Designing and Constructing a Heater Stage for a Physical Vapor Deposition Chamber

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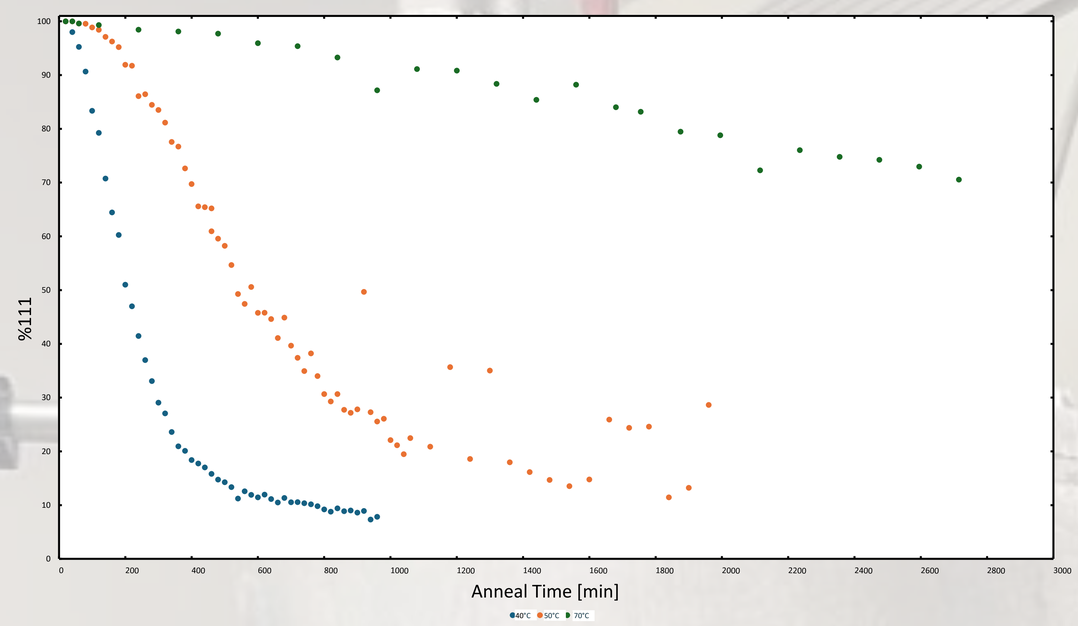
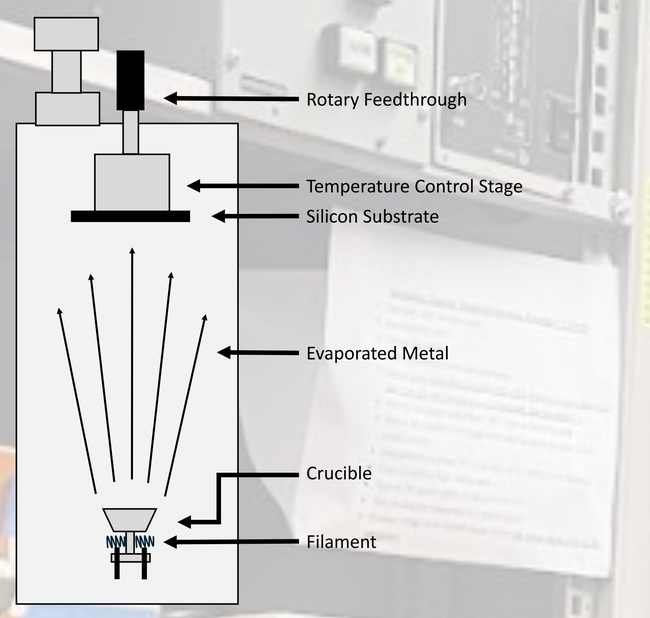
Deposition Temperature Affects Film Behavior



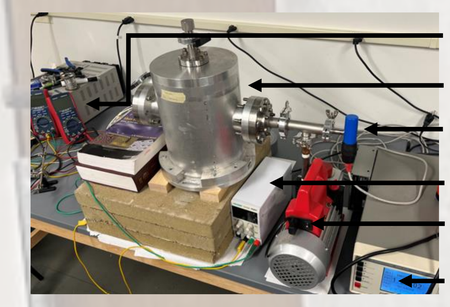
1200 nm thick Ag samples were deposited at 40 nm/s on 50 nm of Ti. The samples were then annealed at 100°C with crystallites oriented <111> direction.

The Houghton Evaporator Needs an Improved Substrate Stage

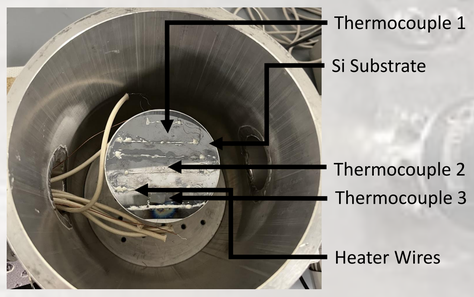


The Houghton physical vapor deposition chamber is pictured (left) with an ion gauge to measure the pressure inside the chamber, with rough and turbo pumps to decrease the pressure to around 1 x 10^-6 Torr

Tested Substrate Temperature Consistency

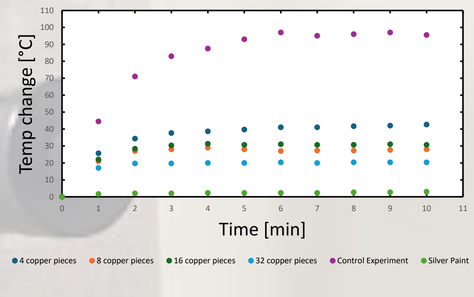


6.5 W were applied to the substrate for 10 min under rough vacuum to simulate the radiative power from the filament.



Resistive wire and three thermocouples were epoxied to the substrate, which was mounted to a 10.2 cm diameter, 19.1 cm tall Al heat sink in the chamber.

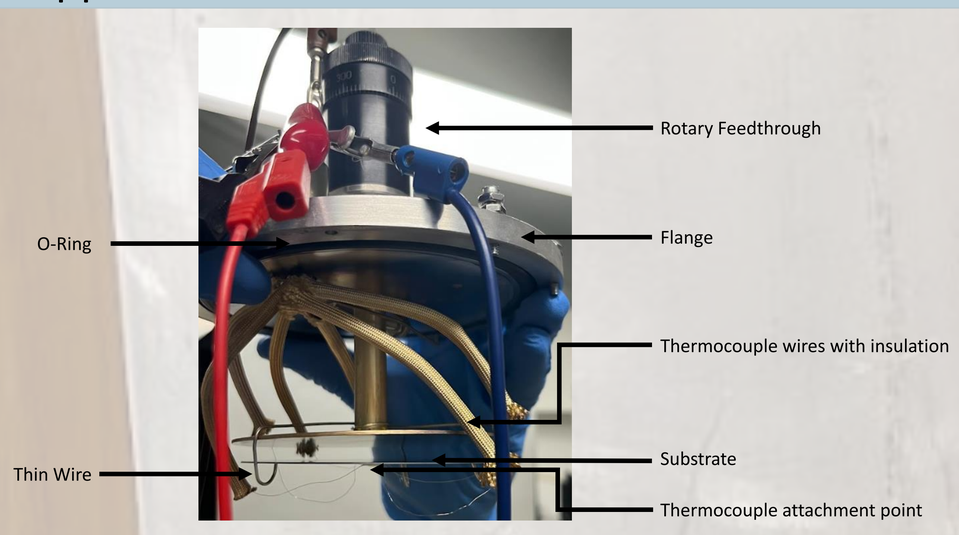
Conductive Materials used to Test Thermal Contact



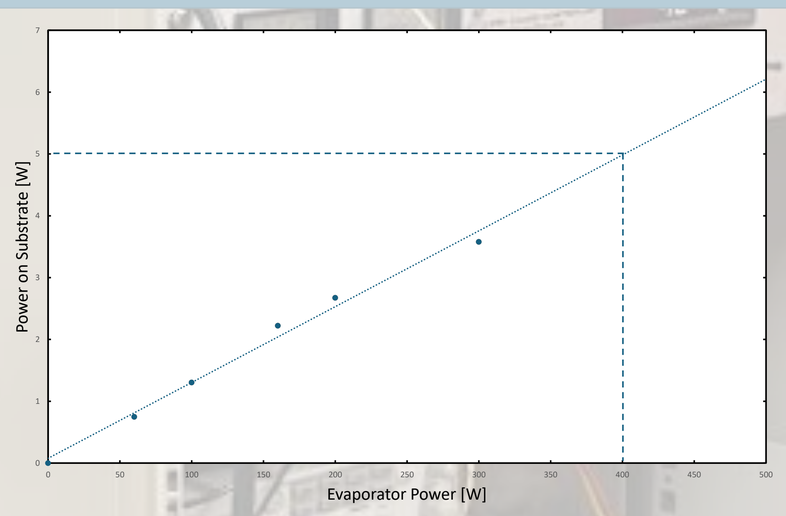
The goal is to maintain constant substrate temperature by maximizing thermal conductivity between the substrate and the stage. Ag paste achieved at least 10 times more consistent temperature than two-sided copper tape.

The substrate was epoxied on an Al heat sink with Ag paste (left) for increased thermal conductivity. To remove the paste, the heat sink was held upside down in an acetone bath (middle). The removability of the paste was tested by experimenting with cure temperature and time (right).

The Power Applied to the Substrate must be Determined



Picture of thermally isolated substrate held in chamber through rotary feedthrough, measuring temperature across substrate with thermocouple wires. Thin wires suspend the substrate with three small points of contact.



The graph shows evaporator power vs. power on the substrate during deposition, which was calculated using $Power = \frac{dE}{dt} = mc\frac{dT}{dt}$, where m is mass, T is temperature, and t is time. At the typical filament power used to make films, 400 W, we expect about 4.5 W that reaches the substrate via radiative heating. This led to an Al heat sink design of 11.43 cm diameter and 6.35 cm height.

Final Product

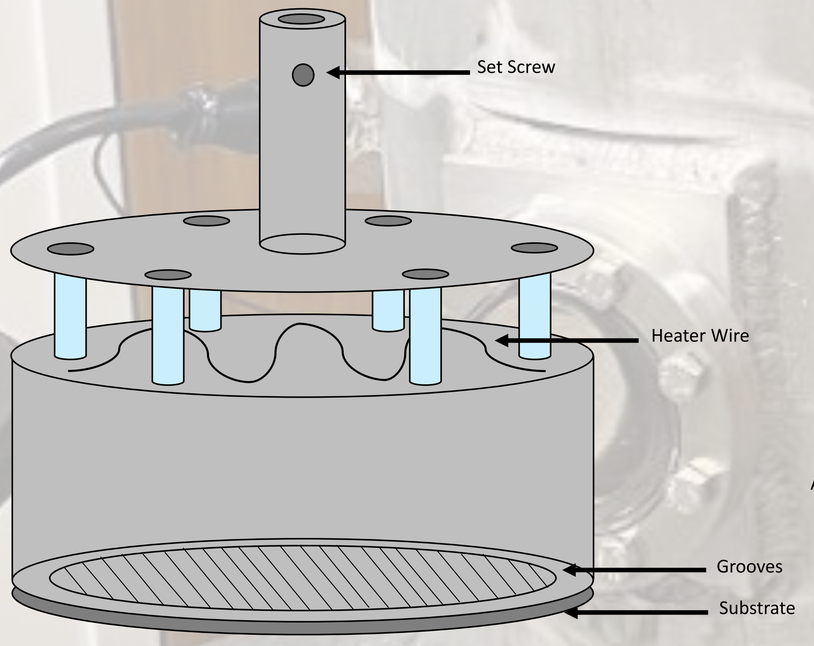


Diagram of temperature control stage. 36 g nichrome heater wire is adhered to the top of the heat sink to set an initial temperature. Set screw is used to attach the system to the rotary feedthrough at the top of the chamber.

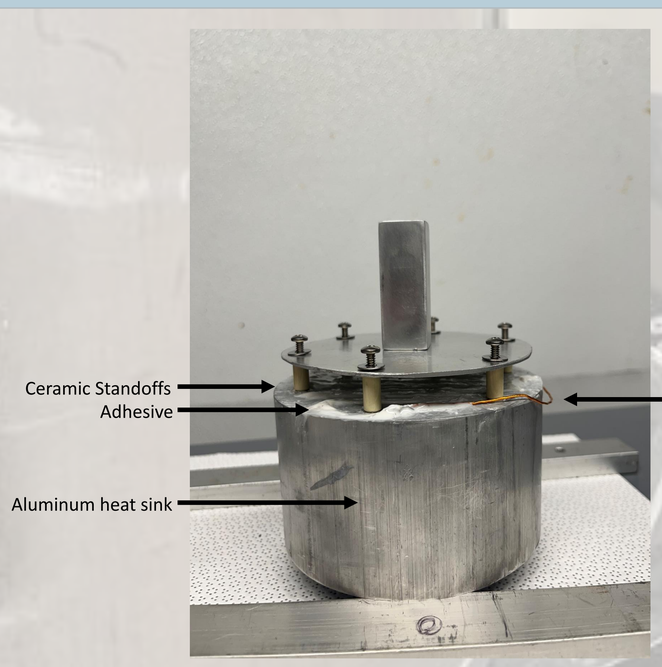
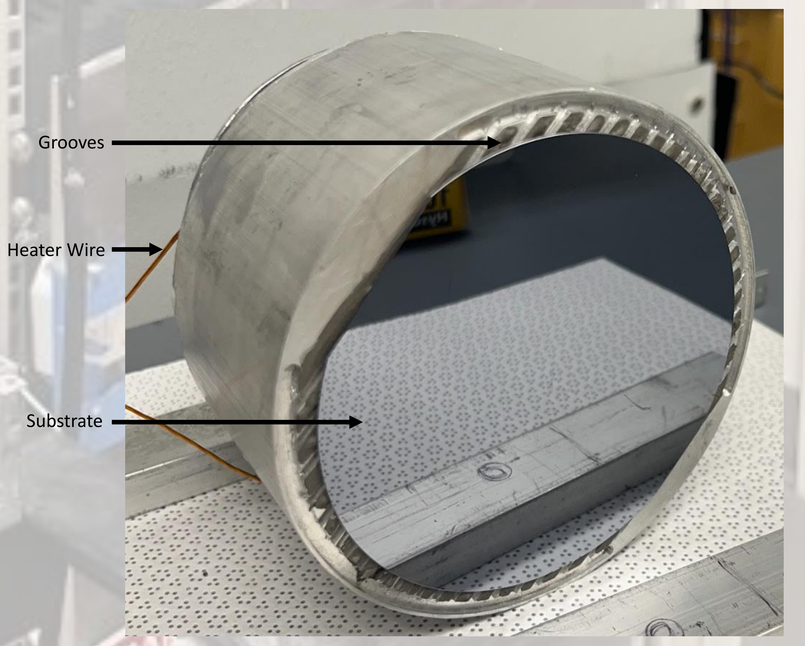


Diagram of the temperature control stage (side view). Al heat sink is 11.43 cm in diameter and 6.35 cm tall. 6 ceramic standoffs 0.64 cm diameter, 1.27 cm tall and provide thermal insulation of the heat sink from the chamber. Insulation allows for even cooling of the substrate.



Picture shows substrate attached to heat sink with Ni paste. Grooves in heat sink are 0.16 cm wide with 0.33 cm spacing, and 0.32 cm wide groove around the perimeter of the heat sink. Groove design allows user to poor water in one place to dissolve Ni paste quickly and not spill over.