

Open Sourcing the Integrated Circuit

A talk by

Haig Norian - haig.norian@gmail.com

and

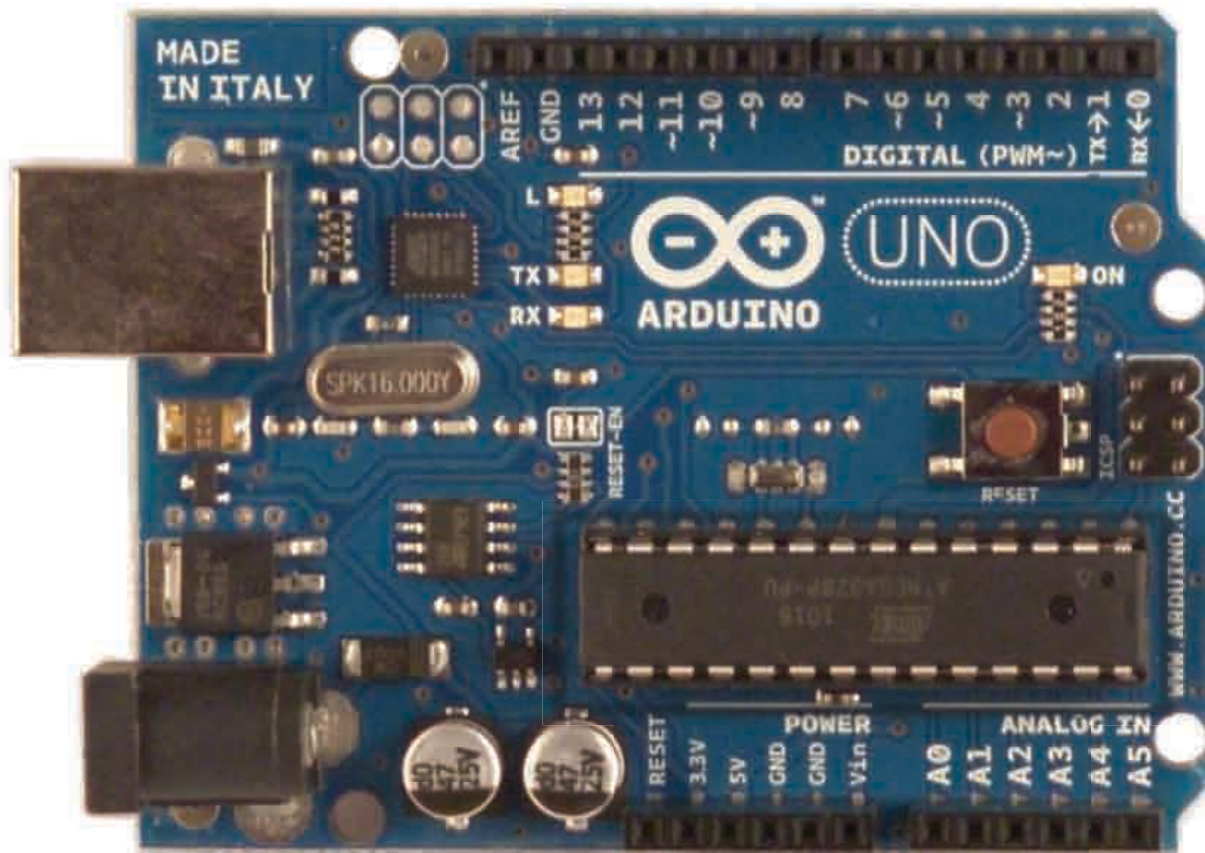
John Sarik - trashbear@gmail.com



Columbia Lab for Unconventional Electronics

How open is open hardware?

- Open source software tool chain
- Open source board design files
- Non-open components



Literal
“black box”

How does a microcontroller work?

- Instruction Set Architecture [ISA]
 - Commands that defines how to store and process data
 - The Atmel AVR is an 8-bit Reduced instruction set computing (RISC) microcontroller

ADD – Add without Carry

Description:

Adds two registers without the C Flag and places the result in the destination register Rd.

Operation:
(i) $Rd \leftarrow Rd + Rr$

Syntax:
(i) ADD Rd,Rr

Operands:
 $0 \leq d \leq 31, 0 \leq r \leq 31$

Program Counter:
 $PC \leftarrow PC + 1$

16-bit Opcode:

0000	11rd	dddd	rrrr
------	------	------	------

- Microarchitecture
 - How the ISA is implemented ???

What's inside a microcontroller?

Atmel AVR ATTiny13V

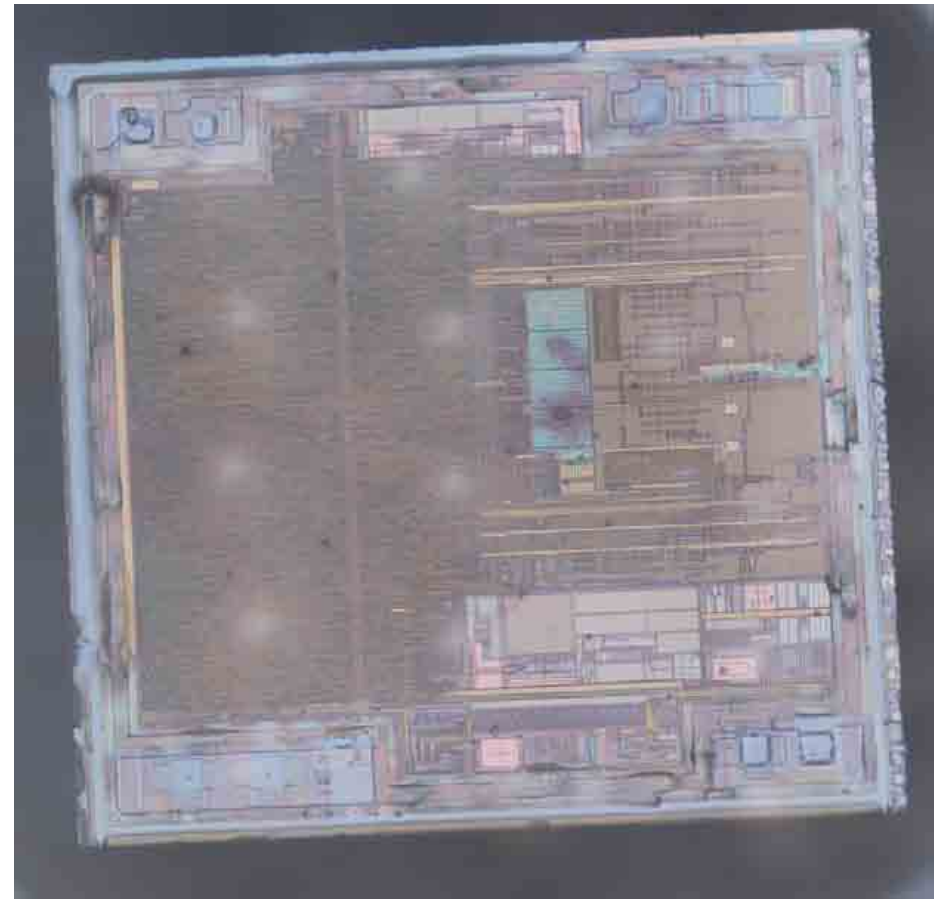
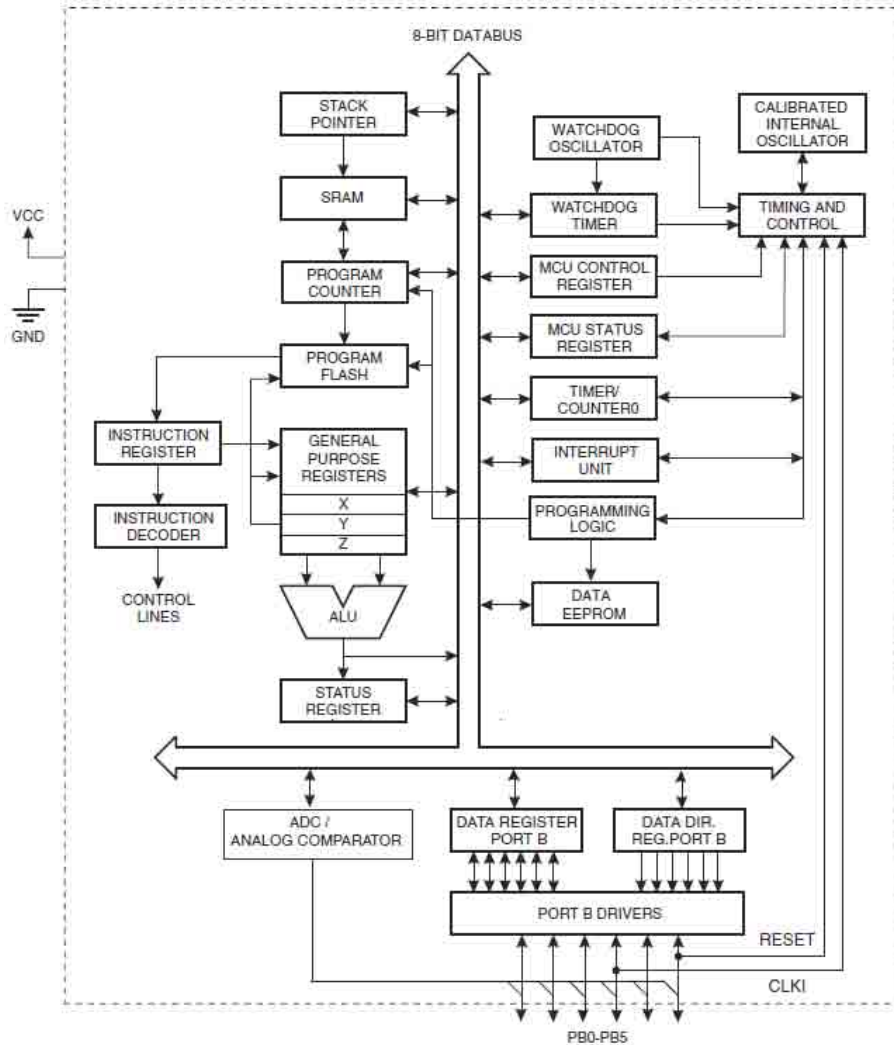
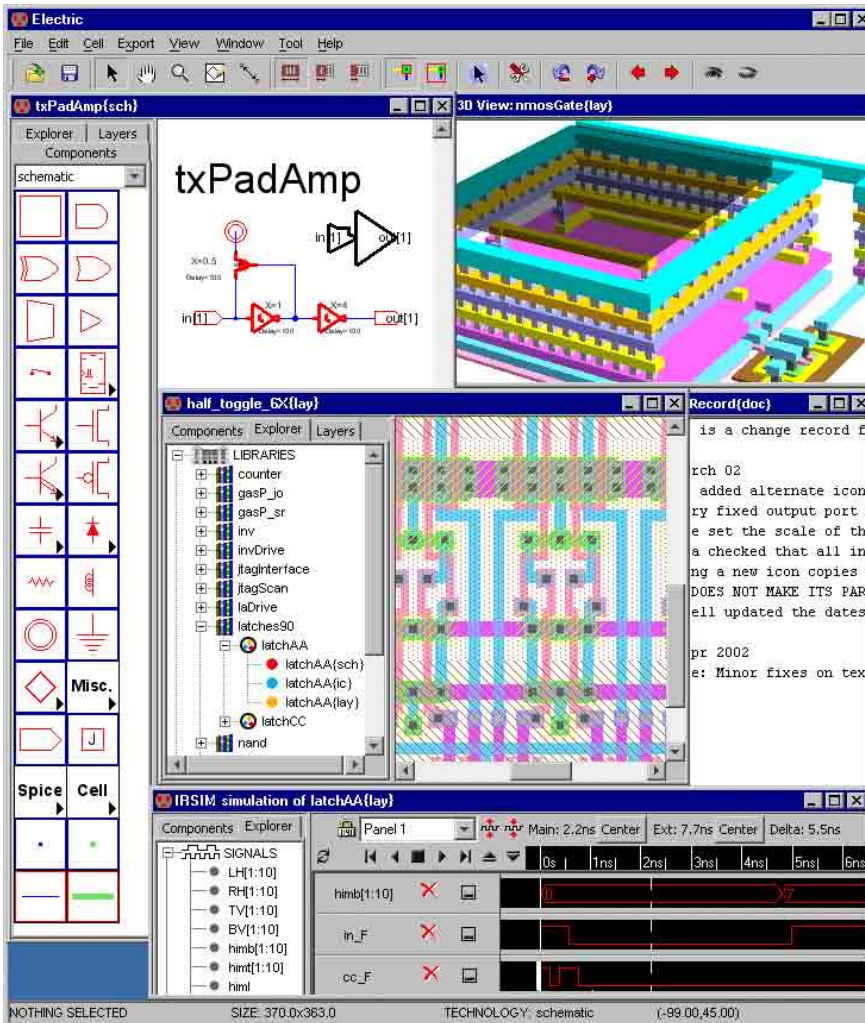


Photo by Travis Goodspeed

What's **really** inside a microcontroller?



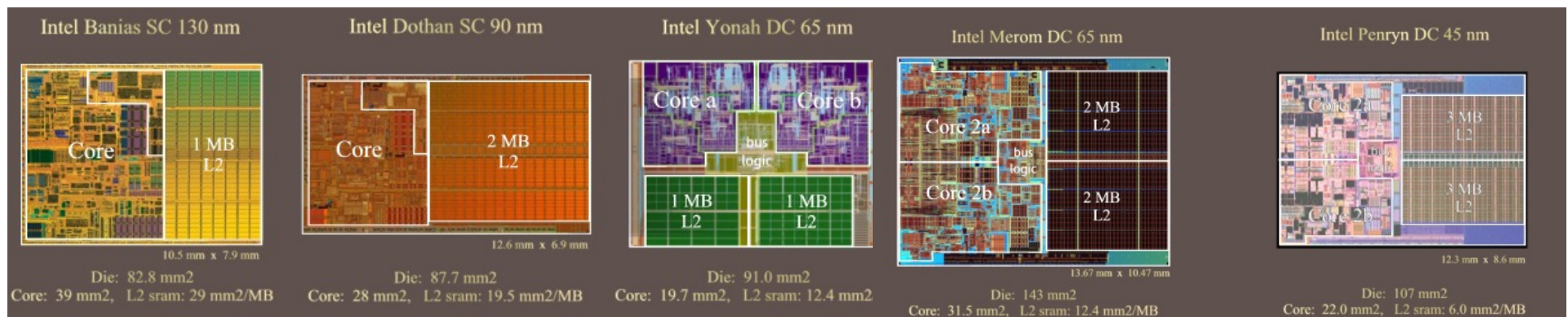
Electric VLSI Design System

- Very-large-scale integration (VLSI) combines millions of transistors into a single chip
- Fedora Electronics Lab is a Linux distro with a collection of open source IC design tools



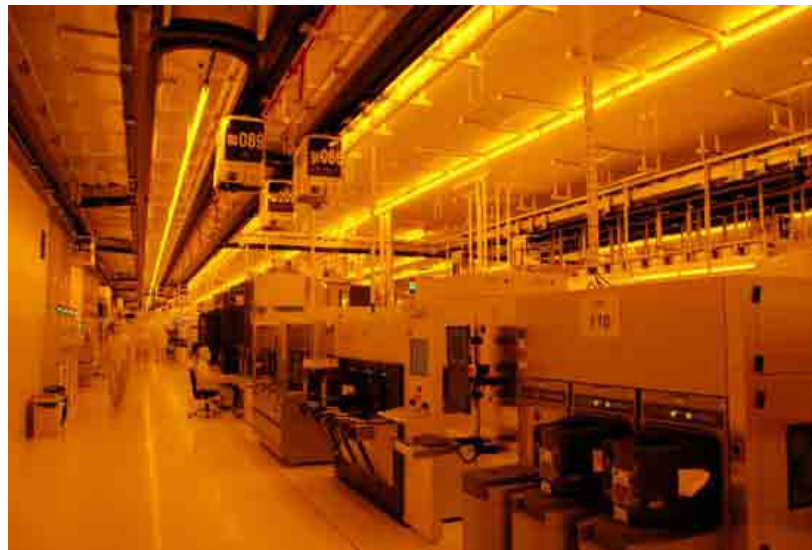
Writing silicon source code

- Start with schematic level simulation
- Create physical layout and simulate
- ICs are designed for one specific fabrication process dependent upon transistor channel length
 - Current standard channel lengths vary from established 350um node [1995] to current state-of-the-art 22nm [2011]
 - Accurate simulations require accurate physical models



Compiling silicon source code

- ICs are fabricated in large batches in foundries
- Innovation is expensive! Globalfoundries newest foundry in Malta, NY costs \$4.6 billion
- However, the fabrication parameters are inherently closed source - protected by patents and trade secrets...



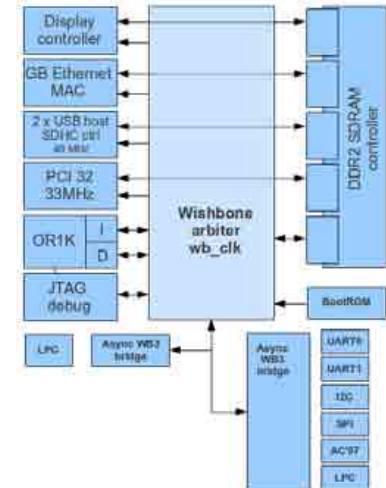
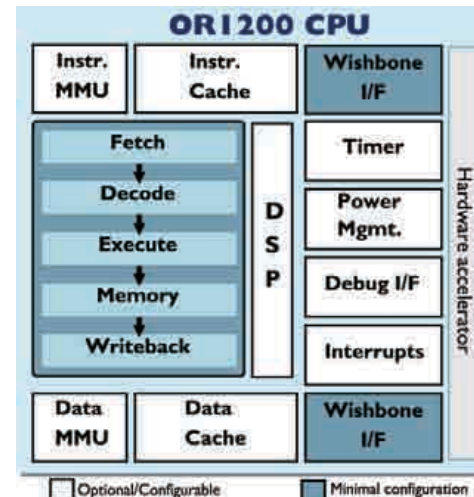
Globalfoundries foundry in Dresden

Open source IC's – Current work

- **OpenCores**

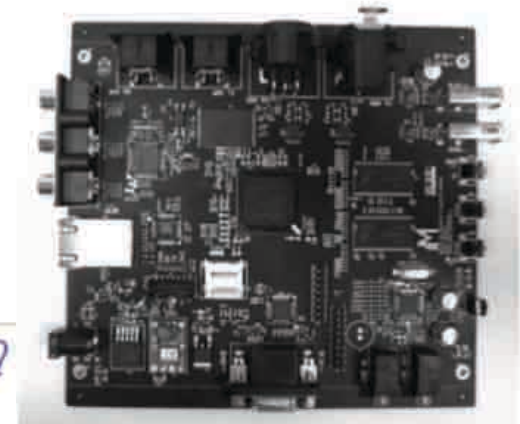
- OpenCores is planning to create an OpenRISC application-specific integrated circuit (ASIC) based on the open source OpenRISC 1000 RISC architecture

**\$18,521.95 from
389 donations so far**
<http://opencores.org/donation>

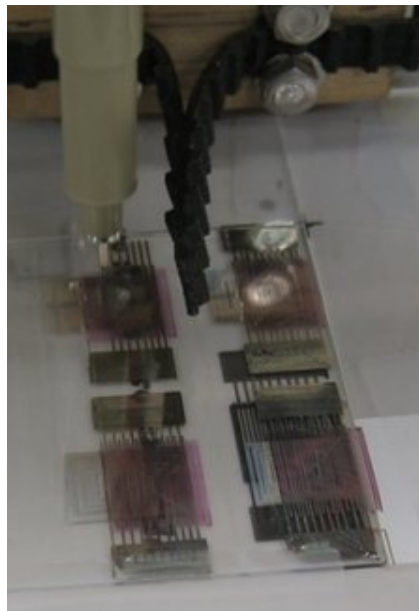
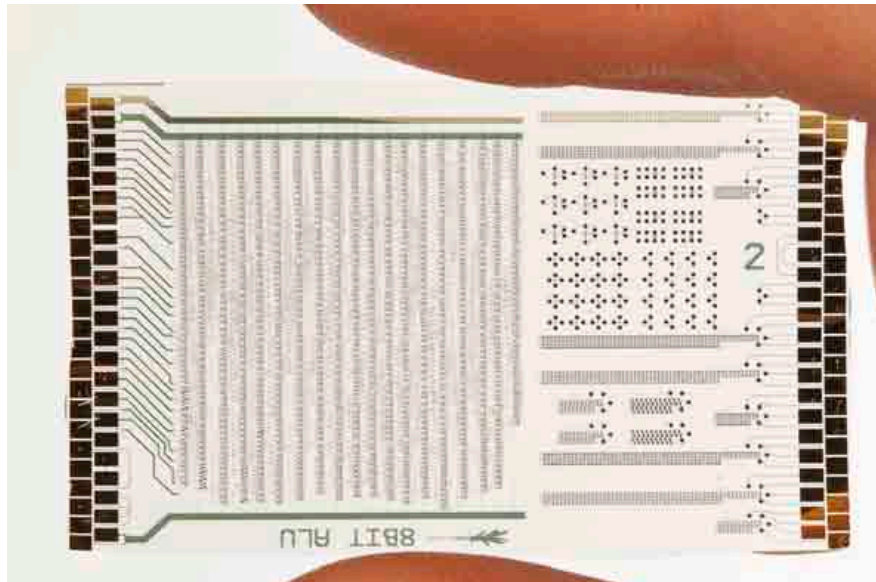


- **Milkymist**

- The Milkymist video accelerator board features a 100% open source system on chip (SoC) design written in Verilog HDL.



An alternative to silicon electronics



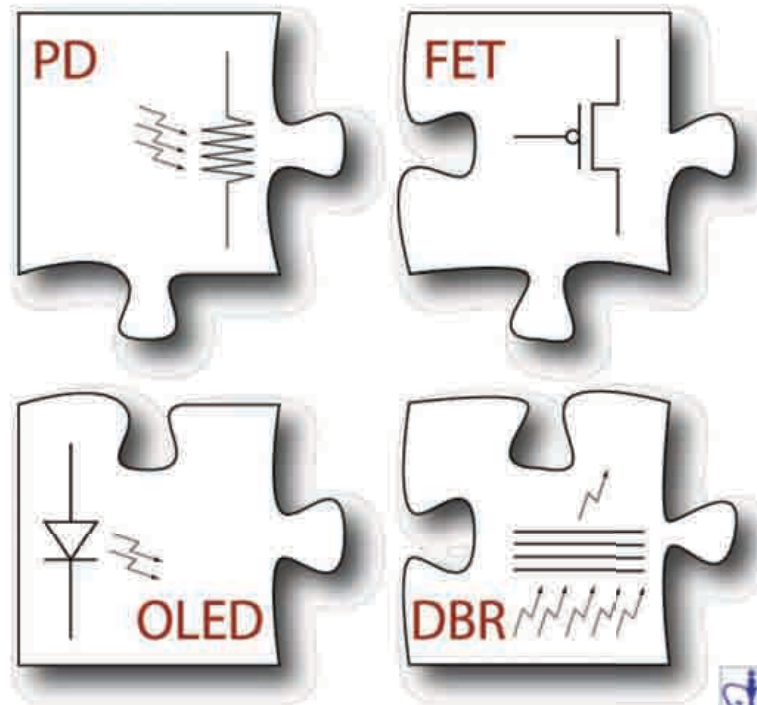
Top: 8-bit organic microprocessor with 4,000 organic thin-film transistors. From imec

Left: Printing organic thin-film transistors with a RepRap. From mr. kim robotics

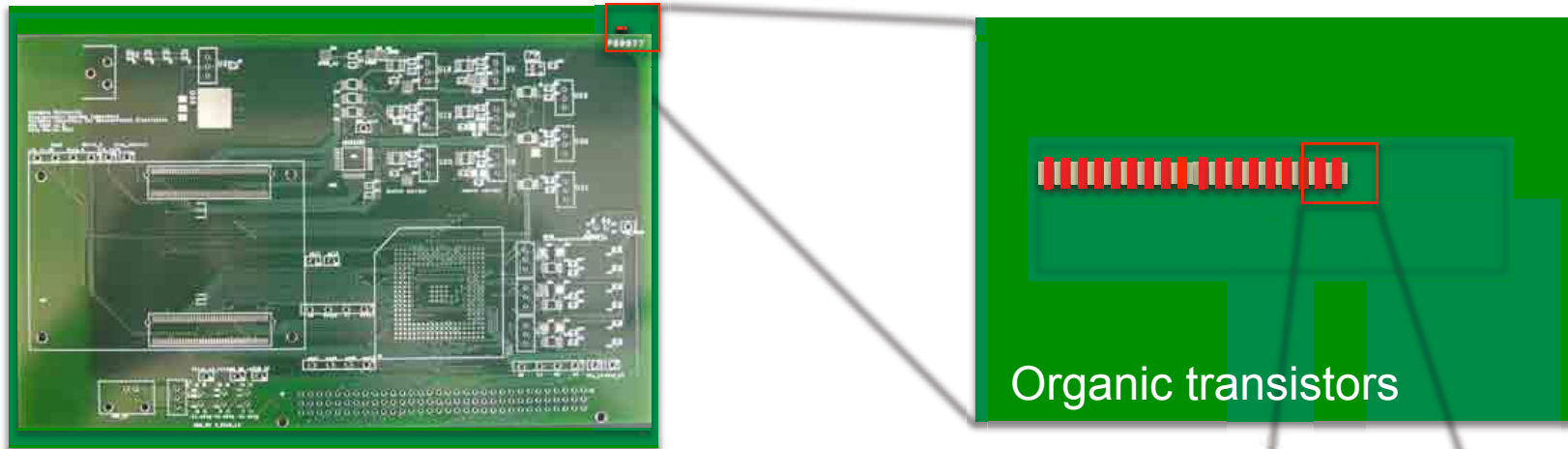
- Electronics built using polymers, plastics, small molecules, and other thin film technologies instead of silicon
- “Good enough” for many applications
- Can build transistors, inverters, op-amps, and microprocessors
- Low cost fabrication such as inkjet printing allows small scale fabrication

Integrating new functionalities

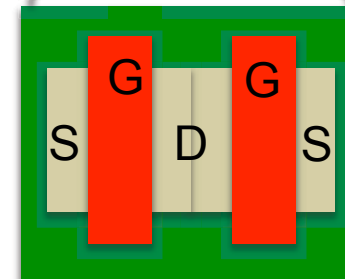
- CLUE is developing a range of component devices that can be integrated on a wide range of substrates to enable unique applications
 - Light emitters
 - Solar cells
 - Strain sensors
 - Photodetectors
 - Thin film batteries
 - Transistors



DIY printable cores



- Use standard PCB platform complemented with printed organic electronics
- Add custom digital logic using inkjet printable organic materials
- Full control over transistor fabrication parameters and digital logic



Conclusion

- Traditional silicon ICs are hard to open source
- “Unconventional” electronics are an attractive alternative
- Now is the time for the community to come together to guide the development of open ICs and open components.

Open Sourcing the Integrated Circuit

THANKS !!

