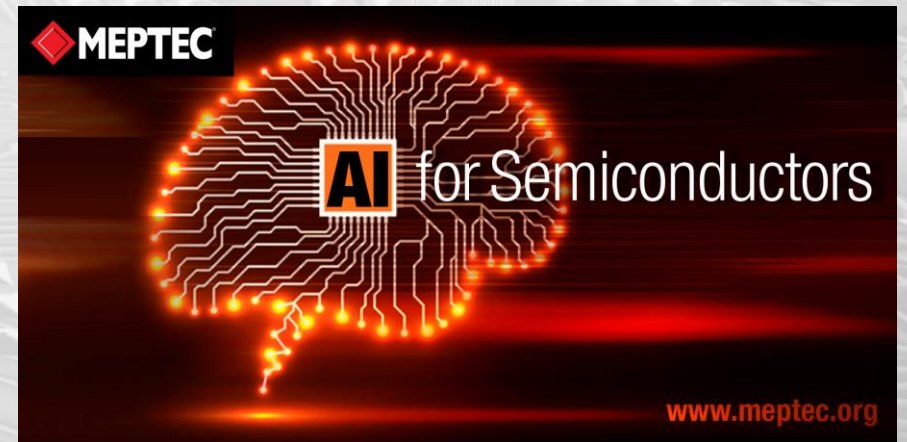


AI Applications in Test

Ken Butler, Keith Schaub
Advantest



Analytics in Test Operations is Not a New Thing

- 30+ years of analyzing test data and making product decisions
- Today we are moving to increasingly smaller geometries and chiplet-based designs
- The resolution of the decision (wafer → zone → region → die → subdie) also keeps getting smaller
- Drives the need for increasingly complex and powerful analytics and computing

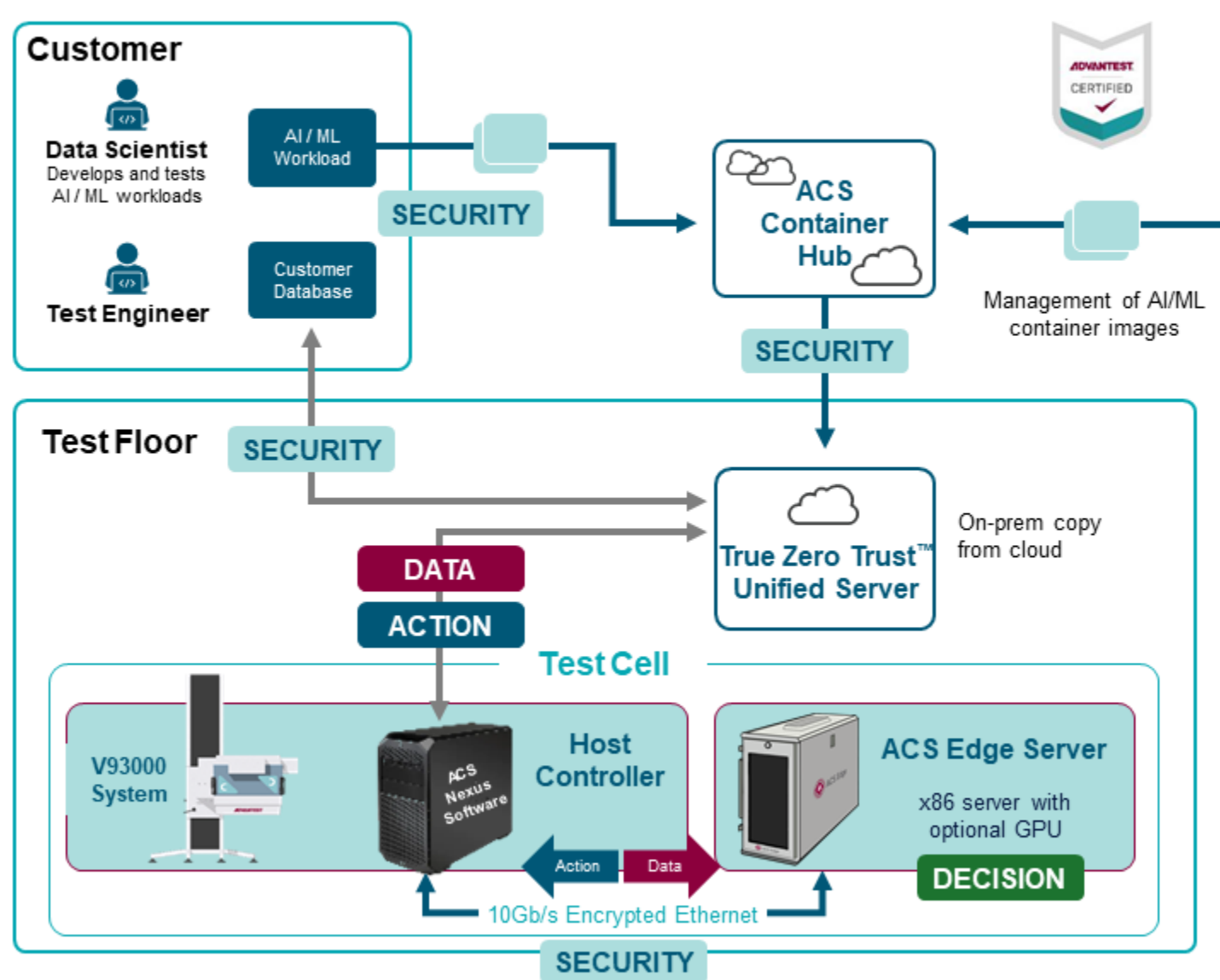
Example: Evolution of Test Outlier Solutions

Period	Downgrade	Basis, Additions
Mid 1990s	By lot	Probe yield
Mid-late 1990s	By wafer	Probe yield, then Tukey analysis
Late 1990s	By die	Wafer spatial rules
Early 2000s	By die	Within-die delta I_{DDQ} , V_{MIN}
Mid 2000s	By die	Zonal Tukey analysis
Mid-late 2000s	By die	Location Averaging algorithm
Since then	By die	Multivariate, ML, real-time compute

We are at the Beginning of a Long Journey with AI in Test

- Building out infrastructure to support secure data movement and **real-time inferencing**
- Creating partnerships and libraries of applications
- Proliferation of on-die sensors enriches available data, particularly for advanced package products
- AI tools will likely aid the test program development process

ACS Real-Time Data Infrastructure for AI in Test Operations



ACS RTDI Platform Key Features:

- Real-time inferencing in test with ms latencies
- Secure data movement for IP protection
- Inferencing app portability across test insertions
- Standardized real-time data streaming, control interface, & APIs
- Open Solutions Ecosystem: Build your own apps or plug-in from others

Plethora of Use Cases, Applicable Across Test Lifecycle

Category	Use case	Post-test or real-time	Benefits	Applicable Test Operation(s)				
				E-Test	Wafer	Package	SLT	Burn-in
Clustering	Grouping similar parts	Both	Cost, reliability			✓	✓	✓
	Silicon grading	Real-time	Quality, reliability	✓	✓	✓		
	Power reduction	Real-time	Yield		✓	✓		
	Smart pairing for chiplet devices	Both	Yield		✓			
Material flow	Adaptive test flows	Both	Throughput					
	Dynamic parametric test	Near-real-time	Throughput	✓				
	Dynamic wafer probe	Near-real-time	Throughput		✓			
	Statistical process control	Real-time	Throughput	✓	✓	✓		
	Stuck part analysis	Real-time	Throughput			✓		
Outliers	DPAT/simple/multivariate/ML outliers	Both	Quality, reliability		✓	✓		
Test resources	Adaptive test time reduction	Real-time	Cost		✓	✓		
	Predictive maintenance	Both	Cost	✓	✓	✓	✓	✓
	Shift left (detect failures early)	Both	Cost		✓	✓		
	RF digital predistortion	Real-time	Cost		✓	✓		
	RF demodulation	Real-time	Cost		✓	✓		
	VMIN/FMAX/other search reduction	Both	Cost		✓	✓		

Shift Left: Trying it on our own chips...

- ASIC device in ATE test head, expensive package and final test cost
- Predict and eliminate likely final test fails at wafer sort?

From training data

	Predicted PASS	Predicted FAIL
True PASS	98.05%	1.95%
True FAIL	55.30%	44.70%

From fresh data/verification

	Predicted PASS	Predicted FAIL
True PASS	94.63%	5.37%
True FAIL	63.84%	36.16%

- In this example, can predict ~36% of final test fails at wafer sort
- **Model parameters, performance can be adjusted depending on overkill tolerance**
- Increased FT yield increased to ~95%, significant savings given the **high package and FT costs**

L. Taubensee, R. Latty, B. Galy, M. Sauer, K-P Behrens, "Test Time and Cost Reduction Using Intelligent Prediction from ML Models," 2023 *Advantest VOICE*, May, 2023.

Another Example: Adaptive Probe Cleaning (APC)

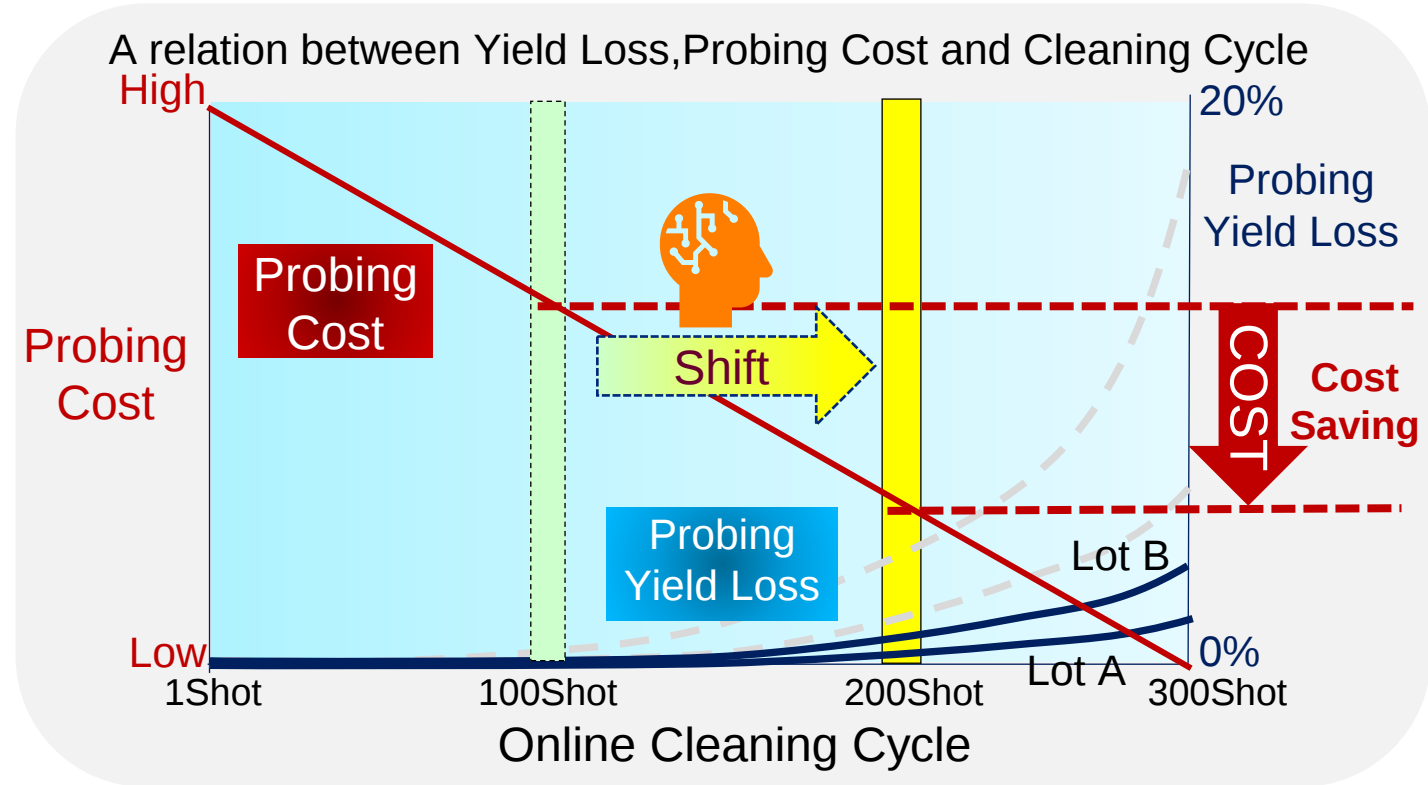
Change in mindset

Using AI algorithms to assess the “dirtiness” of probe needles in real time, and clean only when the needle is dirty affecting yield.

Drastically reduce cleaning frequency without any yield loss impact.

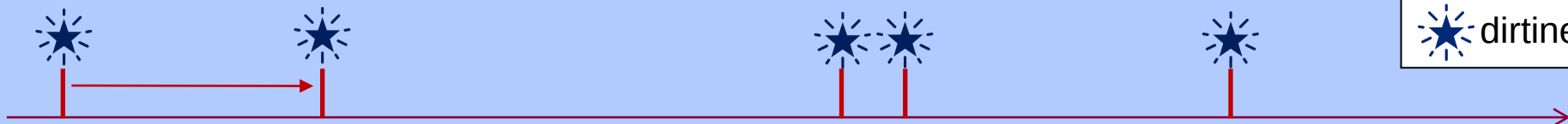
“Adaptive Probe Cleaning (APC)”.

H. Sugimura, Y. Sakai, S. Kishimoto, “Adaptive Probe Cleaning (APC) – Test Cost Reduction Using AI Technology,” 2022 *Advantest VOICE*, May, 2022.



APC
online
cleaning

Adaptive and variable timing



Elapsed time/Prober shot direction

Looking Ahead: Generative AI Test Program Generation

- Example: Prompting Chat GPT-4 to generate test code for power amplifier adjacent channel power ratio (ACPR) test
- Response is that it is not trained on test code, likely due to the proprietary nature of the source

The slide is titled "TEST VISION SYMPOSIUM" and "IN CONJUNCTION WITH SEMICON WEST". The main heading is "Prompt and GPT-4 Response". The prompt text is: "Generate the code for the SmarTest 8 software for the V93000." The response text, shown in a dark chat bubble, is: "The V93000 semiconductor test system from Advantest uses a proprietary software known as SmarTest to run its testing programs. However, as of my last update in September 2021, there is no publicly available API or sample code for this software. The code for SmarTest is typically developed using the system's built-in software tools and is specific to the test plan for the device under test (DUT). It would define the test conditions, measurements to be made, pass/fail criteria, and how to handle the data generated by the test. If you're working with the V93000 system, you would likely need to go through Advantest's training or work with their technical support to get the necessary knowledge to develop your test programs. If you need assistance with a specific aspect of setting up or running a test, please provide more details and I'll do my best to help based on the general principles of semiconductor testing." The slide also features the "semi" logo in the bottom right corner.

K. Schaub, "The Future is Here: GPT-4 as an Expert Assistant for Semiconductor Test and Product Engineers," 2023 SEMICON West Test Vision Symp., July, 2023.

Looking Ahead: Generative AI Test Program Generation

- Example: Prompting Chat GPT-4 to generate test code for power amplifier adjacent channel power ratio (ACPR) test
- Response is that it is not trained on test code, likely due to the proprietary nature of the source
- Prompt: Do it anyway



K. Schaub, "The Future is Here: GPT-4 as an Expert Assistant for Semiconductor Test and Product Engineers," 2023 SEMICON West Test Vision Symp., July, 2023.

Looking Ahead: Generative AI Test Program Generation

- Example: Prompting Chat GPT-4 to generate test code for power amplifier adjacent channel power ratio (ACPR) test
- Response is that it is not trained on test code, likely due to the proprietary nature of the source
- Prompt: Do it anyway
- Does a good job of creating the structure of an ACPR test
- Imagine how well it could do if trained properly
- **Challenge: How to train while protecting important test IP**

TEST VISION
SYMPOSIUM

IN CONJUNCTION WITH
SEMICON
WEST

Prompt and GPT-4 Response

Provide the detail of tester.setup()

The `tester.setup()` method in the provided pseudocode is a placeholder for a method that would handle setting up the test environment, configuring the device under test (DUT), and preparing the tester to execute the test.

Here's a high-level example of what this method might do, based on the general principles of RF testing and the setup for an Adjacent Channel Power Ratio (ACPR) test:

```
java
public void setup() {
    // Connect to the tester
    tester.connect();

    // Configure the RF signal generator
    tester.configureSignalGenerator(FREQUENCY, POWER_LEVEL);

    // Connect the RF signal generator to the DUT
    tester.connectSignalGeneratorToDUT();

    // Configure the spectrum analyzer
    tester.configureSpectrumAnalyzer(FREQUENCY, SPAN, RESOLUTION_BANDWIDTH);

    // Connect the DUT to the spectrum analyzer
    tester.connectDUTtoSpectrumAnalyzer();

    // Set the biasing and control signals for the amplifier
    tester.configureDUT(BIAS, CONTROL_SIGNALS);
}
```

This is a simplified and generic example. The actual steps you would need to perform would depend on the specifics of your test setup and the capabilities of the V93000 system and SmarTest software. For instance, you might need to add additional configuration steps, error checking, and exception handling.

[Regenerate response](#)

semi

K. Schaub, "The Future is Here: GPT-4 as an Expert Assistant for Semiconductor Test and Product Engineers," 2023 SEMICON West Test Vision Symp., July, 2023.

For AI in test, the sky's the limit...

- Possible applications at every test insertion
- LLMs to aid with program development
- Many, many interesting use cases
- Benefits products, infrastructure
- Only limited by our creativity

Closing Thought

“

**Some worry that AI will take their jobs.
The reality is that someone using AI will.**

Jensen Huang

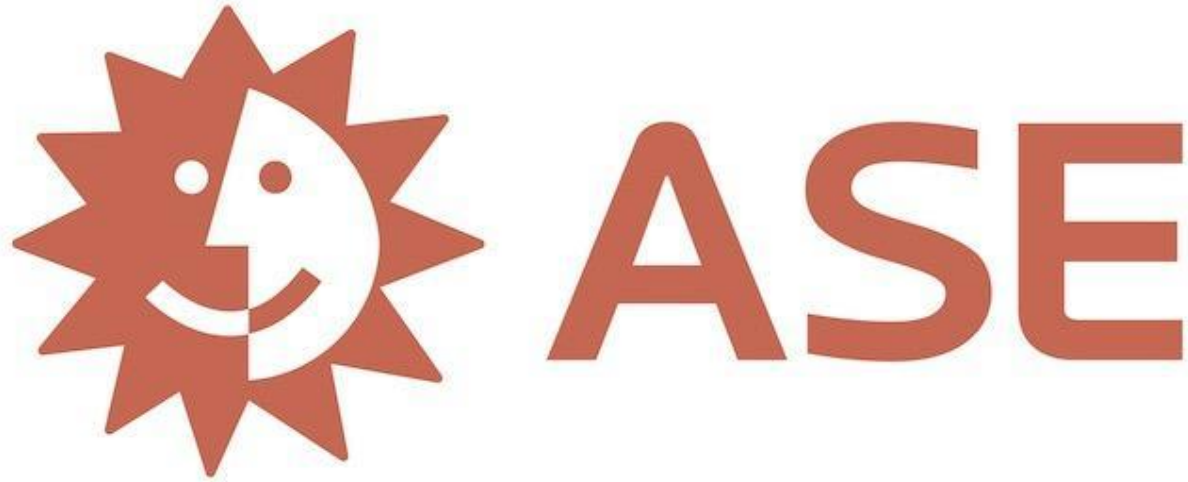
Founder of Nvidia giving NTU commencement speech May 2023

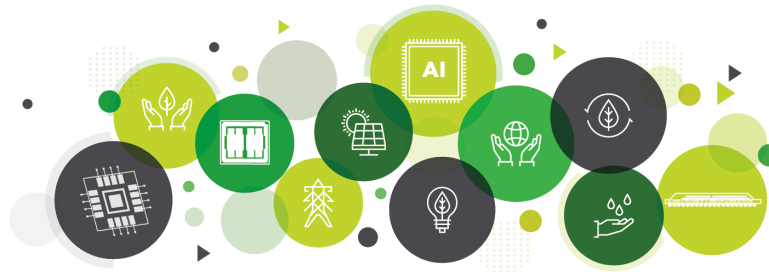
Source:

https://substackcdn.com/image/fetch/f_auto,q_auto:good,fl_progressive:steep/https%3A%2F%2Fsubstack-post-media.s3.amazonaws.com%2Fpublic%2Fimages%2Fc317bf0-a0c7-4c2e-9297-5c937ec37075_2010x1072.png



Thank you to our sponsors!





ASE is enabling the **heterogeneous integration** and **chiplets** era through **VIPack™** while delivering sustainable advanced packaging innovations for...

AI | HPC | Data Center | Automotive | 6G | IoT | and more.

 @aseglobal

 @aseglobal

 aseglobal.com

COPYRIGHT NOTICE

This presentation in this publication was presented at the **AI for Semiconductors** (June 12-13, 2024). The content reflects the opinion of the author(s) and their respective companies. The inclusion of presentations in this publication does not constitute an endorsement by MEPTEC or the sponsors.

There is no copyright protection claimed by this publication. However, each presentation is the work of the authors and their respective companies and may contain copyrighted material. As such, it is strongly encouraged that any use reflect proper acknowledgement to the appropriate source. Any questions regarding the use of any materials presented should be directed to the author(s) or their companies.

www.meptec.org