NEXT-GENERATION ELECTROSTATIC AIR FILTRATION MASK

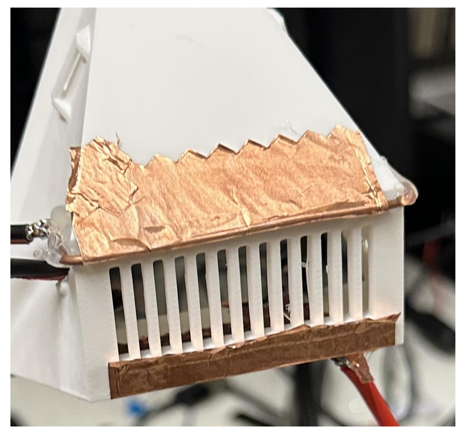
STUDENTS: BOBBY WENG, JOSH CORBETT, JT PIKUL, WILLIAM PHILLIPS, NGHI HUYNH

Introduction

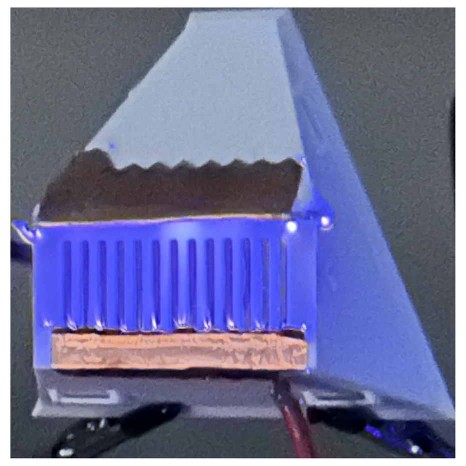
- Project originated during the COVID-19 pandemic to explore alternatives to traditional disposable paper masks.
- A study by National Geographic in 2021 found that 3.4 billion single-use masks were discarded of daily, resulting in 1.6 million tons of plastic waste, our reusable mask would cut down single use mask waste significantly.
- Beyond COVID-19, particles such as smoke, gas, dust, allergens, and other bacteria can be captured by the mask.

Plasma Generation

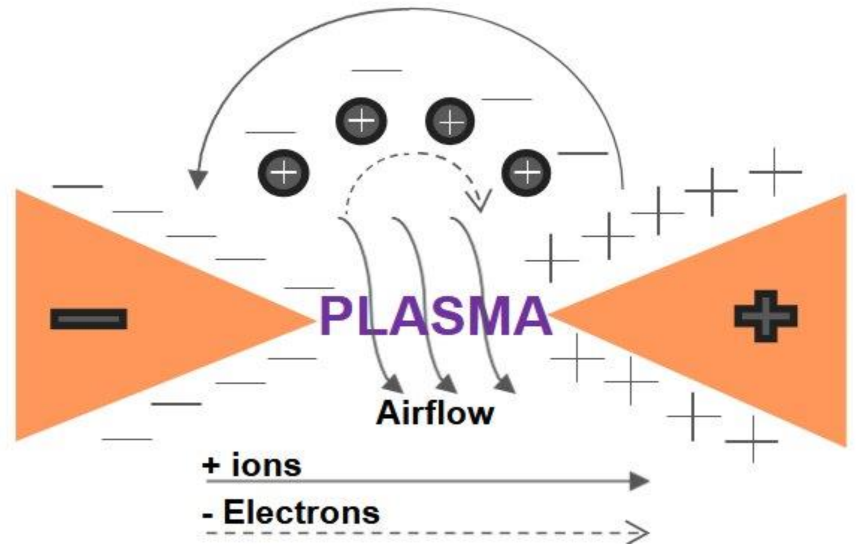
- Electrostatic precipitates (ESPs) are used to capture particles through a strong electric field.
- Two oppositely charged electrodes to make the ESP: one as a discharger and one as a collector.
- Corona discharge created from ESPs when a high voltage direct current (HVDC) source is used.
- Strong electric field ionizes airborne particles, with the positively charged ions creating an airstream.
- The positive(discharge) electrode repels the positive ions; the negative (capture) electrode collects ionized particles.
- Airflow is created between the electrodes, allowing purified air to pass through plasma to the user.



Mask turned off; no plasma generation.



Mask turned on; plasma glow visible.

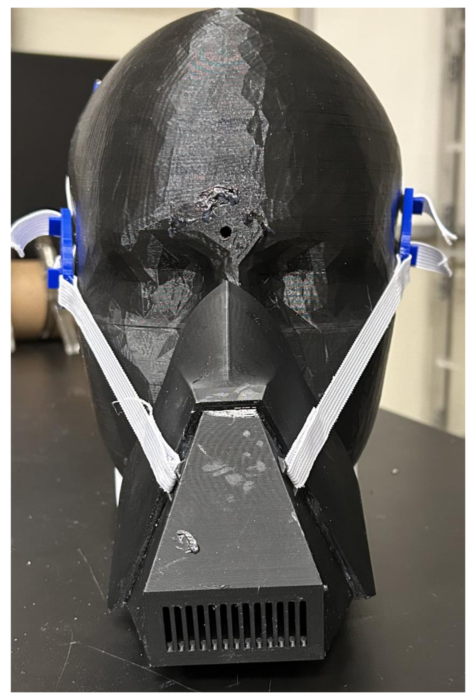


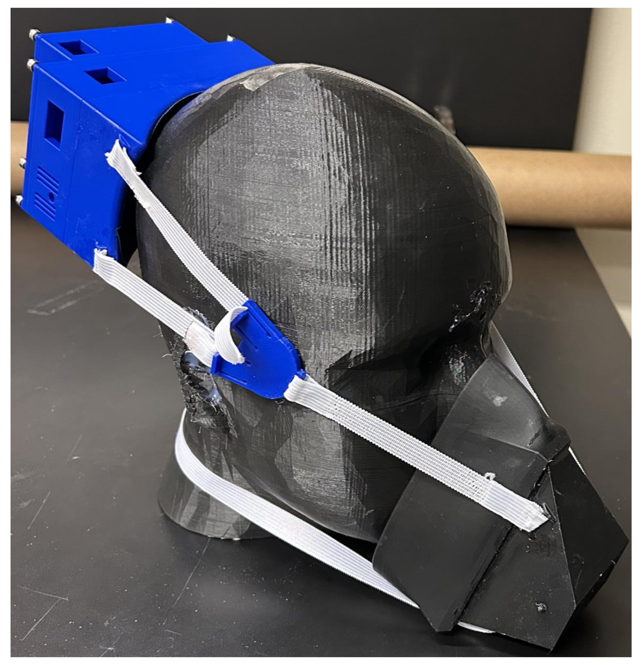
Objectives

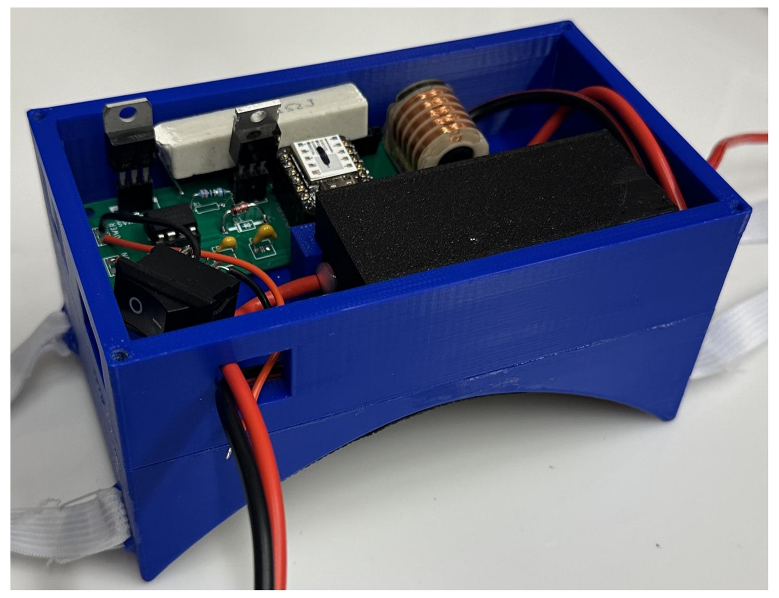
- Improve power circuit to eliminate arcing between electrodes.
- Minimum one hour of continuous operation powered by a rechargeable battery.
- Integrate a microcontroller to drive PWM generation and sensor modules.
- Implement sensors and an LCD screen to monitor mask conditions.
- Redesign mask to improve ergonomics, reduce weight, improve overall user comfort, and improve user safety.

Mask Design

- **Electronics Storage:** The electronics module is now fully modular, including separate compartments for the battery, PCB, switch, voltage multiplier, and a cooling fan. Its curved back fits naturally on the user's head, secured with elastic straps and rubber grip tape for added stability.
- **Front Shield:** Made from PLA, the front shield holds the electrodes 18mm apart for optimal plasma generation. It connects to the electronics housing via elastic straps and a coupling piece.
- **Rear Shield:** Currently fabricated with Spider Wire 75A, the rear shield conforms to the user's face. It links to the front shield using a trapezoidal interface with both adhesive and pin connectors. A proof of concept with a silicone rear has been injection molded with Dragon Skin 30A for the next iteration.

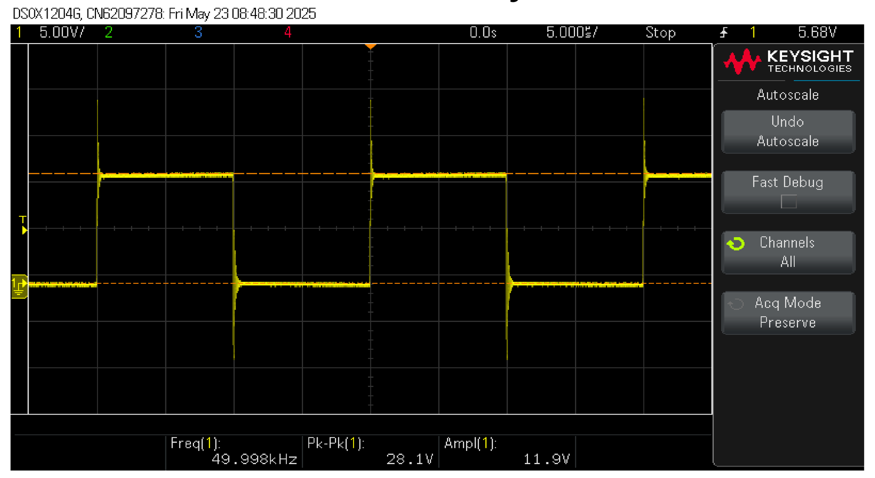


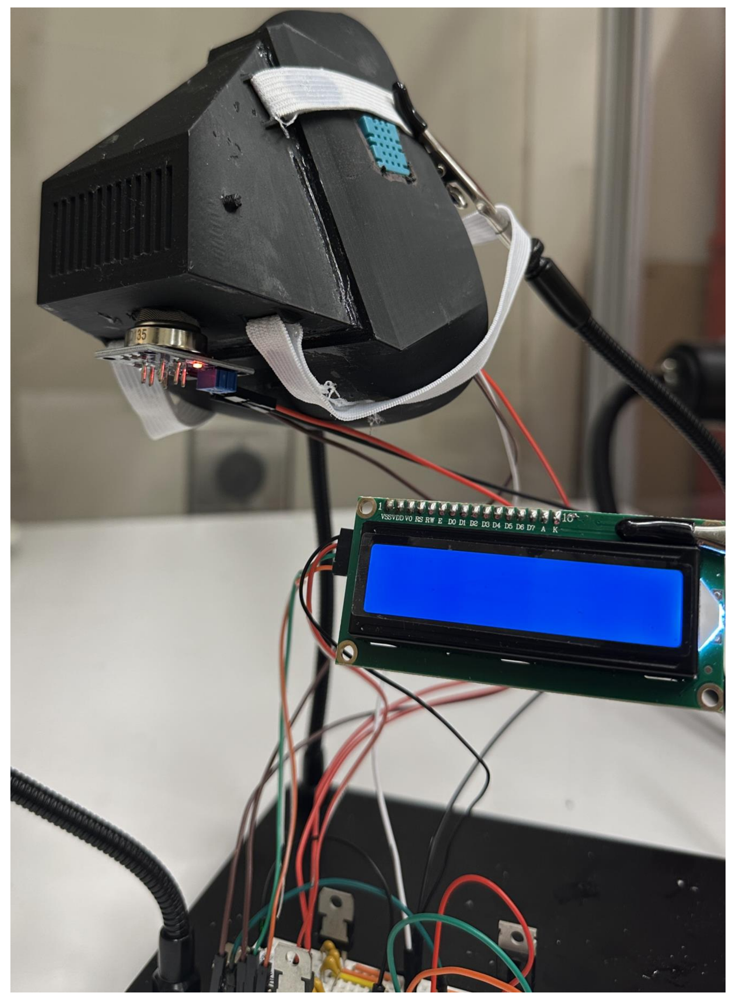




Sensor-Driven Control Feedback

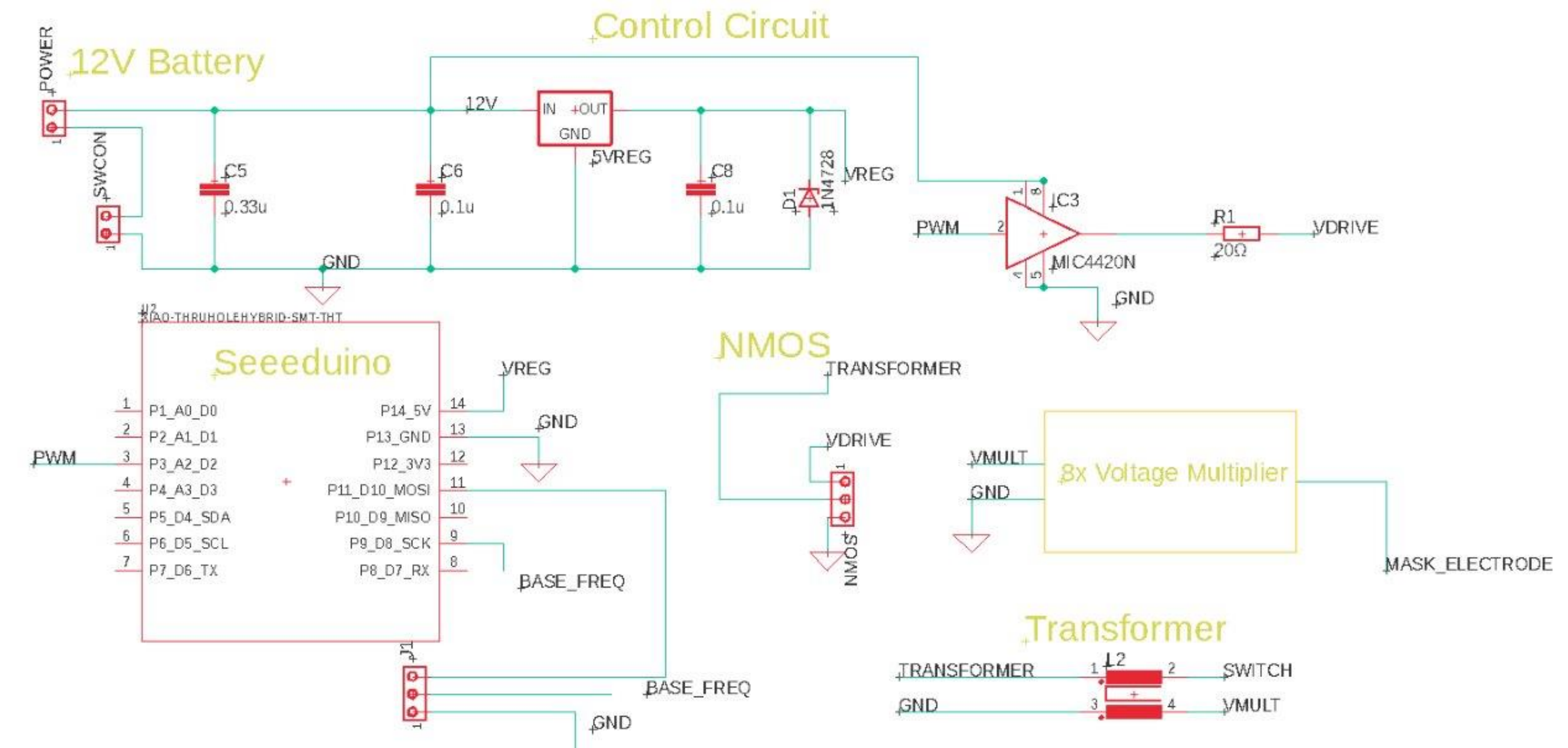
- **Seed Studio XIAO SAMD21:** Microcontroller that incorporates Arduino libraries to implement a scheduler that manages the sensor data, PWM duty cycle, battery percentage calculations, and information display.
- **MQ-135 Air Quality Module:** Detects harmful gases (e.g., CO2, NO2, ammonia, smoke) and boosts filtration if pollutant levels exceed safety limits.
- **DHT11 Temperature & Humidity Module:** Measures ambient temperature and humidity to optimize electrostatic performance.
- **Liquid Crystal Display (LCD):** Displays data acquired by the sensors and monitor battery life.

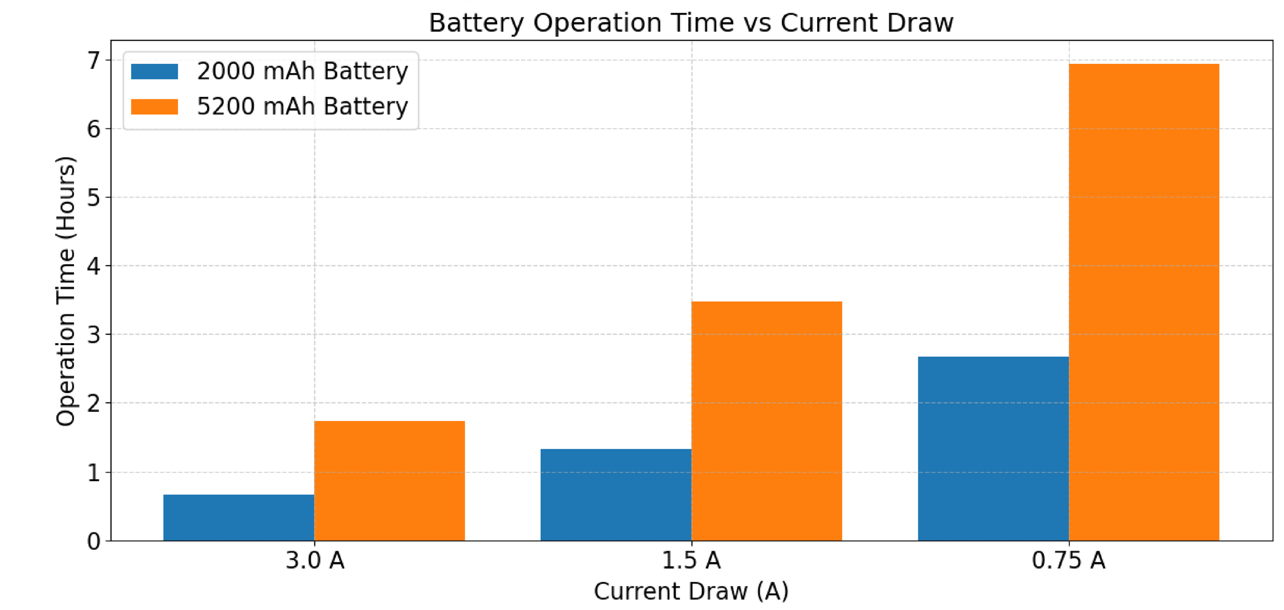




Fully Reengineered Power Circuit & PCB

- Redesigned the HVDC circuit to produce a higher voltage output that is more stable and added circuit protection to prevent component damage.
- Integrated all parts into a more compact PCB, significantly reducing system size and weight, enabling a lighter and more comfortable mask housing.
- Implemented a larger 5200mAh 12.6V rechargeable battery capable of producing 17.5kV across the electrodes for over 6 hours.





Conclusions & Future Work

Our team has successfully:

- Designed a HVDC circuit capable of producing stable plasma at 17.5kV.
- Refined mask fitment, ergonomics, and weight, improving on original mask's fitment and practicality.
- Implemented sensors to monitor vital information about the mask's filtration performance and conditions.
- Developed an effective and reusable filtration mask created for long-term wear and enhancing air quality for pandemic use and beyond.

The next steps for this project will be:

- Extended particle capture testing.
- Fine-tune ergonomics(weight distribution, breathability, adjustability).
- Durability: Temperature and impact resistance tests, life span.
- User surveys & testing.

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

ADVISERS: ALEXANDER MAMISHEV, WINSTON SUN

SPONSOR: UNIVERSITY OF WASHINGTON SENSORS, ENERGY, AND AUTOMATION LABRATORY