URCAD
UNIVERSITY RESEARCH AND CREATIVE ACHIEVEMENT DAY

Oral Presentations – Afternoon Session 3

Location: AIH 217

Time: 12:00 PM – 2:00 PM

Cooling System Incorporation of Compressed Dry-Air

Jayson Arichavala, Tom Bukovsky, Benjamin Fields, and Daniel Glucinski
Mechanical Engineering
Advisor: Dr. Luz Amaya

Modern chipmaking relies on photolithography processes that introduce heat into the reticle during wafer production, threatening the dimensional accuracy required for precise feature transfer. To address this, a compact and cost-effective cooling system has been designed and validated in response to specific requirements from ASML. The proposed solution utilizes compressed dry air delivered through a vortex tube cooler, which can discharge air at below-zero degrees Celsius with no moving mechanical components, eliminating concerns related to foreign object debris (FOD) and water vapor contamination common in liquid-based alternatives. A custom test chamber measuring 400 mm × 400 mm × 62 mm was 3D printed using PLA filament to recreate an EUV lithography manufacturing environment. An aluminum plate in contact with a 20 W heating element simulates the thermal load introduced during photolithography, while a transparent acrylic cover plate allows for visual observation during testing. The chamber features interchangeable inlet geometries, enabling systematic evaluation of how nozzle design affects cooling performance, turbulence characteristics, and acoustic output. Beyond temperature management, the system addresses critical operational constraints including low noise, vibration mitigation, and cleanroom compatibility. Turbulent airflow inherent to vortex tube operation poses a risk of dimensional shifts in the wafer product, making the relationship between flow rate and vibration a central design consideration. A sound level meter positioned one foot from the chamber records decibel levels across operating conditions, and four thermocouples distributed across the aluminum surface captures steady-state temperature data. Theoretical heat transfer and fluid dynamics analysis, including Reynolds number estimation and compressible flow modeling, were conducted alongside Computational Fluid Dynamics (CFD) simulations to evaluate airflow behavior and pressure distribution prior to fabrication. Experimental results across varying vortex tube cold fractions and inlet geometries are compared against a zero-flow baseline to determine optimal operating conditions and cooling effectiveness. This project demonstrates the feasibility of a clean, low-maintenance, air-based cooling solution that meets the stringent demands of EUV lithography environments, offering a scalable alternative to liquid cooling where vibration, contamination, and cost are critical constraints.

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Lake Debris Removal Device

Majd Al Abas, Anthony Arizaga, Akib Lodhi, Joshua Perez
Mechanical Engineering Technology
Advisor: Dr. Luz Amaya

Water is an essential necessity for supporting wildlife, human and ecological needs because of fresh drinking water, biodiversity of all life, as well as possibilities for recreational use. Serious medical issues, such as infections and other waterborne ailments, can result from contaminated water. Urbanization, agricultural runoff, industrial discharge, and inappropriate waste disposal are some of the many causes of pollution. With the rise of pollution levels, all bodies of water are becoming more and more susceptible to being uninhabitable. The crucial need for a workable, affordable, and ecologically responsible way to reduce pollution is addressed by this senior design project. This project focused on creating a remotely controlled waste collecting system that can gather floating trash such as bags, bottle caps, plastic bottles, and wrappers. The completed prototype has a battery-operated thruster system, a specially designed conveyor belt system for constant waste collection, and a sturdy construction made of PLA plastic reinforced with carbon fiber tubing for cost effectiveness, buoyancy, and resistance to corrosion. A conveyor-based collecting approach was chosen as the best compromise between cost, ease of use, and performance after various design options were compared using a Pugh Matrix. SolidWorks was the program used for modeling a majority of the components. The completed assembly showed efficient waste collection with minimal environmental disruption, according to field tests. The tests verified the device's ability to navigate through ponds, gather significant volumes of waste, and function dependably. Additionally, this project provided valuable practical engineering experience, improved on areas with basic to minimal knowledge on such as programing, 3D printing, machining as well as financial literacy.

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Unmanned Ground Vehicle (UGV)

Karen Ninson, Konnor Busiere, Lionel Wanyama, Quan Ly
Electrical and Mechanical Engineering
Advisor: Dr. David Broderick and Dr. Luz Amaya

This capstone project presents the development of an unmanned ground vehicle (UGV) designed for outdoor testing and operation in urban environments. The primary objective of the system is to support security and inspection tasks by enhancing operator situational awareness prior to entering potentially unsecured areas. In its current design iteration, the UGV utilizes GPS and IMU data for localization, orientation, and navigation during outdoor missions. The platform features a lightweight, rigid, and modular predominantly metal chassis engineered for durability, along with a conventional steering system suitable for typical urban terrain, enabling stable and reliable operation. By integrating positioning, motion sensing, and wireless communication, the system delivers a practical operator-centric solution that improves safety and operational efficiency in outdoor patrol and monitoring applications.

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3D Fabricated (902-928 MHz) Microstrip Antenna ISM band Application

Alvato Prendi, Arianna Clarke, and Le Nguyen Czaja
Electrical Engineering
Advisor: Dr. David Broderick

A compact microstrip patch antenna design for the 902–928 MHz Industrial, Scientific, and Medical (ISM) band is developed to support low-cost, reproducible wireless prototyping for applications such as RFID, IoT sensor nodes, metering, and industrial telemetry. The design targets operation near 915 MHz with a 50 Ω input match at the SMA reference plane, linear polarization, and performance objectives including $|S11| \leq -10$ dB across as much of the ISM band as practical and a realized gain on the order of 2–3 dB. To improve accessibility and enable rapid iteration without specialized RF PCB fabrication, the antenna structure is implemented using a 3D-printed ABS dielectric body with a conductive silver coating forming the radiating patch and ground conductor. Initial dimensions are established using closed-form microstrip patch equations and then refined using full-wave electromagnetic simulation in Ansys HFSS to determine final geometry and feed placement. A fabrication and test workflow is defined for prototype construction and VNA-based validation, with final tuning and experimental verification planned as remaining work. The resulting methodology and documentation are intended to serve as a reusable template for future student projects and low-cost ISM-band systems.

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Protection application of Lightweight Meta Structures

Hasan Aburumi
Mechanical Engineering
Advisor: Dr. Mohammad Reza Vaziri Sereshk

The expanding use of lattice structures for protective applications can be further extended to sacrificial components in cashbox for civilian vehicles and blast-box for military armor vehicles. To fulfill these roles effectively, it is essential to enhance their impact absorption capabilities—not only to dissipate energy but also to prevent structural damage and reduce the risk of injury to occupants. Structural analysis of 3D printed cell structures. Analysis is performed on Ansys workbench and then verified by running actual testing. Both analysis consists of studying critical buckling, stress, strain energy, and deformation of cells when it's subjected to a compression load. This is used to evaluate effectiveness of some novel lightweight meta-structures for absorbing energy and mitigating impact.

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Instrumentation of Thermocouples for Heat Sink Data Collection

Konrad Piech, Benjamin Goode, and Kurt Freda
Electrical Engineering
Advisor: Dr. David Broderick

Access to safe drinking water remains a significant challenge in many regions worldwide and is further magnified during natural disasters. When damaged infrastructure makes the energy cost of delivering water unfeasible, it becomes more practical to source water locally. However there remains in energy cost because of desalination, purification, or condensation. This work extends previous work by Dr. Luz Amaya and Dr. David Broderick to provide a potable water source which condenses atmospheric moisture using thermoelectric cooling devices. Improving upon the efficiency of such a device such that energy and moisture can be sourced locally will lead towards a reliable and continuous source of water independent of a supply chain. One aspect that affects the efficiency of the final device is the heat sink design of the hot-side of the thermoelectric cooling (TEC) modules. As such, it becomes necessary to gather real world data of the performance of several heat sink designs in a simulated environment. This work consists of the control of the TEC devices, and the instrumentation of a significant number of thermocouples required gather the necessary data. The primary goal of the work is to create a custom printed circuit board (PCB) which reads and stores data from up to sixteen temperature sensing thermocouples for the purposes of experimental data collection. The secondary and tertiary goals are to control several TEC modules and conduct appropriate testing.