Remote Temperature Sensing for Scanner Auger Microprobe

A.M. Lewis[1], C. H. Skinner[2]

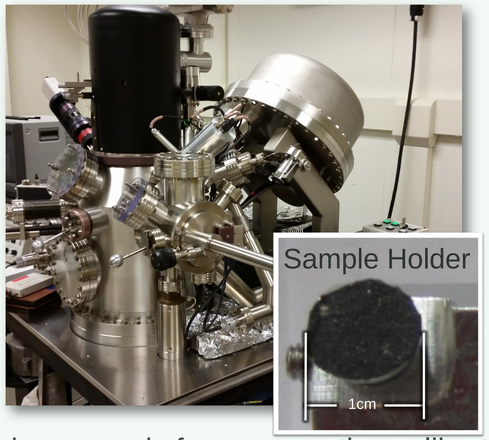
[1]Department of Mechanical, Aerospace and Nuclear Engineering, Rensselaer Polytechnic Institute, Troy, NY 12180, USA

[2]Princeton Plasma Physics Laboratory, Princeton, NJ 08542, USA

Background

- Liquid lithium is a potential plasma-facing material in tokamaks.
- Recent studies show that solid lithium can wet a stainless steel surface at room temperature.
- This process will be studied at higher temperatures in a Scanning Auger Microprobe, using a heated stub as the sample holder.

Scanning Auger Microprobe (SAM)



- This research focuses on the calibration of the infrared pyrometer that will be used to measure the lithium sample temperature.

IR Pyrometer

- Allows for manual emissivity choice
- Calibrated with a type K thermocouple
- Hot objects—coffee mug, soldering iron and electrically heated sample holder

Setup of pyrometer, lens and viewport

Emissivity

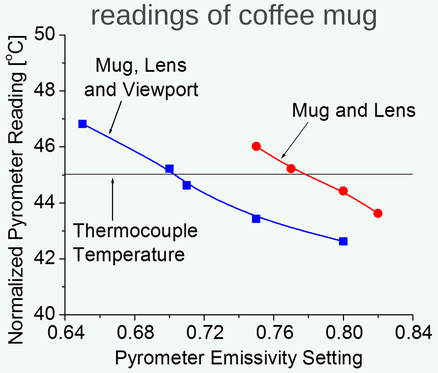
- Pyrometer uses the Stefan-Boltzmann Relation to determine temperature

$$I\left[{}^{W}/_{m^2}\right] = \varepsilon\sigma(T^4 - T_a^4)$$

where I is the net thermal power, σ is Stefan's constant, and T_a is the ambient temperature

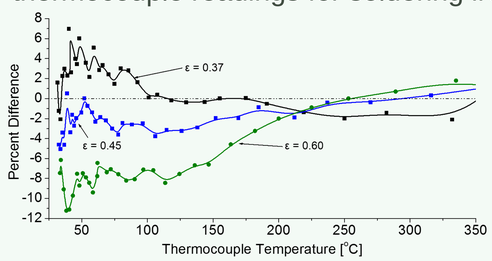
- The emissivity, ε, is the ratio of thermal radiation of the object to that of a black body at the same temperature.
- Black carbon tape is used to increase the emissivity of the sample holder surface
- An 'effective emissivity' accounts for 'grey body' emission, ZnSe transmission losses and cold objects in the field of view

ZnSe transmission effects on pyrometer readings of coffee mug



- The pyrometer reading became more sensitive to the emissivity setting at lower temperatures in soldering iron tests

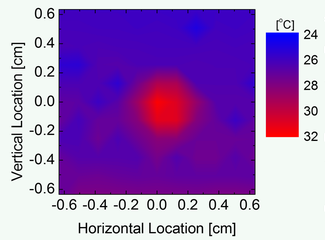
Difference between pyrometer and thermocouple readings for soldering iron



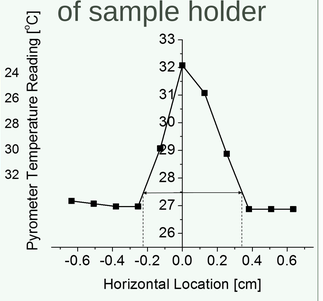
Field of View

- The field of view at the location of the sample holder is 0.6 cm in diameter

Pyrometer readings of sample holder

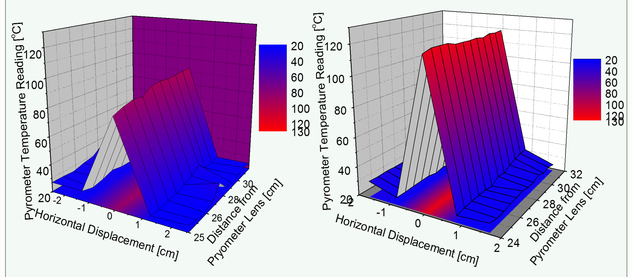


Slice through center of sample holder

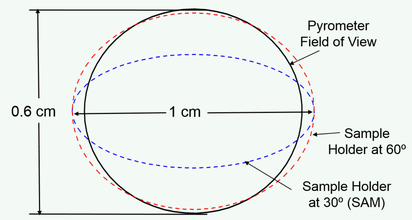


- The field of view was relatively constant with distance from the pyrometer
- The temperature readings were much higher for the 60º angle than the 30º angle because at 60º the sample holder filled more of the field of view

Pyrometer readings at varying distance from pyrometer lens for sample holder at (a) 30º angle and (b) 60º angle to optical axis



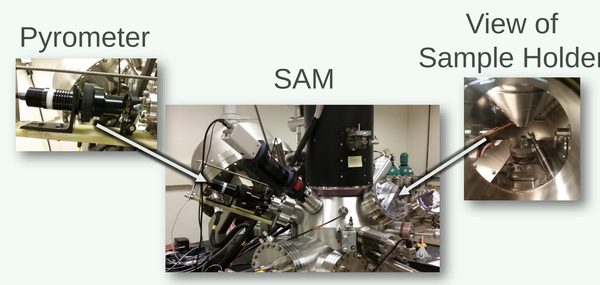
Projected areas of sample holder at 30º and 60º on pyrometer field of view



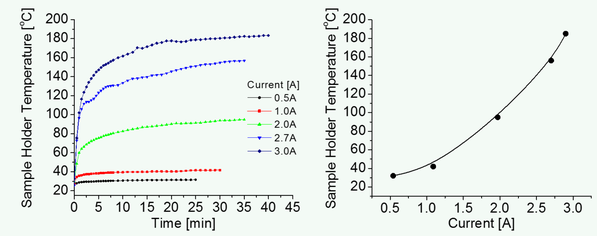
- Detailed measurements showed that the temperature did not vary more than 3ºC across the surface of the sample holder

SAM Calibration

- Pyrometer was mounted on SAM with optical axis intersecting the sample holder

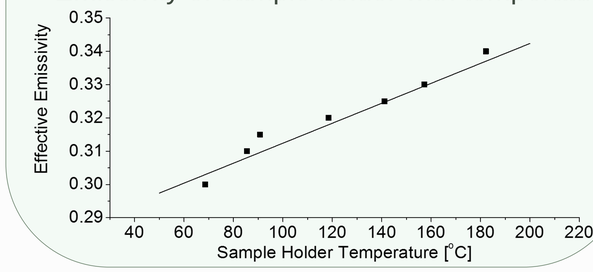


TC Temperature of sample holder with current



- The effective emissivity of the sample holder setup changed slightly with temperature

Emissivity of sample holder with temperature



Conclusions

- With the appropriate emissivity setting, the pyrometer can track the sample holder temperature to within 5%.
- The effective emissivity of the sample holder setup increased with temperature in a relatively linear fashion.
- Future work will include using the pyrometer to measure the temperature of the lithium sample in wetting experiments.

This work was made possible by funding from the Department of Energy for the Summer Undergraduate Laboratory Internship (SULI) program. This work is supported by the US DOE Contract No.DE-AC02-09CH11466.