Ming II: A Flexible Platform for NAND Flash-based Research

Trevor Bunker **Michael Wei** **Steven Swanson**

2012 Flash Memory Summit

Non-Volatile Systems Laboratory
Department of Computer Science and Engineering
University of California, San Diego

NVSL
Non-volatile Systems Laboratory

UCSDCSE
Computer Science and Engineering

Why Study Flash?

- NAND Flash is everywhere
  - Consumer electronics
  - Data centers

- Broad research field
  - Circuits
  - Computer Architecture
  - Systems
  - Applications

Why is it Hard to Study Flash?

- Not all flash is created equally
- Researchers are limited to simulation of flash devices
- A prototyping platform would give researchers complete access to raw flash

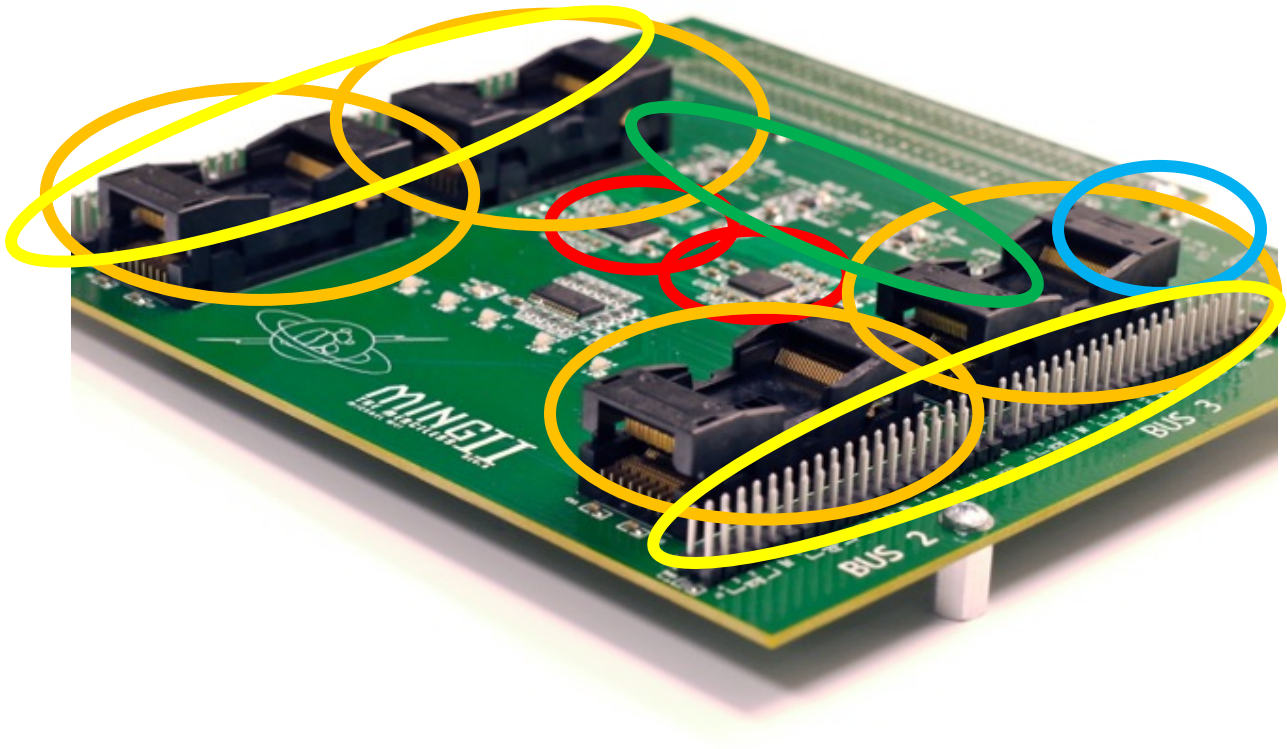
Examples of Research with a Characterization Platform

- Measuring flash characteristics (e.g., latency, power, bit error ratios, lifetime, etc.)
- Prototyping new flash translation layers (FTLs)
- Developing new flash-based file systems
- Identifying performance and power tradeoffs

Ming II Goals

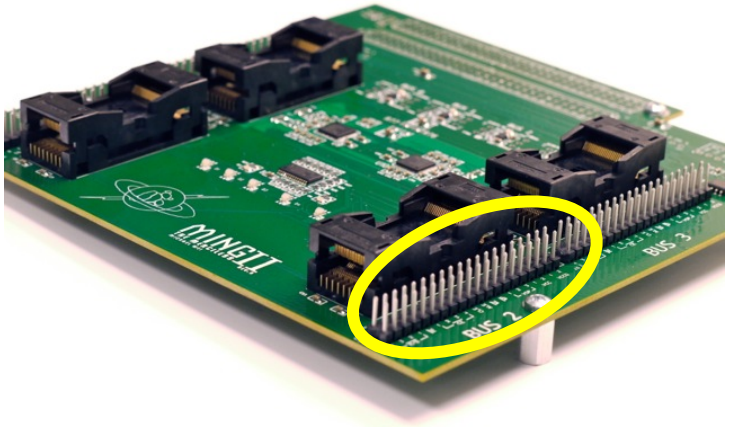
- Flexible testbench for flash characterization
- Give the user complete access to raw flash
- Support a broad range of flash chips
- On-board power sampling for fine-grain measurements
- Development environment that is easy to use

Ming II Characterization Board

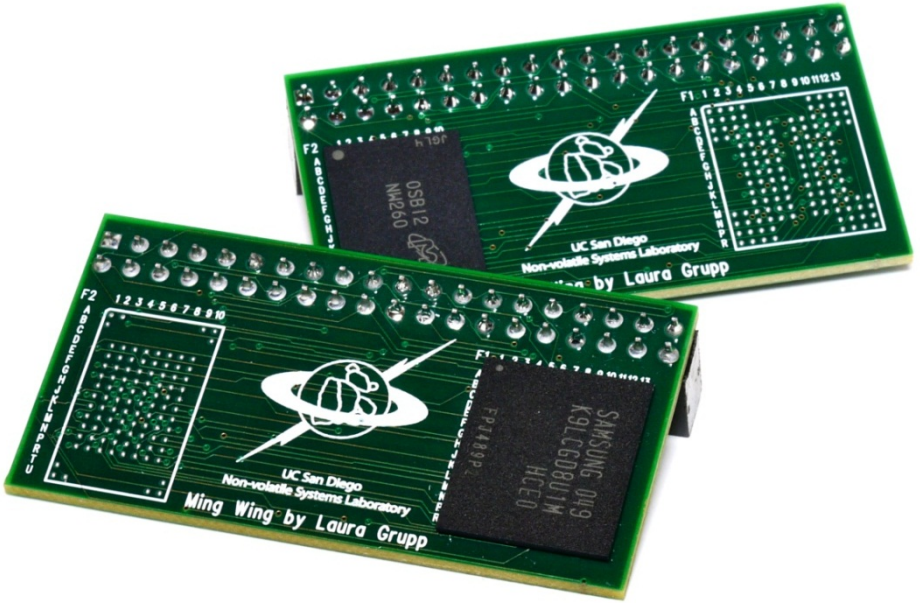


- Four TSOP-48 sockets – four chip enables
- Two ADCs for power sampling
- Temperature sensor
- Voltage override for current protection
- Headers for oscilloscope

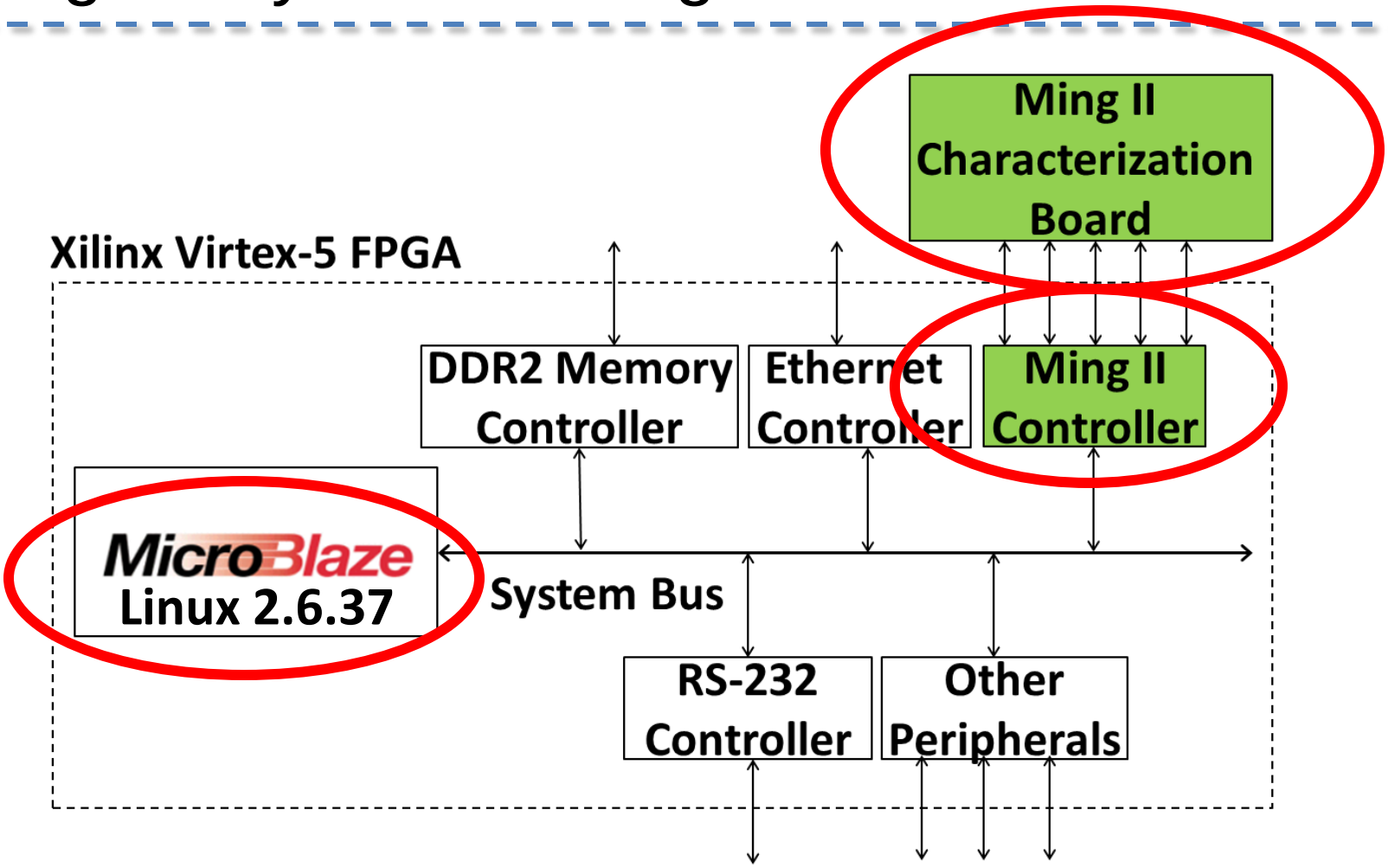
Ming Wing Daughter Board



BGA, LGA, and other type packages



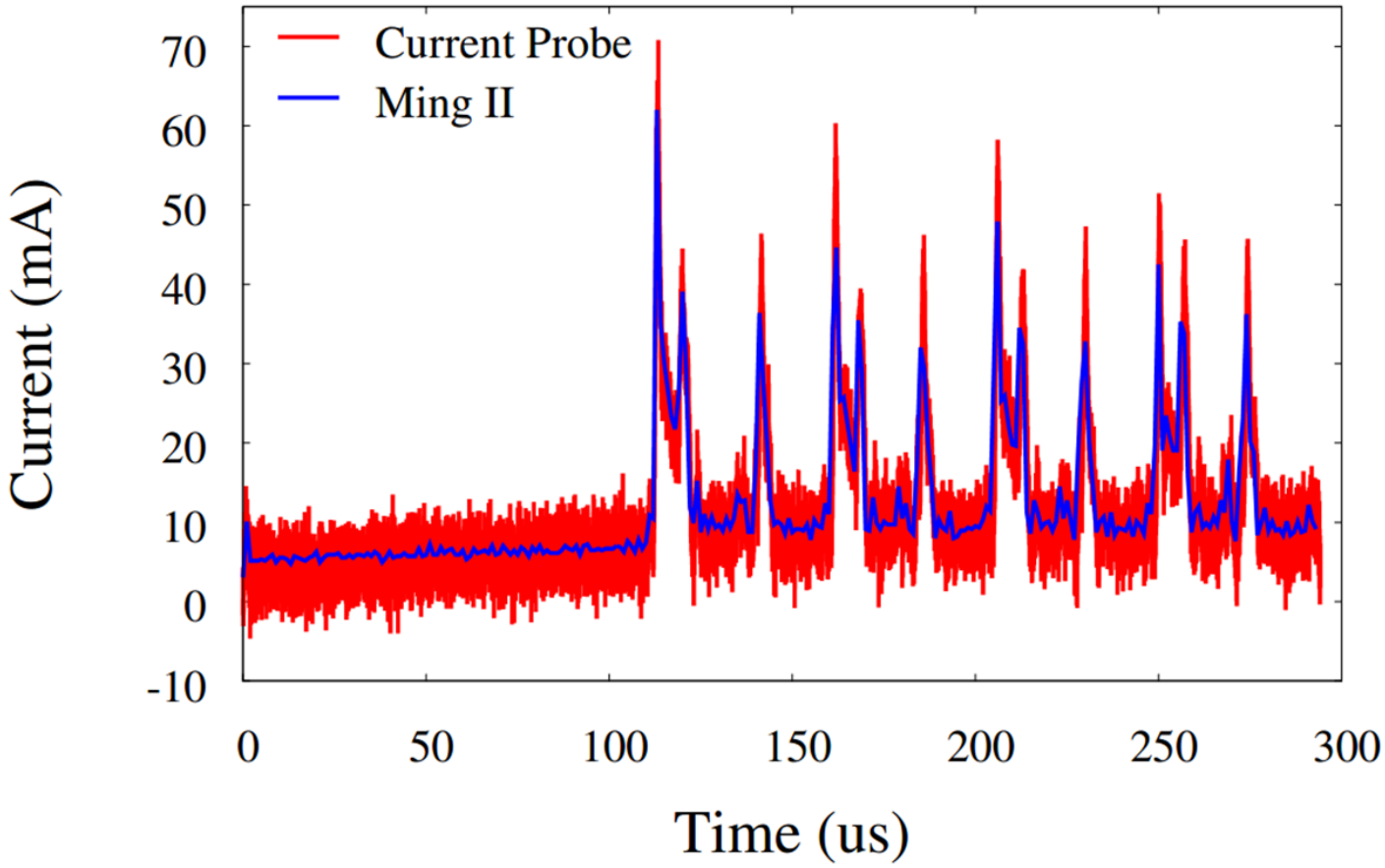
Ming II System Diagram



Ming II Power Measurements

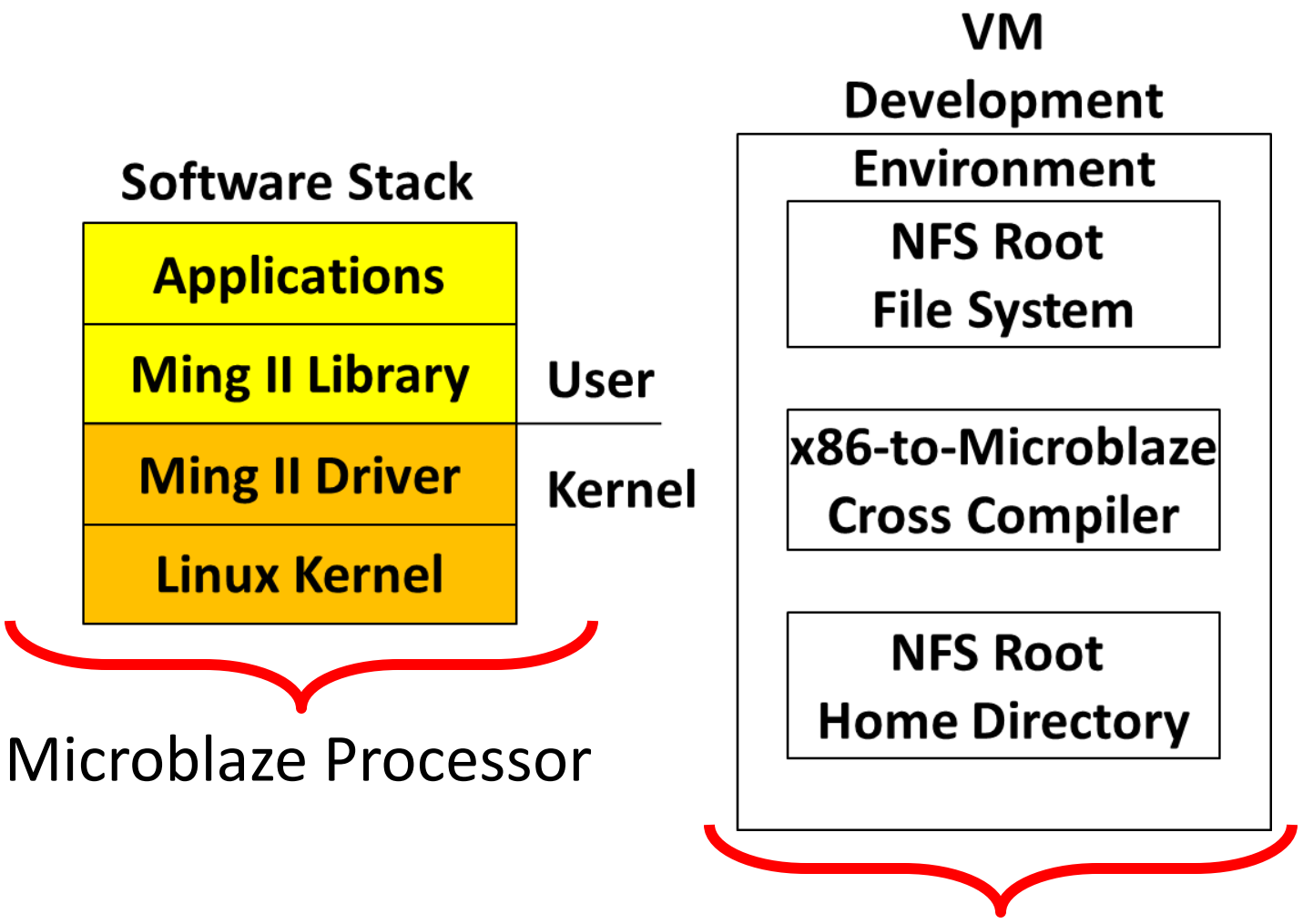
- ADCs acquire 1 Msamples/sec at 14-bit resolution (47.5 µA)
- Fine-grain measurements
- Configurable interface to automate sampling
- Self-calibrating
- Don’t need an oscilloscope
  - Significantly cheaper and easier to use than oscilloscope/current probe solution

Ming II – Oscilloscope Comparison



* 2 kB page program on an SLC chip

Ming II Development Environment



Example

Login via SSH

Insert the Driver

```
login as: root
root@10.0.2.45's password:
$ insmod gordon.ko
$ ./readallids 4 4
Bus 0 Chip 0 ID: 0x2c 0xdc 0x90 0x95 0x54
Bus 1 Chip 0 ID: 0x20 0xdc 0x80 0x95 0x20
Bus 2 Chip 0 ID: 0xec 0xd3 0x51 0x95 0x58
Bus 2 Chip 1 ID: 0xec 0xd3 0x51 0x95 0x58
Bus 3 Chip 0 ID: 0x2c 0x68 0x04 0x46 0x89
$ ./readparam 3 0 1
ONFI Marker: O N F I
Supported Revision Numbers: 1.0, 2.0, 2.1
Device Manufacturer: [redacted]
Device Model: [redacted]
JEDEC Manufacturer ID: [redacted]
Bytes Per Page: 4096
OOB Bytes/Page: 224
Pages/Block: 256
Blocks/LUN: 4096
# LUNs: 1
# Bits/Cell: 2
# P/E Cycles: 5000
```

```
$ cat 2kRandom | ./verify 0 0 15 0 2048
Reading 2048 bytes of data from stdin...done.
Erasing the block...done.
Reading 2048 bytes of erased data...done.
Verifying 2048 bytes of erased data...PASSED.
Writing 2048 bytes of data...done.
Reading 2048 bytes of data...done.
Verifying 2048 bytes of data...PASSED.
```

Read the IDs of all of th

Run a simple integrity test

Read the parameter page of chip 0 of bus 3

Conclusion

- Ming II is a flexible platform for flash-based research
  - Supports a large range of chips
  - Fine-grain latency and power measurements
  - Easy to use development environment

- Ming II is available to license to researchers and engineers. If you are interested, please contact Prof. Steven Swanson at swanson@eng.ucsd.edu.

- The full technical report is available on our lab's website: http://nvsl.ucsd.edu.

Questions

NVSL
Non-volatile Systems Laboratory

UCSDCSE
Computer Science and Engineering