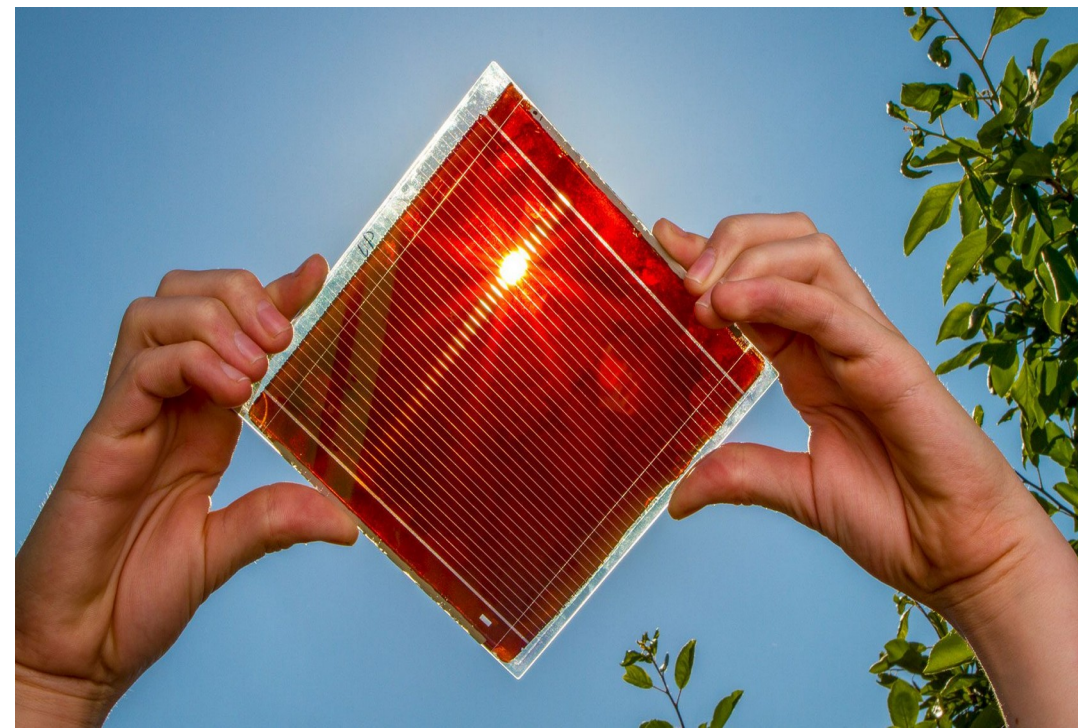
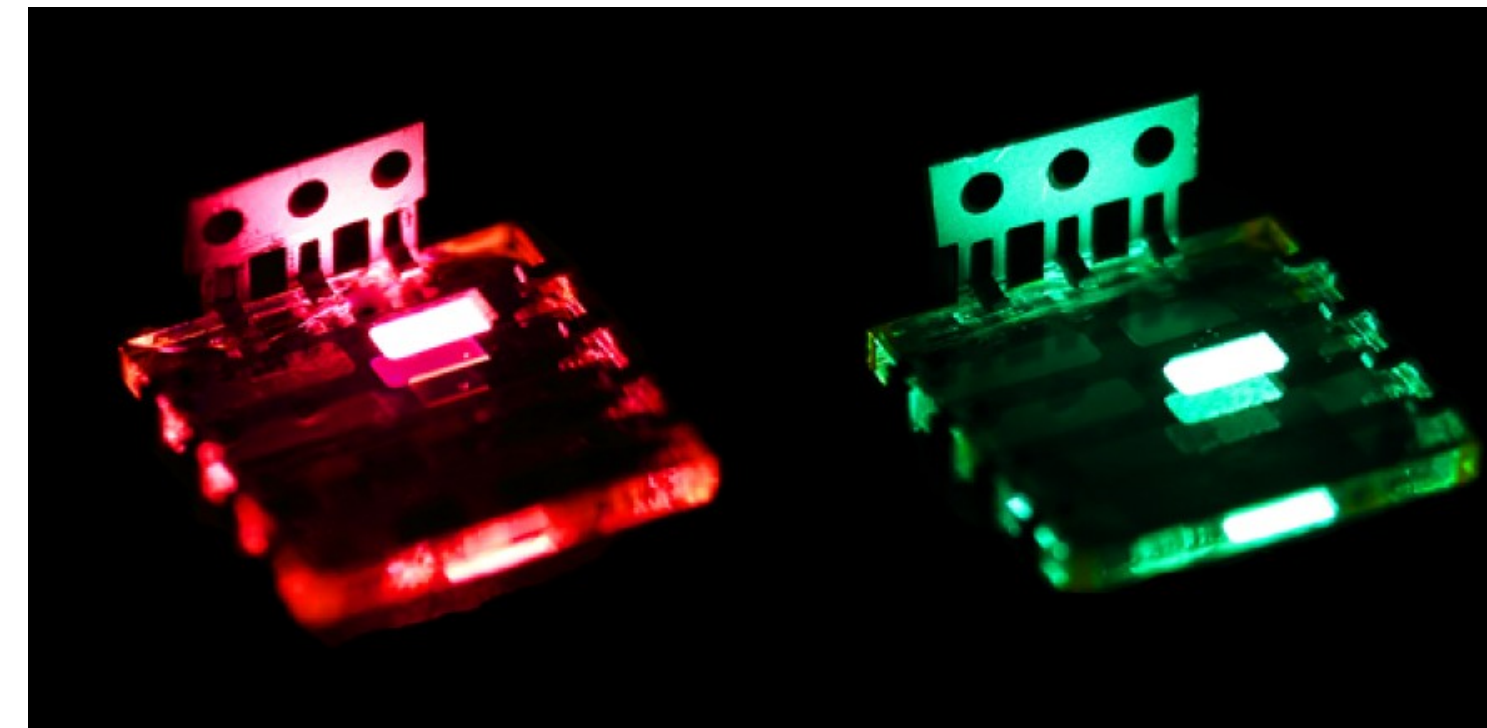


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Introduction



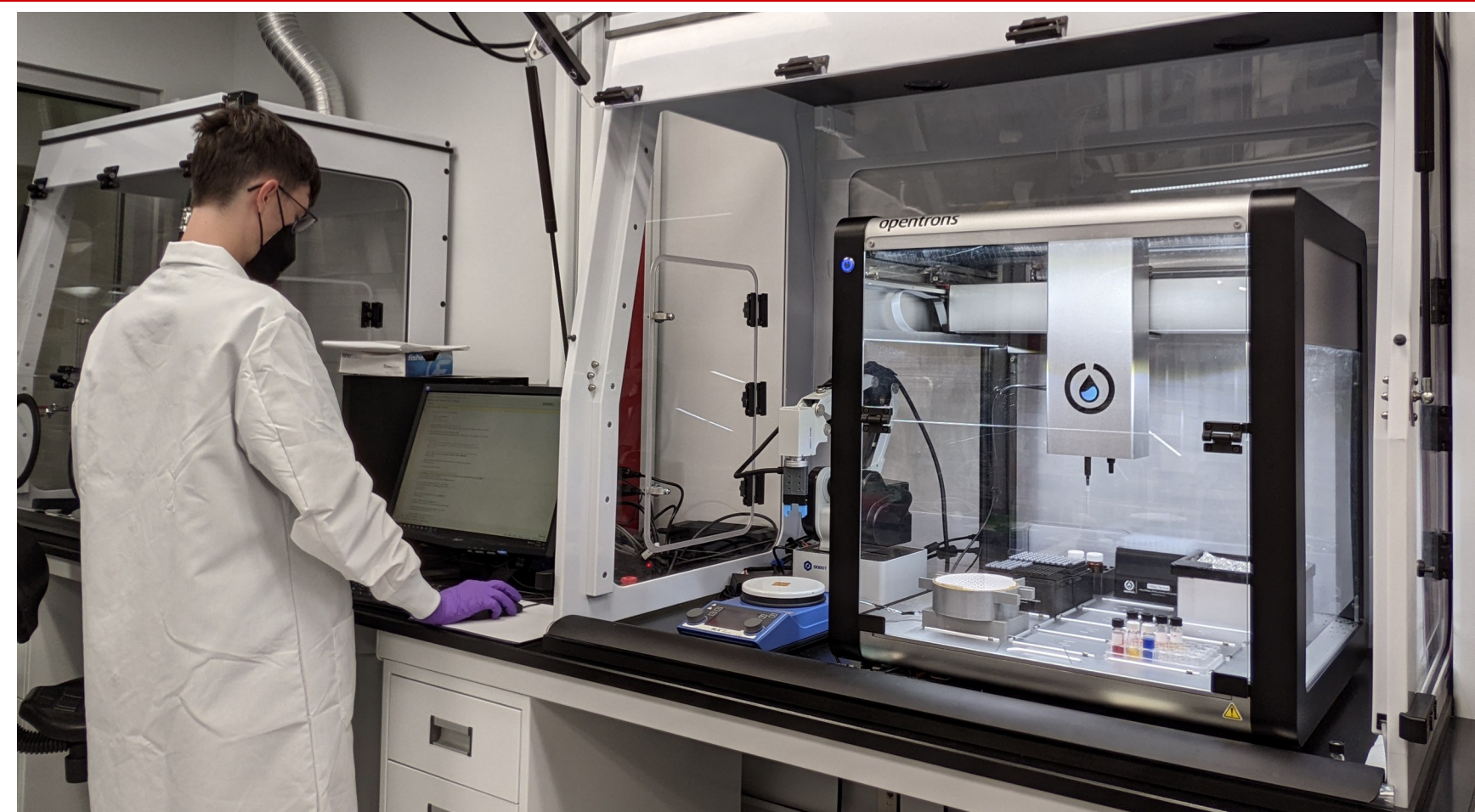
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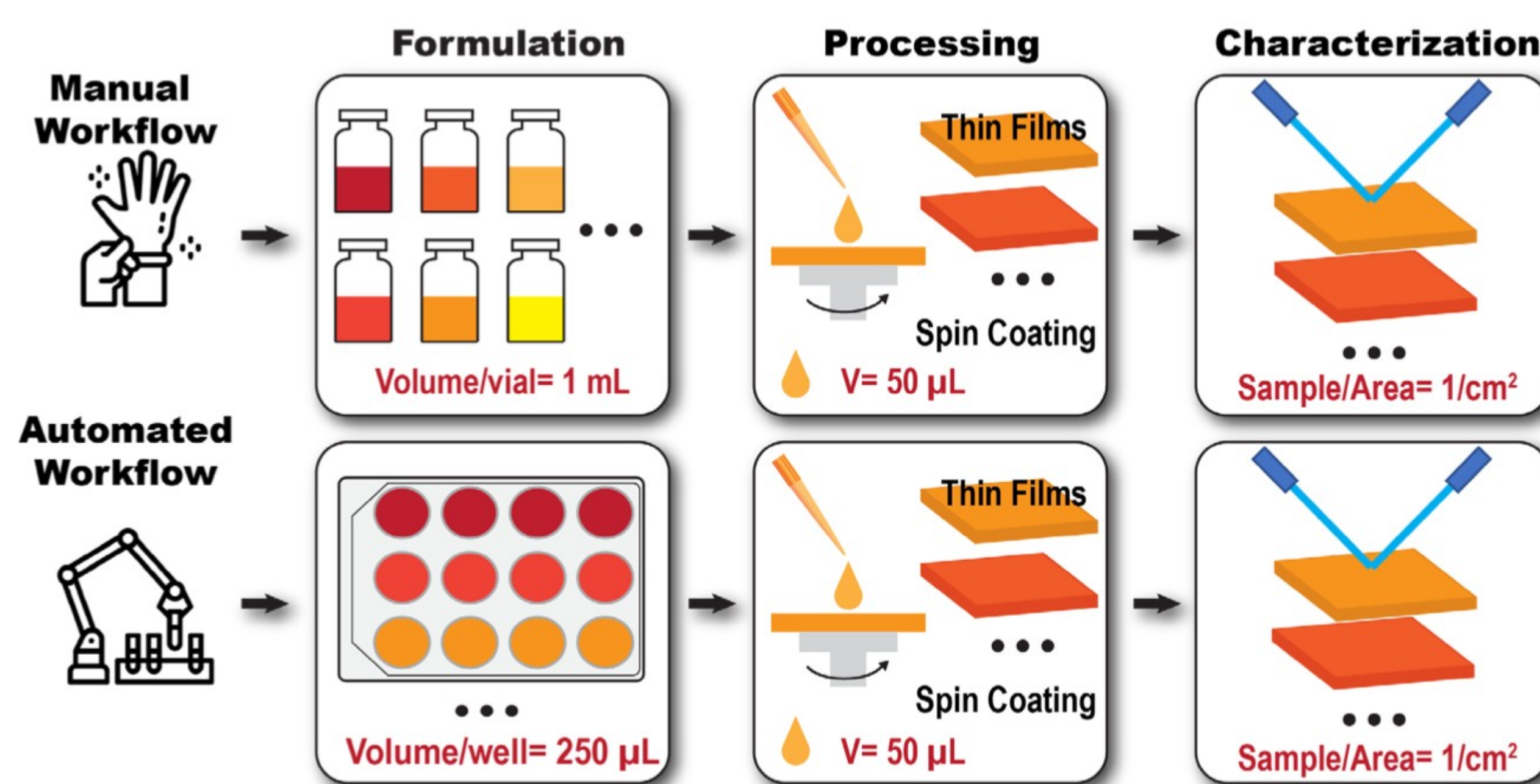
Metal-halide perovskites are a promising new semiconductor material for photovoltaic, LED, and optoelectronic devices. Hybrid perovskites have many beneficial properties compared to silicon. Advantages include strong absorption, bandgap tunability, efficient charge transport, and high defect tolerance. But, current mixtures have poor stability.

Motivation



Optimizing this material requires testing many chemical mixtures. Testing tens or hundreds of samples may take weeks for a student to create and test. We have developed a platform that automates most of the perovskite creation and testing process. Our project aims to free up the chemist while testing many different material combinations.

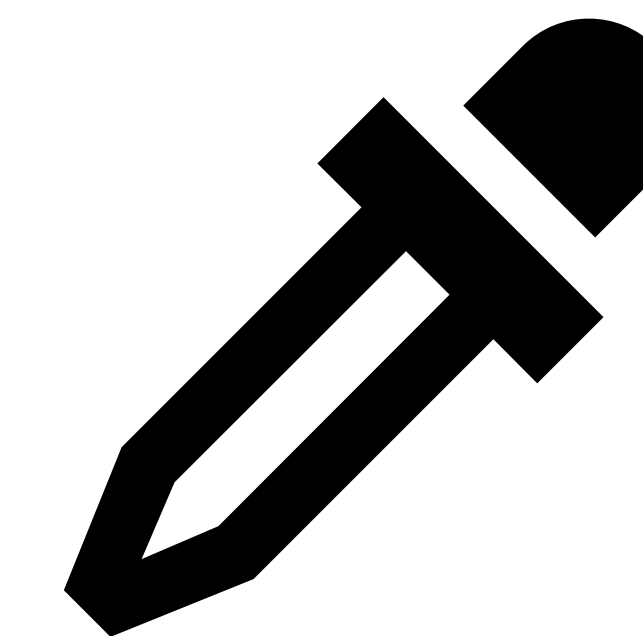
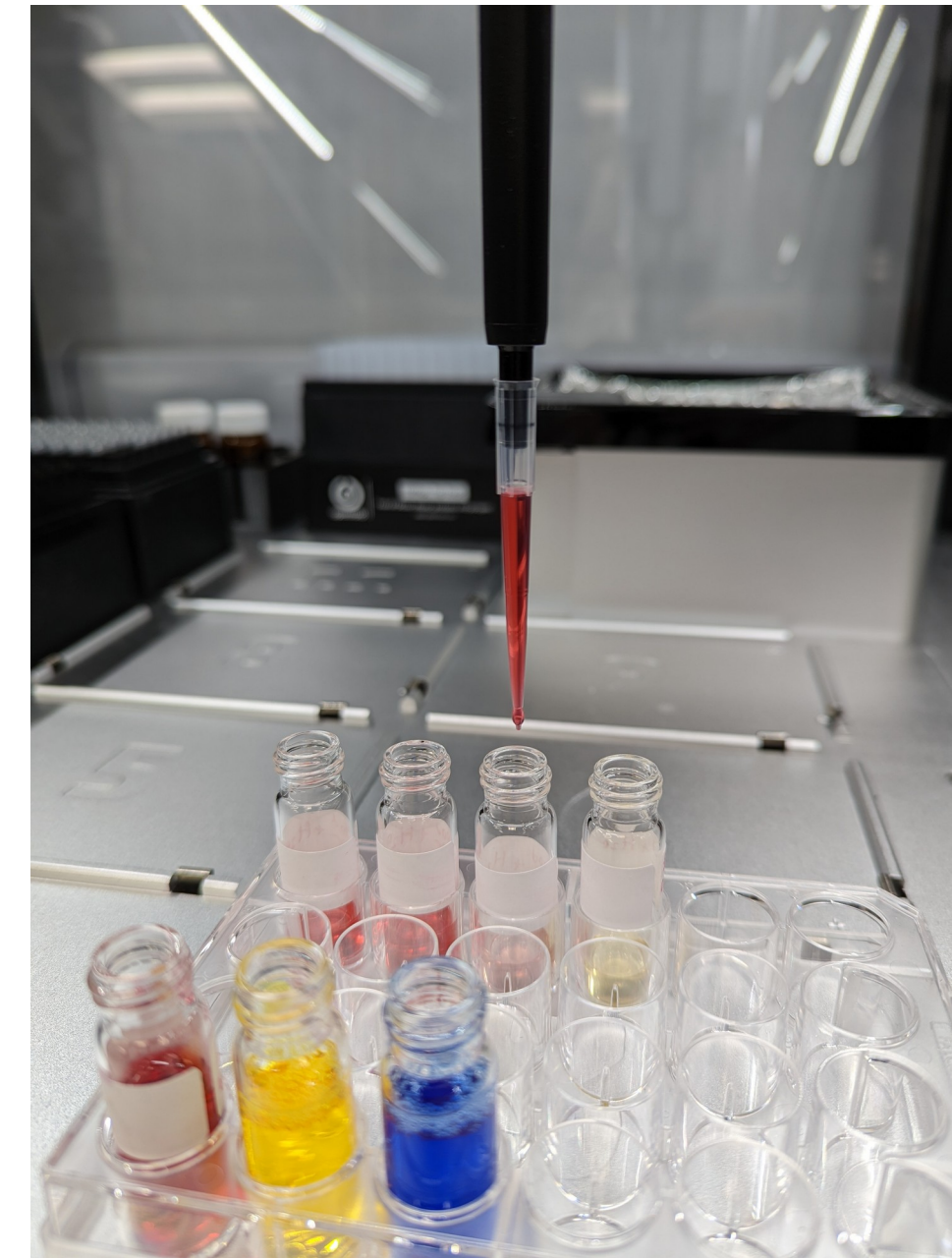
Manual vs Automated



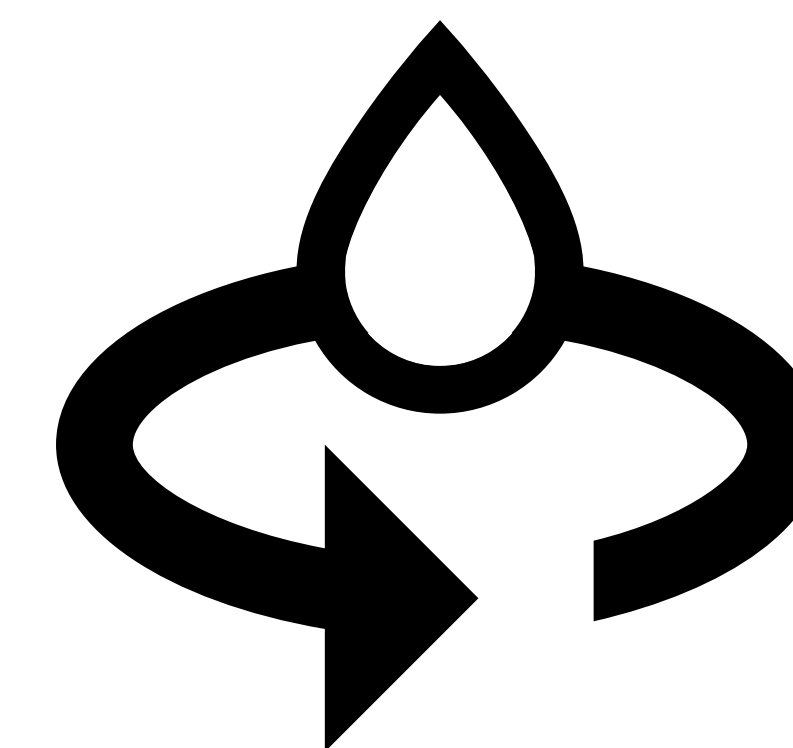
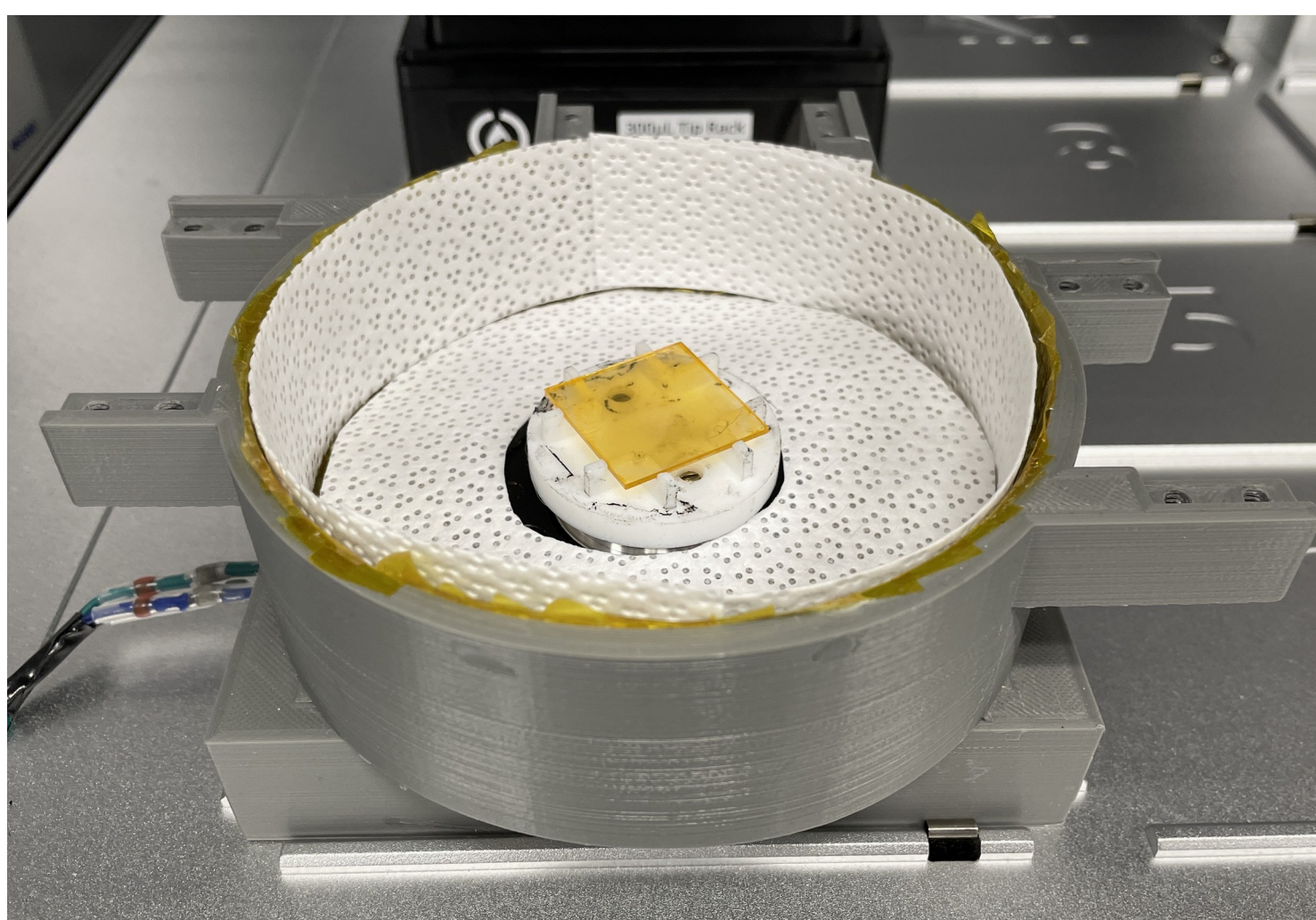
- Manual workflows require a larger quantity of base chemicals be prepared which produces more waste.
- An automated workflow increases repeatability from run to run with computer controlled timings and triggers.
- Sample characterization with an automated platform can be performed without supervision. This frees up the student to perform other experiments.

Platform Overview

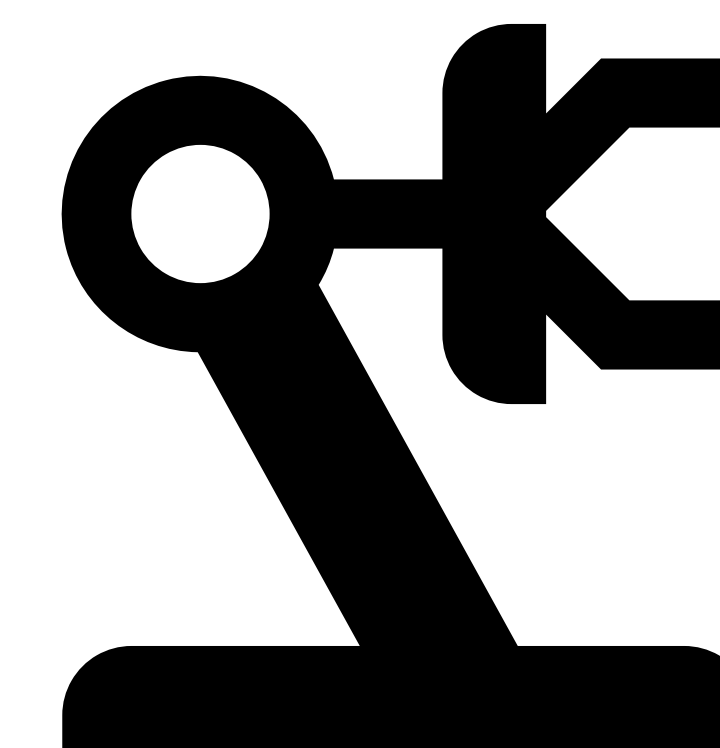
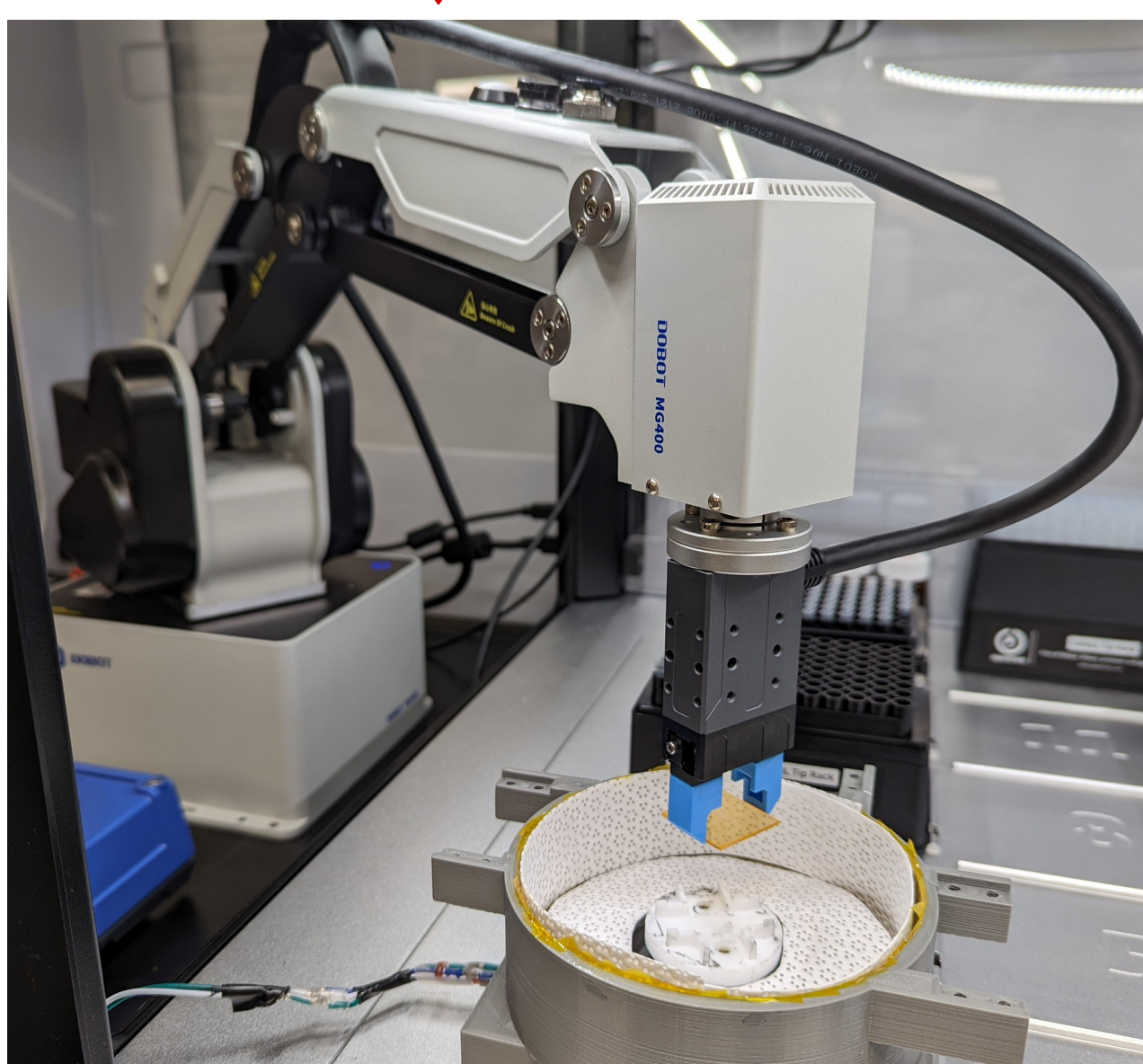
Our platform incorporates five stages in the perovskite production and analysis process.



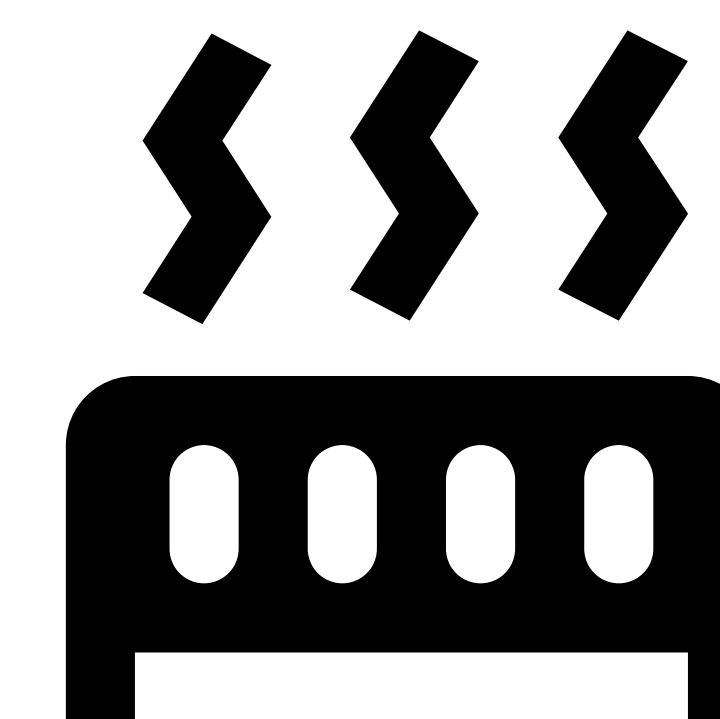
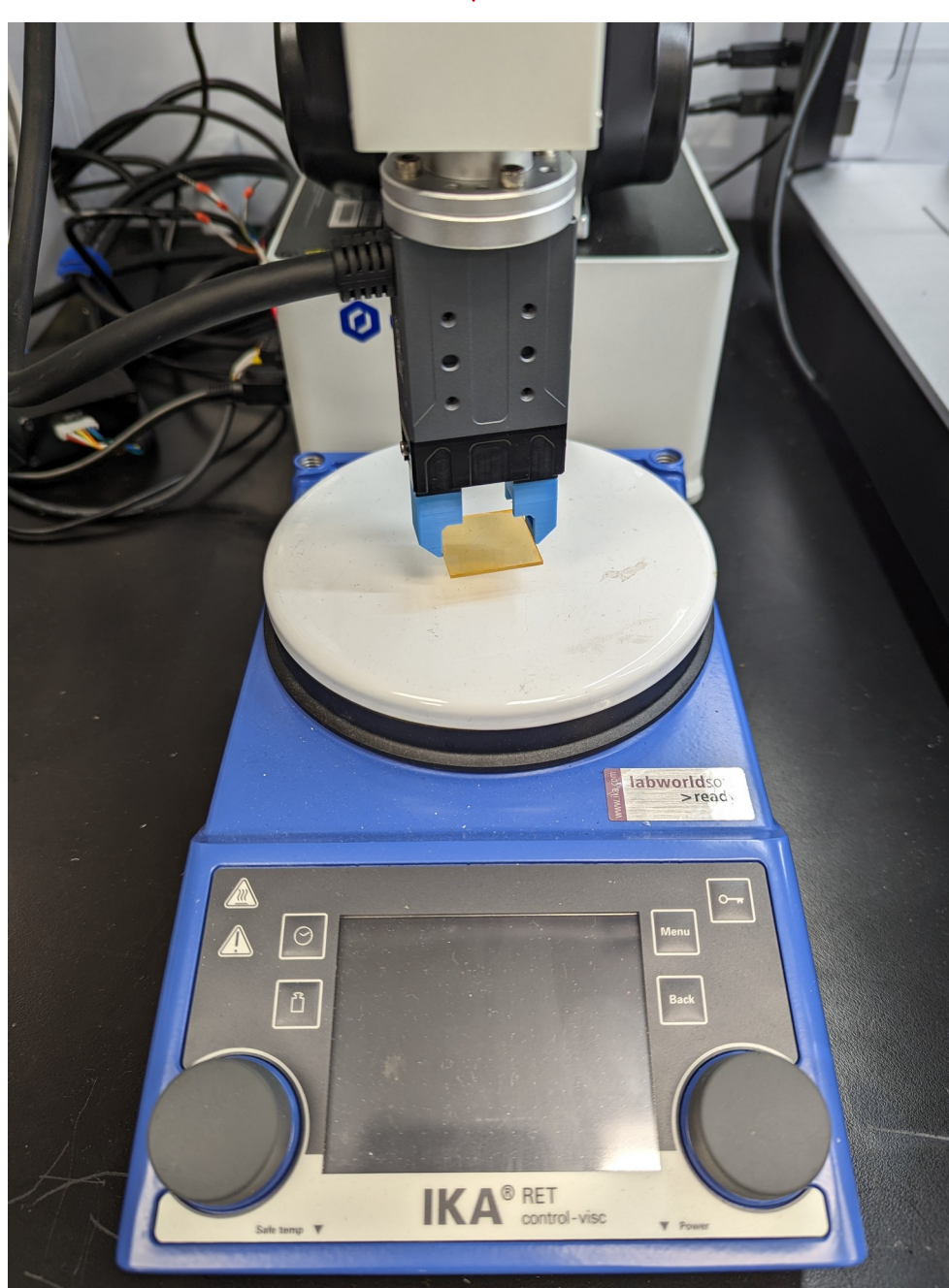
Automated pipetting, mixing and liquid handling



Spin-coating

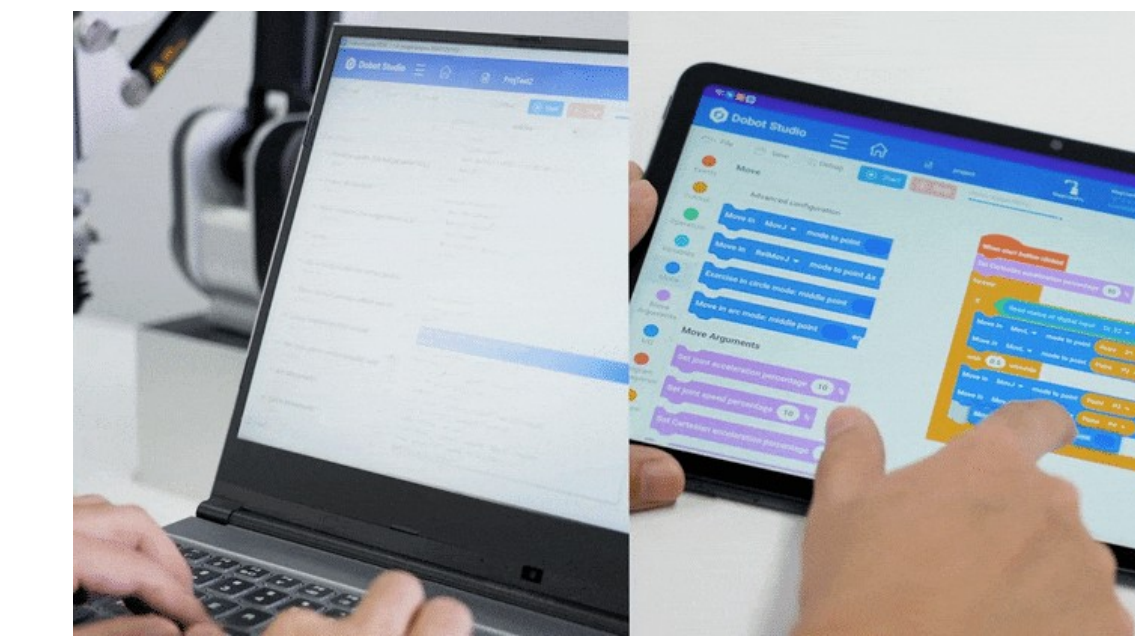


Substrate handling



Computer controlled annealing

Platform Software



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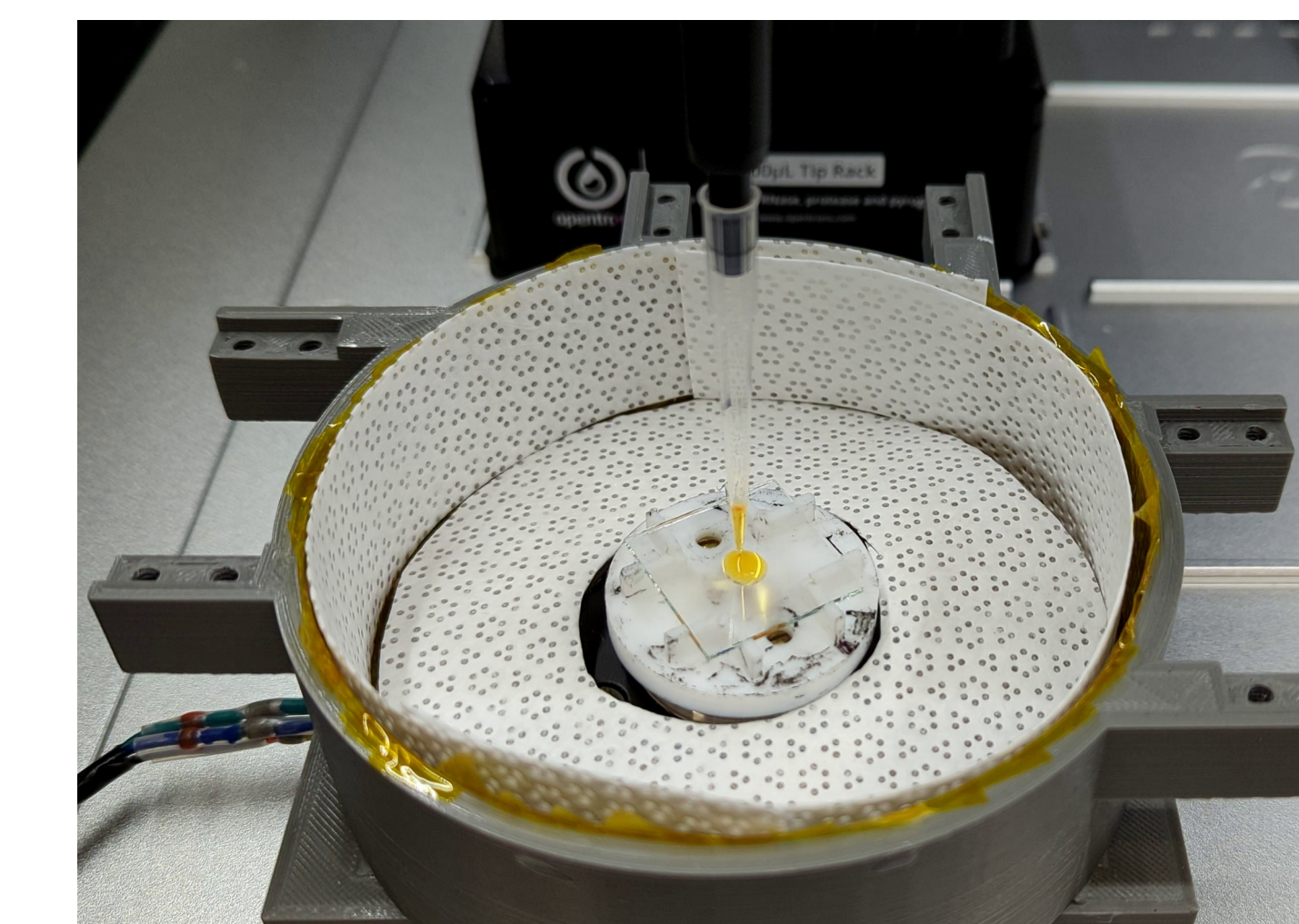


- Each piece of hardware can be independently tested and operated with easily written software.
- A Raspberry Pi built-in to the Opentron acts as the central controller orchestrating all connected hardware.
- Python code design follows a chronological sequence allowing the developer to easily order platform operations.

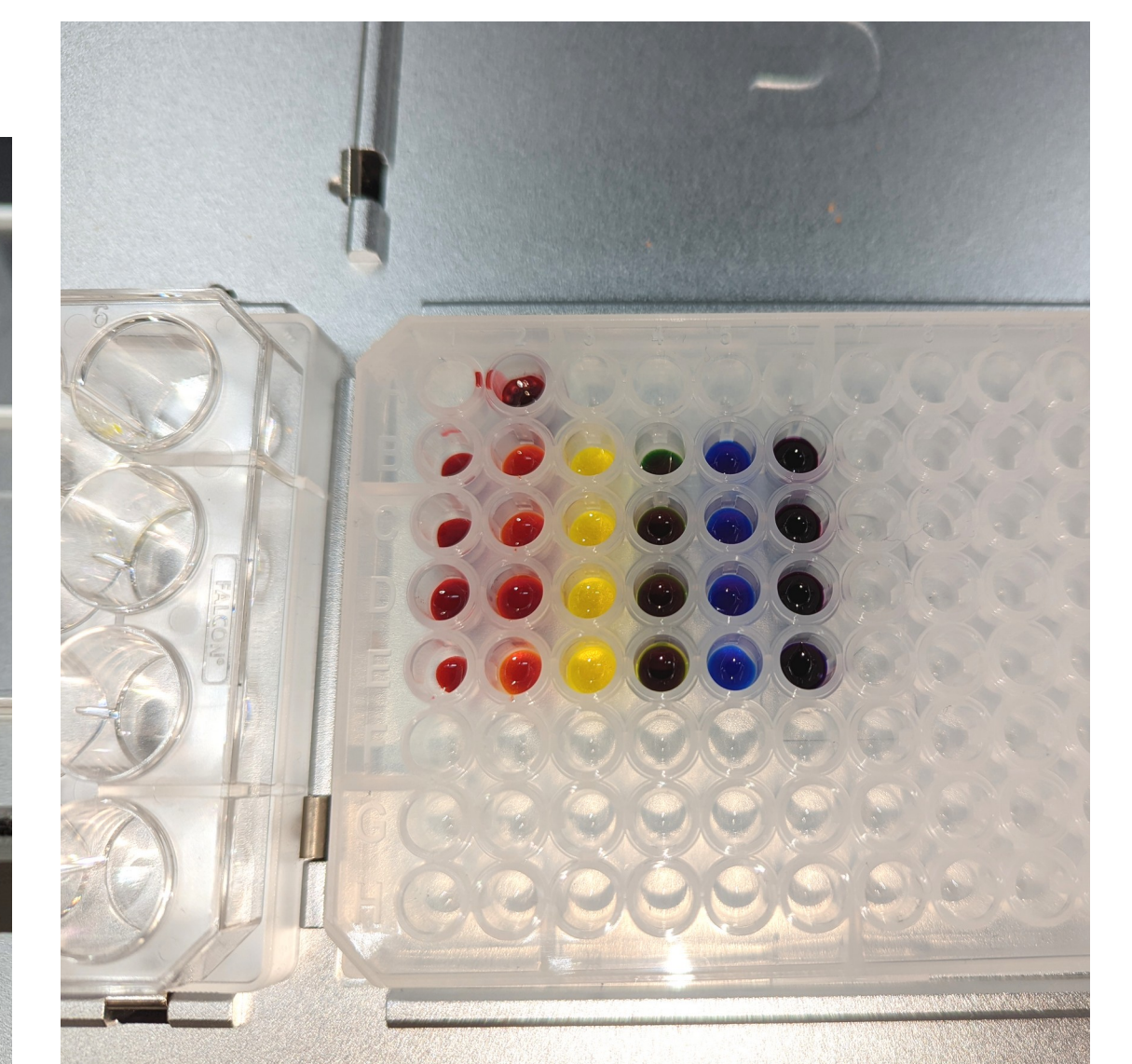
Achievements

Our current platform can perform the following functions:

- Autonomous liquid mixing
- Computer controlled spin-coating



Seamless spin-coating integration



Robotically mixed food coloring

Next Steps

- Fully integrate the robotic arm with the spin-coater and Opentron protocols.
- Set up automated hot plate control from software.
- Apply automated protocol technology to slot-die coating systems.
- Implement Bayesian optimization based on output substrates.