Physical Attacks and Inspection of Electronics

EEL 4930

Class Periods:

TBD

Location: TBD

Academic Term: Fall 2019

Instructor:

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- Office Phone Number: 352-294-1075
- Office Hours: TBD

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, failure analysis techniques combined with image analysis and machine learning. In additions, students will also learn about the associated countermeasures. *Lecture. Credits 3.*

Course Pre-Requisites / Co-Requisites

- EEL 3112- Circuits 2
- Permission of the instructor

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.

In this course students will learn the principle of 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. There will be lab demos for each and every microscope so students can watch from close how the machines are operated and learn about the associated challenges on how one can use them for hardware security.

Materials and Supply Fees

N/A

Recommended Textbooks and Software

Course lectures and notes are developed by the instructor.

Recommended Reading

- M. Tehranipoor, 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	- image processing - machine learning - filtering, de-noising, etc.	-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
4	Integrity and Reliability Analysis	- X-ray tomography	- finite element modeling	- Bond wire and ball shear tests - Non-destructive testing for integrity analysis - Ionization effect on ICs from X-rays during inspection
5	PCB Reverse engineering	- X-ray tomography	- 3D image reconstruction - image segmentation - machine learning	- PCB reverse engineering (RE) - Non-destructive PCB RE
6	IC Reverse engineering I	ASAP-1	N/A	- IC depacking and thinning
7	IC Reverse engineering II	- FIB/SEM	N/A	- IC delayering, large area imaging, etc.
8	IC Reverse engineering III	- FIB/SEM	-Netlist extraction sing PiX2Net - machine learning	- Basics of automated RE
9	Trojan Scanner	- FIB/SEM	- image processing - machine learning	- Advanced tools for 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	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
12	Semi and non-invasive physical attacks on ICs II	- Photon Emission Microscope (PEM)		- Fault injection using laser. -Attacks on PUFs, microprocessors, etc.
13	Invasive physical attacks on ICs	FIB/SEM	- passive voltage imaging	- Introduce attack modules for data extraction
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

Excused absences are consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx) and require appropriate documentation.

Evaluation of Grades

Assignment	Percentage of Final Grade
Homework	20%
Mid-term exam	25%
Final presentation	25%
Final Exam	30%
TOTAL	100%

Assignments: Students will be assigned to collect images from ICs using some of the microscopes in the lab and analyze them based on the algorithms taught in lectures for either reverse engineering or attacks. Each student will be given few samples to work on.
Final presentations: There will be papers assigned to each student to present. The presentations are expected to show the understanding of the topic from the stand point of what they have learned through the semester.
Mid-term and final exam will be testing your knowledge on the material from lectures covered through the semester.

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 suppor*t*, 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.