Experiment Proposal
EE 491
Client : Dr. Bong Wie

Sean Nichols
Chi Hoe How
Yishu Mei

Introduction

From the past few meetings, microbolometer sensors have been a topic of discussion. Is it a viable option or are there better choices out there? Assuming we are able to scale the distance as well as target object to a small enough size for testing,will we be able to detect our target along with Earth's thermal noise in the background? We have found that the microbolometer's sensitivity range covers the emission spectrum of an asteroid.

We have reached a consensus with Dr. Bong Wie's students that a microbolometer sensor is the most economical choice for our project. In this document, we explore ideas for testing and characterizing parameters of a microbolometer sensor for space application. The purpose of this document is to inform our client of our intentions with the project so that he may give us consent to continue on with our plans.

Goal

We understand that Earth's ambient temperature will be a large source of noise in our experiments, but if we can detect and measure a small target in our scaled down experiment with this level of noise, a space application should be viable. Our understanding of the project thus far is to design an experiment to characterize a low-cost sensor and simulate conditions that it will encounter when in outer space. The goal of our experiments is to confirm that a low-cost sensor can succeed on a critical space mission without failure. We plan to work with Dr. Bong Wie's graduate students so that we can design our experiment in order to characterize real world parameters for their simulations.

Plan

Signal to noise ratio, or SNR, is a parameter that is not very well documented between sensors. Instead of signal to noise ratio, there is another term that characterizes noise in microbolometers that we talk about in the next paragraph. We believe that SNR is not documented because it may change as a function of distance from the object, IR emission of the object, and possibly our optical setup. We plan to look for a way to characterize SNR with our experiments.

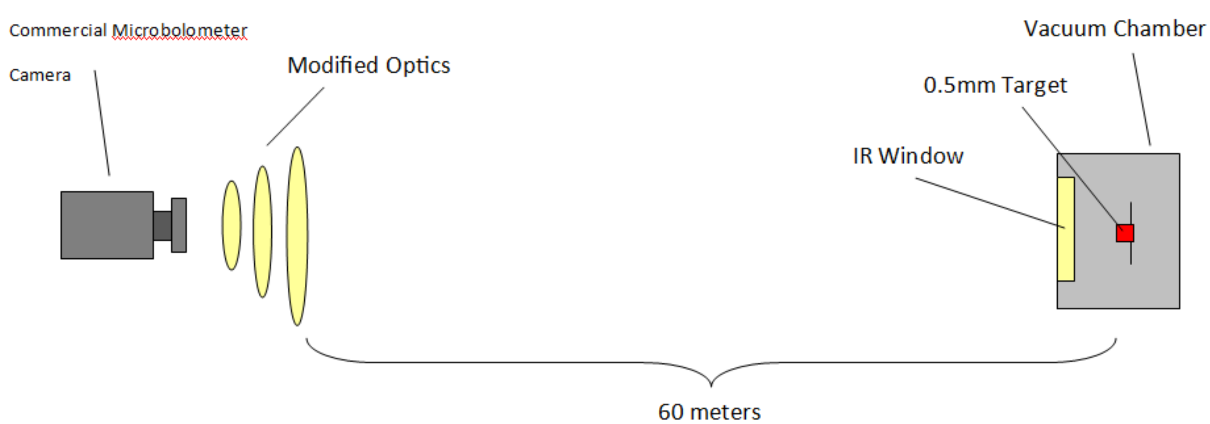
A parameter called Noise Equivalent Temperature Difference or NETD, is a common characteristic that is well documented between microbolometers and is usually on the order of 10-30 milliKelvin in magnitude. This parameter notes the smallest temperature difference that the sensor can detect, thus can be related to thermal sensitivity. If we have one object at 273 K, and another object at 273.01 K, then the sensor can differentiate between the two. Our experiment will test to see if this sensitivity will suffice for the final application.

Since we plan our experiment to be a scaled down version of a space mission, we can also see if our system will be able to take viable measurements of the target from great distances. These measurements may include temperature, IR intensity, and wavelength profile if possible. If Dr. Bong Wie's students have any other parameters they desire to be measured, we will take them into account and design our experiment to accommodate them.

Experiment Setup

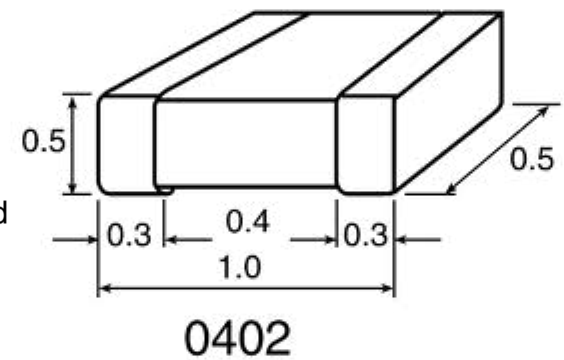
As we are not able to run our experiments over the vast distances in space, the tests must be scaled down to a level where tests can be performed while maintaining validity.   We also want to keep the costs as low as possible, so we decided to take the test case of tracking the 50m object 10 minutes out while travelling at 10 km/s. If we scale these parameters down by a factor of 10^5 we can realize an experiment setup that is small enough for testing. The target size will be 0.5mm in its largest dimension and the detector will be placed 60m away from the target. Below is an image of our tentative experiment setup.

Image not to scale!



We are still deciding on what the target will be, but we have come up with two possible options. The first option is a surface mount technology (SMT) resistor, and the second being an unlensed mid-wave IR emitting diode. The purpose of the vacuum chamber is to allow us to better control the IR emission, and to give a better thermal background.

The package size of the surface mount resistor in question is 0402. The entire package size is 1mm, but if we assume the contacts as negligible, that leaves us with around 0.4mm - 0.5mm of resistive element. We will be able to control the amount of heat being dissipated through the resistor and therefore control the IR emission intensity. The drawback to this method is that we will not have much control over the actual wavelength of IR emission as that is most likely a function of the material of the resistive element. The good news is that there are *many* types of surface mount resistors and, through some research and testing, we should be able to find a good match for an asteroid profile. The image to the right demonstrates the dimensions of the 0402 SMT package.



Mid-wave IR emitting LEDs are hard to come by, and as such are more expensive than the resistive option, *but* they may offer more accurate control of the emission of IR as they directly produce photons. The resistive option dissipates current as heat which in turn produces IR photons. This LED option converts electrical current directly into photons and will give us greater control over IR emission intensity. One preferred characteristic is that the silicon die should be much smaller than 0.5mm resulting in a smaller distance needed for our experiment. One drawback to this is that they may not cover an asteroids emission profile, and since they are much more expensive than a resistor, they are not as abundant resulting in difficulty finding different types.

<u>Conclusion</u>

With these assumptions and calculations based around the microbolometer, we have decided that these are the best options for our experiments to obtain results that closely resemble real-life space. We plan to further discuss our options noted here in this document with Dr. Bong Wie's team in order to keep moving forward.