

Growing YAG and GGG Optical Quality Crystals



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MSE Research Experience for Undergraduates

School of Mechanical and Materials Engineering

Motivation

YAG (Yttrium Aluminum Garnet) and GGG (Gadolinium Gallium Garnet) crystals are used in, lasers, scintillators, x and gamma ray detection and many other applications. The GGG crystal has the potential to be much better at these applications than the YAG crystal but due to inherent defects in the crystal, caused by the way they are currently produced, their use is extremely limited.

Group Objective

Our ultimate objective was to use the Czochralski process of crystal growing to make a defect free GGG crystal.

Personal Objective

My personal project within the GGG project was to calibrate the scale, which is attached to the pulling rod and used to pull the crystal out of the melt.

Experimental Set up

The scale is located above the furnace and attached to the pulling rod and the entire attachment moves up and down. It was thought that the vibrations from the movement would cause false readings on the scale.

Experimental Process

A weight was attached to the end of the pulling rod and the furnace was sealed. Then the rod was pulled upwards continuously for an hour at 5 different speeds: 3, 7, 10, 14, and 21 steps per second. A program recorded the scale every 2 seconds onto an excel spreadsheet. This was done twice, once with the vacuum filled with air, and again with the argon in the furnace and the crucible heated to temperature.

Results

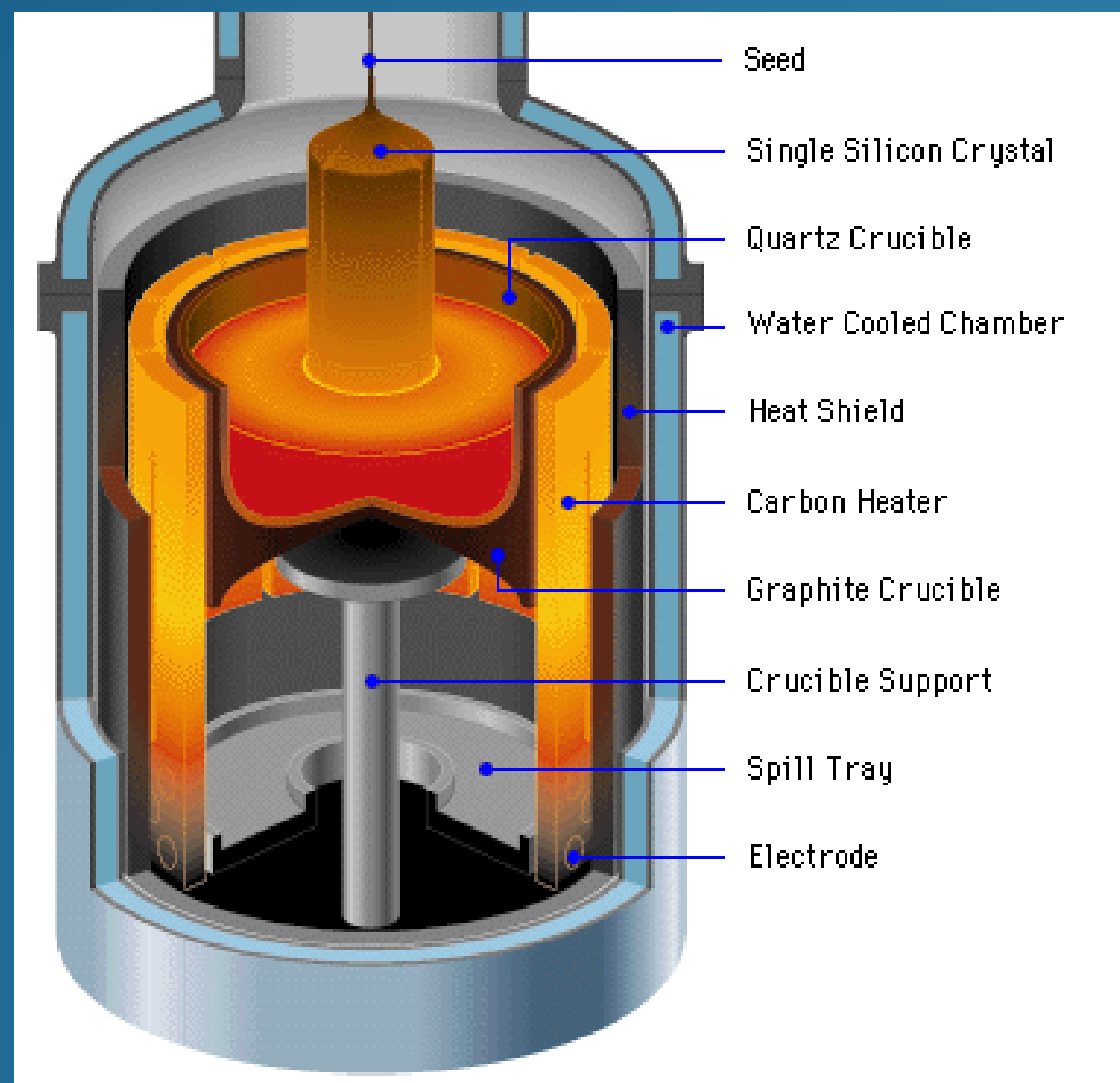
The results for the first trial were mixed, some trials had the scale changing by up to 0.03g and other times there were no false readings given. It also was not apparent if the scale was affected more by faster or slower pulling speeds.

Conclusions

The goal of these tests was to see if there was a predicable pattern of false readings given by the scale due to vibrations within the pulling mechanism. What we found was that while it appears vibrations can cause false readings on the scale they are in no way predictable therefore there is no way to mathematically account for them while pulling a crystal.

Future Research

At the time this poster was made, we still had yet to run the tests with the power supply on and the furnace at temperature. Once that is done future research could be done on finding ways to prevent vibrations within the machine from affecting the scales readings. Also if a clear pattern is ever seen, a formula could be written to correct the scale so accurate numbers are always given.



Czochralski Process

Process

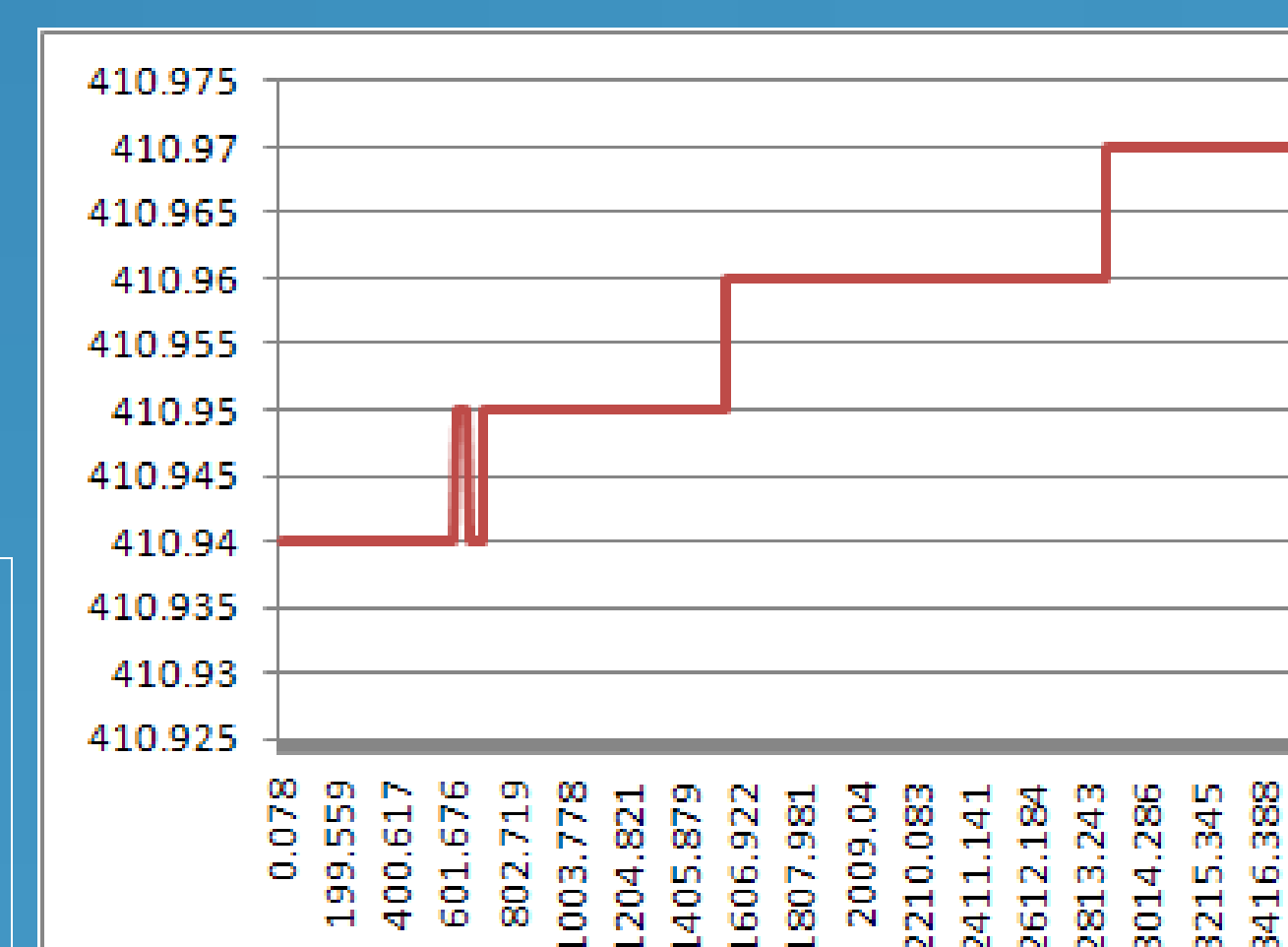
The Czochralski process works by heating the ingredients for a particular type of crystal in a crucible to its melting point, then dipping a seed crystal in the melt and pulling it out slowly. As the seed crystal is pulled, the melt cools into the desired crystalline structure.



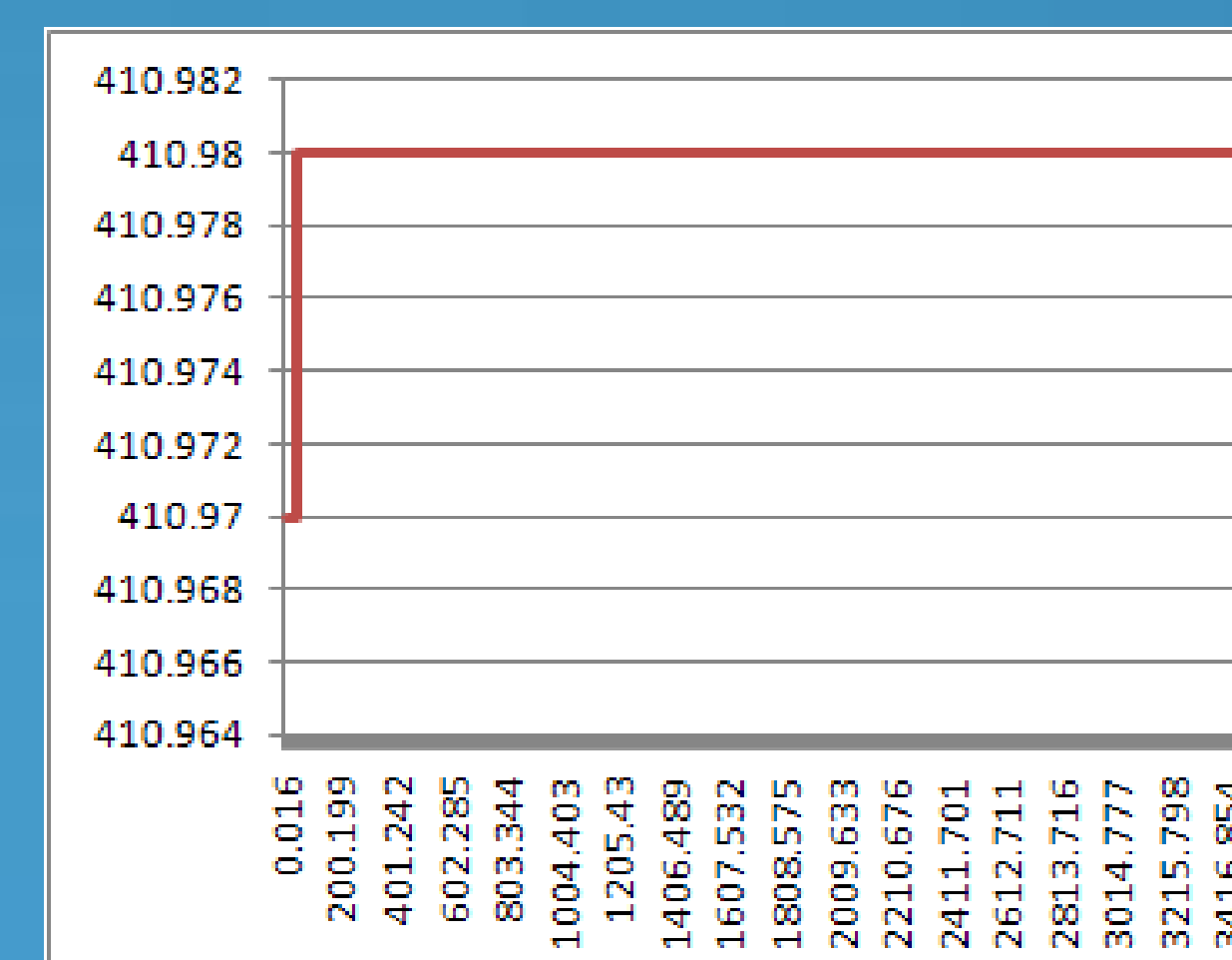
GGG crystal



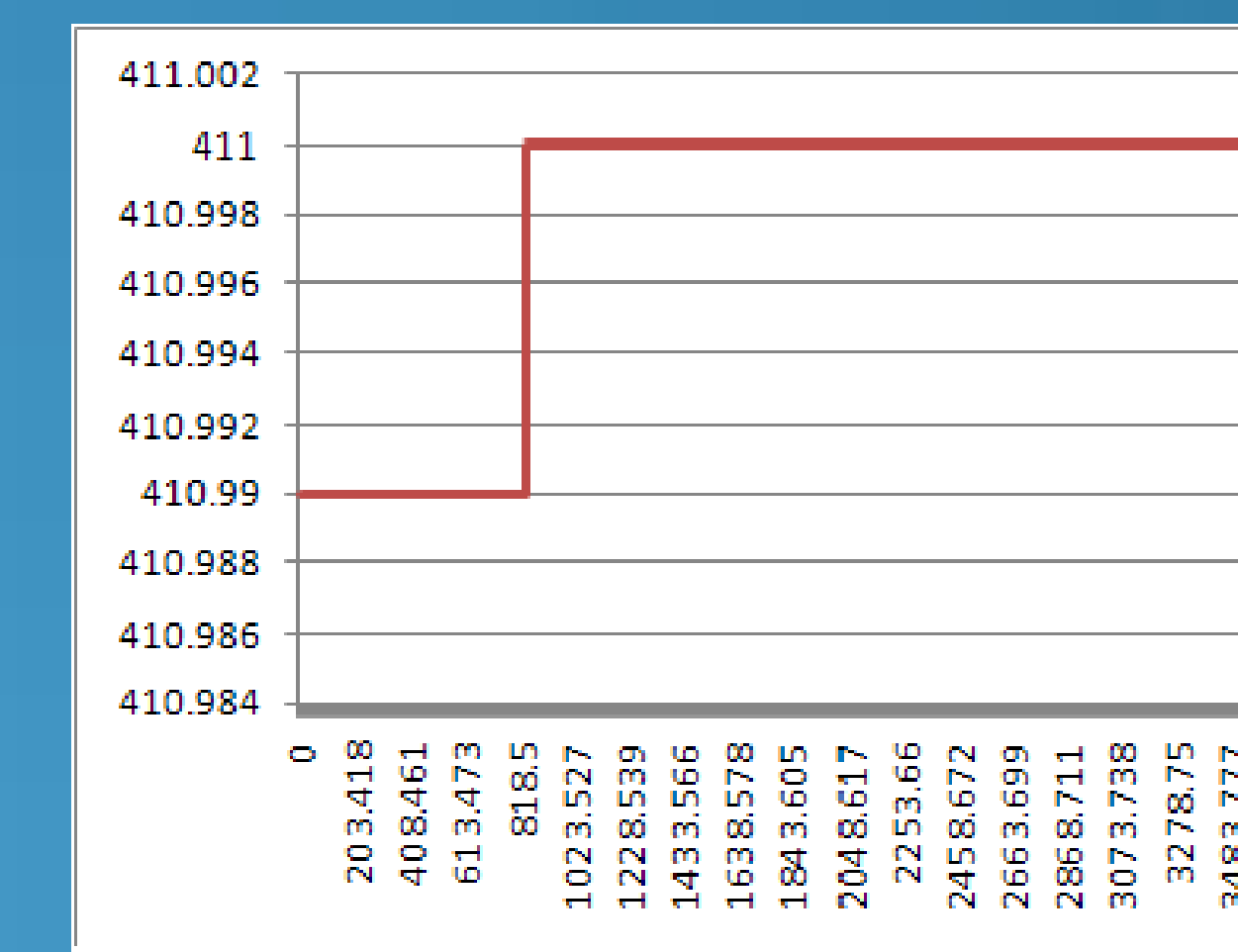
YAG crystal



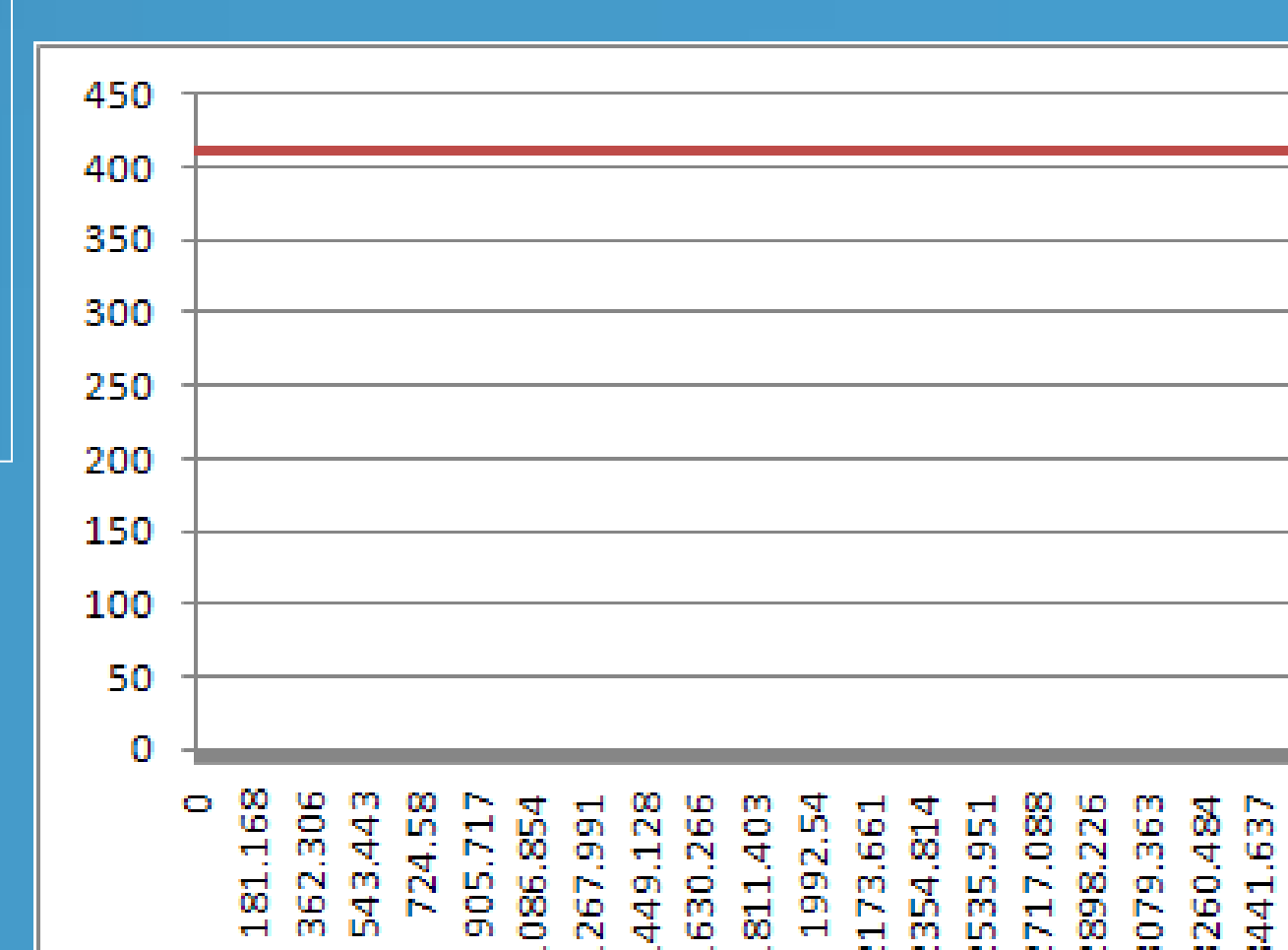
3 steps/sec



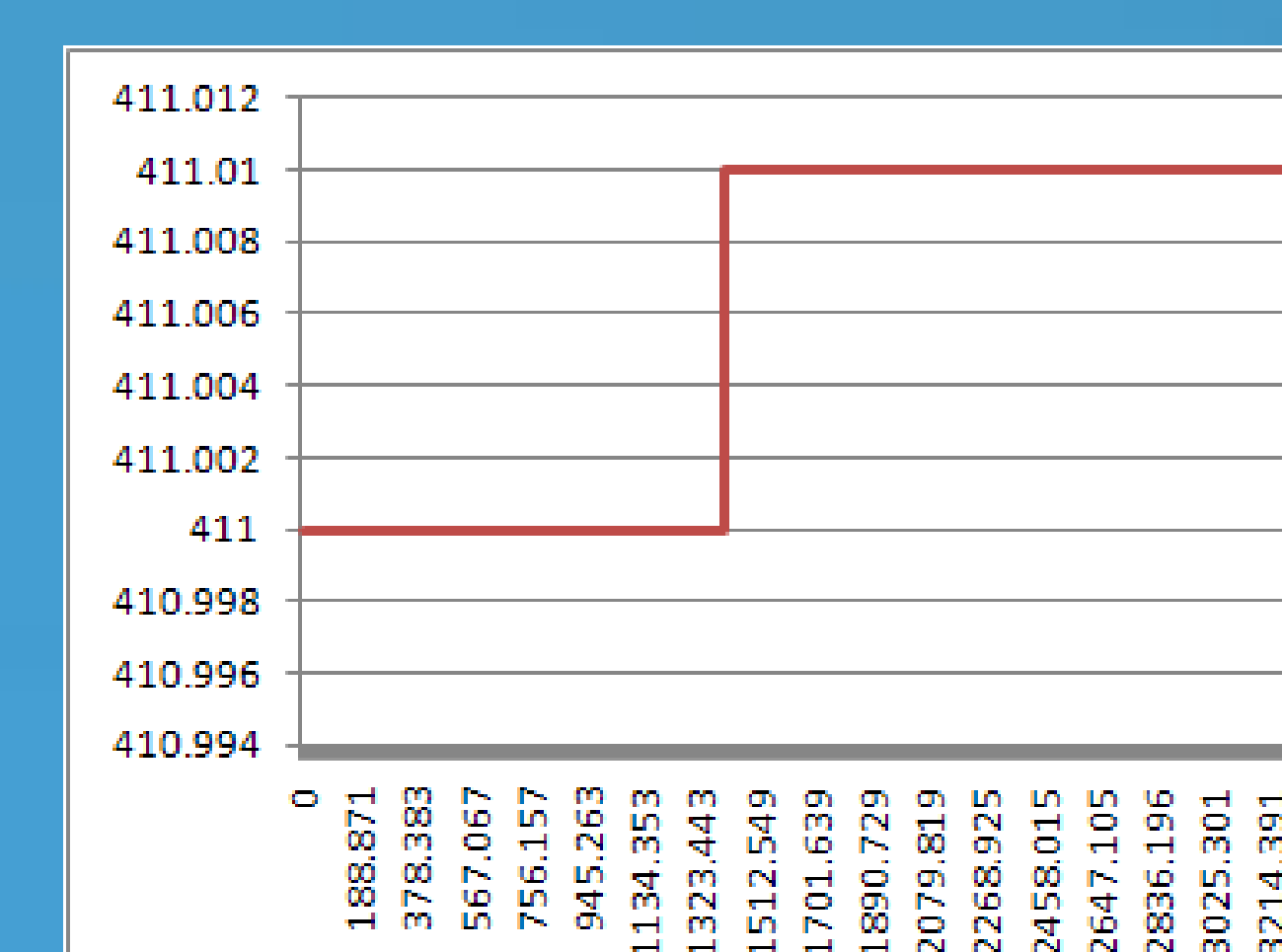
7 steps/sec



10 steps/sec



14 steps/sec



21 steps/sec

Acknowledgements

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