterization system.
- Is based on a cost-effective bench-top instrument.
- Interfaces to a variety of test structures
  - Single devices
  - Wafer level test structures
  - Dedicated test chips.
- Accelerates testing of semiconductor devices in volume.
ProChek Applications

- ProChek serves to
  - Characterize/quantify existing and new processes from a quality/performance perspective
    → gather device data (I/V curves, point measurement data)
  - Characterize/quantify existing and new processes from a reliability perspective
    → evaluate performance degradation over time in function of operation and stress conditions
ProChek Architecture

**Computer GUI**
- Test Setup & Control
- Result Collection
- Result Processing

**Measurement Resources**
- Meas. Supplies (FVMC)
- Meas. Supplies (FVMC/FCMV)
- Temp. Control (FCMV)

**Scenario Processor**

**Data Router & Control Logic**

**Internal Memory**

**Optional External Memory**

**SD SLOT**

**USB 2.0**

**Benchtop System Internals**

**Test Card**
- Test Coupon
- DUT Select/Configuration Shift Registers
- HEAT (VIA, MOS)
- Stress Bus (G, D, S, B)

**Stress Resources**
- TC Supply
- TC SR Control
- Heater/Cooler
- Stress Supplies (FV/FC)

© 2015 - Ridgetop Group & Ridgetop Europe – all rights reserved – copying or distributing without written permission is strictly forbidden
ProChek Resource Overview

- ProChek offers full 4-terminal (gate, drain, source, body) control
  - Resources:
    - 4 Stress resources, serving to apply electrical stress
      - can operate in Force Voltage (FV) or Force Current (FI) mode
    - 4 SMUs, serving to collect data
      - can operate in Force Voltage Measure Current (FVMI) or in Force Current (FI) mode,
      - 10µs sampling, 4K data buffer per instrument, 24bit data
    - Voltmeter
      - Can operate in absolute or differential mode
      - Can operate as “slow” (10µs sampling) or as “fast” (500ns sampling) meter
    - Utilities
      - Utility Voltage source
      - Utility Current source
      - Utility Voltmeter
      - Heater/Cooler control
ProChek Extensions

- ProChek has provisions for expansion with additional (add-on) instruments.
  - New ProChek Plus platform supports up to 24 (48) instruments/SMUs
- User specific test structures can easily be converted to a native ProChek test structure by means of an active interface board.
Analogy: Orchestra

- ProChek resources == musical instruments
- Scenario processor == Conductor
- Test Strategy == Music piece
- User == Composer

  → Controls how the music is played (key, timbre, …)
  
  → Can write his own partitions
    - Generic Test strategy support

  → Can rely on predefined (but yet configurable) strategies (EM, SM, HCI, QBD, TDDDB, xBTI, …)
ProChek Application

- ProChek System
- Device under Test (DUT) or a set of DUTs
- Interface to link DUT with ProChek system
  - Function of DUT nature (packaged, wafer structure, set of DUTs)
    - Simple cable with appropriate connectors
    - Passive Adapter/interface board with DUT socket
    - Active interface board with DUT socket
    - Probe card + link between probe card and ProChek system
Introduction

ProChek & Test Structures

ProChek WLR Application

ProChek Test Considerations & Test Results

ProChek Plus

Summary

Q&A.
ProChek & Test Structures

High Throughput Test Coupon
- Multiple arrays of various types of test devices
- Embedded precision switching matrix
- Parallel stressing of multiple test devices
- Embedded heaters generate temperatures to 250 °C
- Easily ported across fabrication processes

Wafer-level
- Existing test structures
- Direct dock or cable interface
- Connects to active interface board

Package-level
- Existing test structures
- Mounted on active interface board

Optional Extension Cable
- Connects to interface card or probe card
- Remote test structure control

Host Controller
- Easy-to-use software interface
- Test configuration, data extraction & conversion
- Test templates include EM/SM, xBTI, HCI, QBD, TDDB
- Fully programmable test conditions and sequencing of stress-and-measurement operations
- Local data processing
- Data visualization

ProChek Platform
- Benchtop or direct dock to probe card
- Contains/controls all stress/measurement units (SMUs)
- Fast (500 ns to 10 µs sampling) measurements
- Supports all test coupons and individual test structures
- Low-cost stand-alone unit replaces ATE or rack & stack equipment
- Built-in heating/cooling control
Agenda

- Introduction
- ProChek & Test Structures
- ProChek WLR Application
- ProChek Test Considerations & Test Results
- ProChek Plus
- Summary
- Q&A.
ProChek WLR Application

ProChek System
Stress/measurement SMUs

Direct ProChek to Probe card interface

Probe card
Wafer
Wafer chuck

Probe Station
ProChek WLR Application

Active Interface Board

ProChek System

Cable Interconnect to probe card
Agenda

- Introduction
- ProChek & Test Structures
- ProChek WLR Application
- ProChek Test Considerations & Test Results
- ProChek Plus
- Summary
- Q&A.
ProChek’s measured results closely matches test data provided by the foundry.

ProChek measures parameters, devices, and conditions NOT provided by the foundry.

Ids – Vds measurements and simulations in the IBM BICMOS8HP process for different Vgs, from 0.3 to 1.5 V.
Device Characterization

- The ProChek approach allows for a statistical analysis of data relevant to quality monitoring. By increasing the volume of data recorded, a robust analysis can be performed.

- **Ids Vds curves for 48 NFET DUTs**

- **Distribution of On Current in 48 NFET DUTs**
Device Characterization – ONC18

PMOS DUT1 (W/L = 0.42/0.18)

NMOS DUT1(W/L=0.42/0.18)

Annular NMOS DUT1 (W/L = 4.3288/0.10)
ProChek Capabilities

- ProChek can make voltage / current measurements
  - at a 10µs interval (100KHz rate)
  - Collecting up to 500 values per measurement point and per instrument
  - All measurements are running concurrent
- ProChek’s fast voltmeter can make voltage measurements
  - at 500ns intervals (2MHz rate)
  - Collecting up to 20K values per measurement point
  - values can be linearly or logarithmically distributed over time
- Annealing function is designed to evaluate behaviors over time
FAST ?! – what do we mean?

- Ability to make measurements fast!
- Ability to quickly bring the DUT into a state of degradation so that it shows xBTI effects!
- Ability to observe short lived degradation effects cancelled by annealing effects!
- Ability to make measurements
  - very shortly after a DUT is switched from stress to measurement conditions
  - before, during and after the transition from stress to measurement conditions
ProChek xBTI support

On-the-Fly Measurement Support
ProChek xBTI support

IDD only On-the-Fly Measurement Support
ProChek xBTI support

On-the-Fly Single Point Measurement Support
ProChek xBTI support

On-the-Fly Vth Measurement Support
Vth Degradation Results

- Measurement of Vds whilst maintaining Ids constant (IBM9SF – 90nm techno) under voltage stress conditions
Vth Degradation Results

\[ V_{th} = V_{ds} - \frac{2 \cdot I_{ds}}{\sqrt{\mu_n \cdot C_{ox} \cdot \frac{W}{L}}} \]

Test Iterations

Voht
Agenda

- Introduction
- ProChek & Test Structures
- ProChek WLR Application
- ProChek Test Considerations & Test Results
- ProChek Plus
- Summary
- Q&A.
ProChek Plus
ProChek Plus
ProChek Plus

- Configurable Platform
  - 4 slots serving Stress Resources or Low Resolution Measurement Instruments
  - 8 slots serving High Resolution Measurement Resources
  - Each slot can support up to 4 Resources

- Available Modules
  - 4-channel configurable SMU module
  - 2-channel configurable Voltmeter module
  - Test Structure control module
  - System control module
Agenda

- Introduction
- ProChek & Test Structures
- ProChek WLR Application
- ProChek Test Considerations & Test Results
- ProChek Plus
- Summary
- Q&A.
Summary

ProChek

Advanced, dedicated system for fabrication process characterization offering significant advantages to IC designers, process, and reliability engineers.

- Covers reliability concerns of modern nanotechnology processes, including radiation effects
- Covers qualification needs for new and immature processes
- Serving Wafer Level Tests without the need for additional equipment
- Significant cost and time savings
- Slides and recording of the webinar will be available shortly via an e-mail from Ridgetop

- E-mail follow-up questions & comments to:
  - mcpherson.reliability@yahoo.com
  - hans.manhaeve@ridgetop.eu

- Please fill out our brief feedback survey at https://www.surveymonkey.com/r/7MJDP2L

Thanks for your time and interest!
Thank you!

Ridgetop Group, Inc.

3580 West Ina Road
Tucson, AZ 85741