

Physical Attacks and Inspection of Electronics
EEL 6935 Section 19A1, Class Number 13055
Class Periods: T 8-9 (3pm-4:55pm), R 9 (4:05pm-4:55pm)
Location: Larsen Hall Room 239
Academic Term: Fall 2018

Instructor:

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- Office Phone Number: 352-294-1075
- Office Hours: Wednesdays, 4:00 pm- 6:00 pm, MAE 221

Teaching Assistants:

Please contact through the Canvas website

Course Description

In this course we will focus on the physical inspections, physical attacks, reverse engineering, counterfeit detection, etc. of electronics from the device to system level using advanced microscopy and failure analysis techniques. In additions, students will also learn about the associated countermeasures. *Lecture. Credits 3.*

Course Pre-Requisites / Co-Requisites

- EEL 5934: Introduction to Hardware Security and Trust (or permission of instructor)
- Students are encouraged to have familiarity with imaging, chip layouts, GDSII files, etc.

Course Objectives

The focus of this course is to first introduce the advanced techniques for physical inspection and attacks on electronic systems and components. More than ten modules will be discussed in this course to cover all aspects of this topic. The most recent techniques for physical inspection and attacks are based on the tools and methodologies developed for *failure analysis (FA)* in electronics. FA tools are primarily developed to detect a defect during or after fabrication process, but they have good enough resolution to detect Trojans, extract secret keys, or reverse engineer IC if used maliciously. Such tools include different imaging modalities such as optical microscope, scanning electron microscope (SEM), focused ion beam (FIB), photon emission microscope (PEM), X-ray microscopy (XRM), etc. and probe stations, all of which are part of SCAN lab facilities at FICS Research. It is worth mentioning that these attacks require a very sophisticated sample preparation process to expose a targeted area for reverse engineering or other measurements.

In this course students will learn the basics of running such advanced microscopes and how they are used for physical inspection approaches including: reverse engineering, counterfeit detection, invasive and semi-invasive attacks, on electronics from device to system level.

Materials and Supply Fees

N/A

Recommended Textbooks and Software

Course lectures and notes are developed by the instructor.

Recommended Reading

- M. Tehranipour, U. Guin, and D. Forte, Counterfeit Integrated Circuits: Detection and Avoidance, Springer, 2015
- See list provided on the course website

Course Schedule

| Week | Topics | Hardware | Tools and Techniques | Description |
|------|--|---|---|--|
| 1 | Counterfeit detection I | - Optical microscope - X-ray tomography | N/A | -Microscopy methods to detect defects on electronics |
| 2 | Counterfeit detection II | - SEM - Electron Dispersive Spectroscopy (EDS) | - image processing - filtering, de-noising, etc. | - Common defects and the tools to detect them automatically |
| 3 | Reliability analysis | - X-ray tomography | N/A | - Ionization effect on ICs from X-rays during inspection |
| 4 | Integrity Analysis | - X-ray tomography | - image segmentation - finite element modeling | - Bond wire and ball shear tests - Non-destructive testing for integrity analysis |
| 5 | PCB Reverse engineering I | - X-ray tomography | - 3D image reconstruction | - PCB reverse engineering (RE) - Non-destructive PCB RE |
| 6 | PCB Reverse engineering II | - X-ray tomography | - image segmentation | - Image filtering and segmentation methods for netlist extraction |
| 7 | IC Reverse engineering I | - FIB/SEM | N/A | - IC reverse engineering methods; Sample pre, delayering, etc. |
| 8 | IC Reverse engineering II | - FIB/SEM | - image segmentation | - Basics of automated RE |
| 9 | IC Reverse engineering III | - FIB/SEM | - image processing | - Advanced tools for fast accurate RE, Rapid trojan detection, etc. |
| 10 | Anti-reverse engineering | - FIB/SEM - X-ray tomography | N/A | - Introduce countermeasures for RE: blocking materials, sensors, nano rods, vanishing vias, etc. |
| 11 | Invasive physical attacks on ICs | FIB/SEM | - passive voltage imaging | - Introduce attack modules for data extraction |
| 12 | Semi and non-invasive physical attacks on ICs I | - Photon Emission Microscope (PEM) | - electro optical frequency mapping (EOFM) - electro optical probing (EOP) | - reading non-volatile memory data - Extract keys |
| 13 | Semi and non-invasive physical attacks on ICs II | - Photon Emission Microscope (PEM) | | - Fault injection using laser. -Attacks on PUFs, microprocessors, etc. |
| 14 | Micro-probing and nano-probing attacks | - Micro probe - Nano probe | - electron beam induced current (EBIC) - electron beam absorbed current (EBAC) | - Probing attacks - Extract design for obfuscated gates - Anti-probing techniques |
| 15 | Final presentations and report due | | | |

Attendance Policy, Class Expectations, and Make-Up Policy

Students are expected to attend class lectures and participate in class discussions. Please turn off cell phones in the class.

Evaluation of Grades

| Assignment | Percentage of Final Grade |
|-----------------------|----------------------------------|
| Class participation | 15% |
| Assignments | 25% |
| Final presentation | 20% |
| Final Research Report | 40% |
| TOTAL | 100% |

Grading Policy

| Percent | Grade | Grade Points |
|----------------|--------------|---------------------|
| 93 - 100 | A | 4.00 |
| 90 - 92 | A- | 3.67 |
| 87 - 89 | B+ | 3.33 |
| 83 - 86 | B | 3.00 |
| 80 - 82 | B- | 2.67 |
| 77 - 79 | C+ | 2.33 |
| 73 - 76 | C | 2.00 |
| 70 - 72 | C- | 1.67 |
| 67 - 69 | D+ | 1.33 |
| 63 - 66 | D | 1.00 |
| 60 - 62 | D- | 0.67 |
| 0 - 59 | E | 0.00 |

More information on UF grading policy may be found at:
<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu/evals>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Software Use

All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the

individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Campus Resources:

Health and Wellness

U Matter, We Care:

If you or a friend is in distress, please contact umatter@ufl.edu or 352-392-1575 so that a team member can reach out to the student.

Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.