

CML GPU TFC Code User's Manual

Tholfaqr (Dolf) Mardan and David B. Bogy

(An extension of the “CML TFC code User's Manual” by Jinglin Zheng)

Computer Mechanics Laboratory

Department of Mechanical Engineering

University of California

Berkeley, CA 94720

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1. Introduction

The CML GPU (Graphical Processing Unit) TFC (Thermal FlyHeight Control) code version 2.0 is an upgrade from the original TFC code version 1.0. It is more intelligent yet faster than the original TFC code. It has its unique internal structure utilizing the computing power of a GPU efficiently for scientific heavily mathematical calculations. Running example cases showed a speed improvement up to 2X for slider designs. Since TFC simulation is a repetitive task, GPU TFC will save from 1/5 up to 1/2 of the simulation time each iteration depending on the slider design. Thus, using GPU TFC solver will increase the speed of simulation and improve efficiency.

The major changes are made only to the quick solver, which runs under TFC APDL (Ansys Parametric Design Language) macros. Instead of using the regular quick solver, we have used a GPU capable quick solver in the TFC bundle. All the macros stayed the same in functionality as the old TFC code except minor changes needed to point to the GPU TFC solver instead of quick solver. Thus, the new TFC code uses same input files as well same output files. You can download the GPU TFC package from the TFC webpage on the CML website.

Since the TFC code v2.0 using the GPU architecture besides the CPU (Compute and Processing Unit), you need to install the proper hardware and software to support its operation. The GPU TFC v2.0 code has been tested on a NVIDIA GeForce 680 GPU. You can choose any NVIDIA GPU of CC (Compute Compatibility) 3.0 or higher. The latest display driver installation is required for optimum operation and best results. The software and hardware installation will be explained in details in a later sections of this manual.

This user manual is an extension to the “CML TFC code User’s Manual” created by Jinglin Zheng. The operation information mentioned in that manual will be briefly discussed here. Thus, it is recommended that you read Jinglin’s manual as preparation to obtain the full knowledge and proper operation of the TFC code.

2. Features added

The following features and improvements have been added to the GPU TFC code version 2.0:

- It has 16,060 lines of code, which means 4,400 lines added to the TFC code v 1.0.
- One file has been added, kernels.f90 which has 2,320 lines of code and 26 kernel subroutines.
- 8 new modules have been added to enhance the portability of data handled by the code and optimum memory utilization.
- About 50% (2X) speed gain on each iteration has been achieved in one of the slider cases as shown in a later section of this manual.
- NaN (not a number) detection function is also added.

3. GPU TFC solving algorithm

Fig. 1 shows the flowchart of the solution procedure. This process starts from solving the generalized Reynolds equation to obtain the pressure profile in the air bearing and the spacing in the head-disk interface (HDI). The heat transfer coefficients on the air bearing surface (ABS) are calculated and input to the finite element model of the slider. A coupled-field analysis is then conducted to calculate the deformation of the slider. Considering the effects of the ABS deformation on the flying-attitude, the original ABS shape is updated according to this deformation and used for a new round of spacing and pressure calculations. This procedure continues until the flying-attitudes obtained from two consecutive iterations have a difference less than some specified value. In this procedure, the CML GPU TFC solver is adapted to solve the generalized Reynolds equation using the finite volume method. The commercial finite element software, ANSYS, is used to execute the electro-thermal-structural analysis. The CML GPU TFC code runs on a windows-platform computer with certain ANSYS products (modules for electric, thermal and structural analysis) installed.

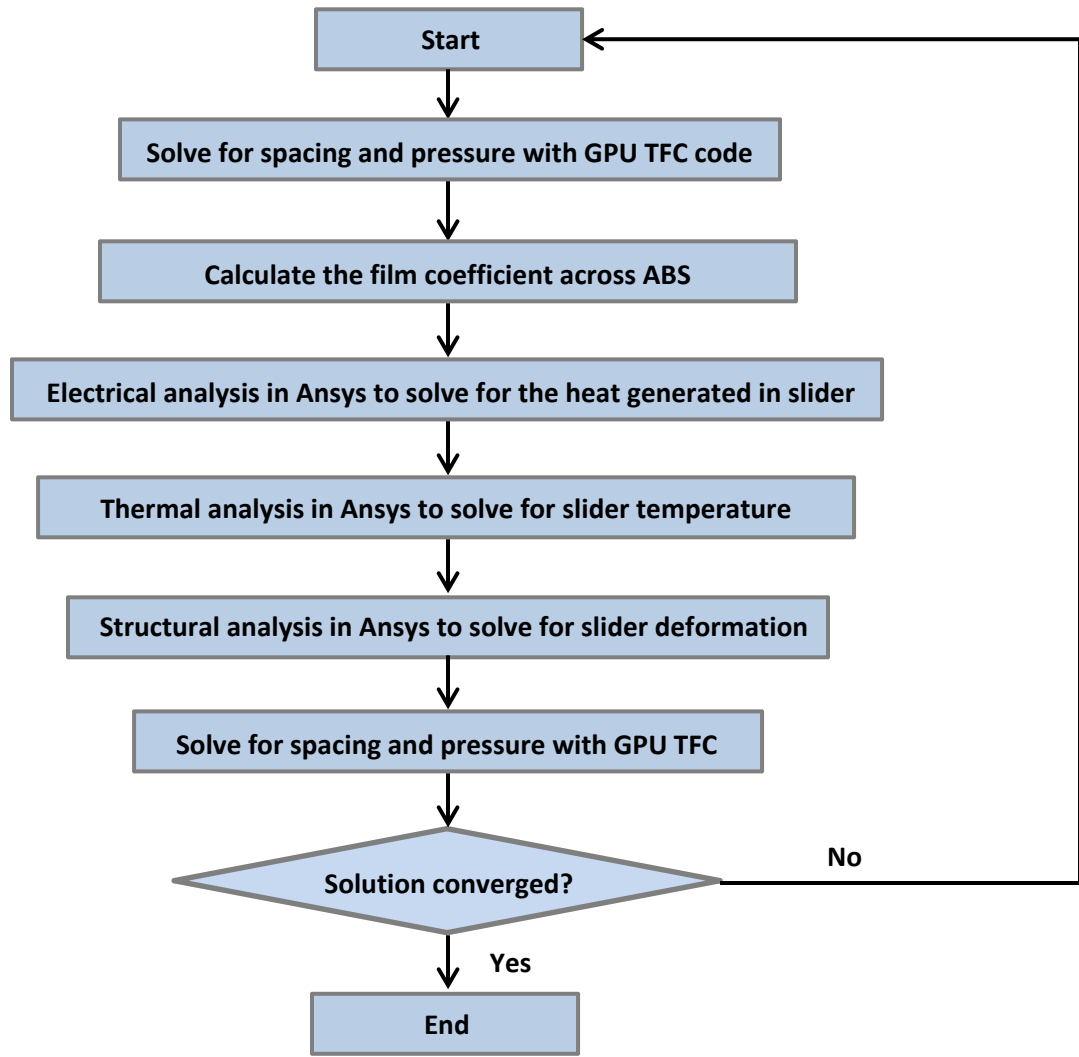


Figure 1. GPU TFC Solving algorithm

4. File structure

Input files and result files are the same as in the TFC code version 1.0. Program files consist of APDL macros that have been modified to point to the new GPU TFC solver. Input files, program files, result files and the relation between files are shown in figure 2.

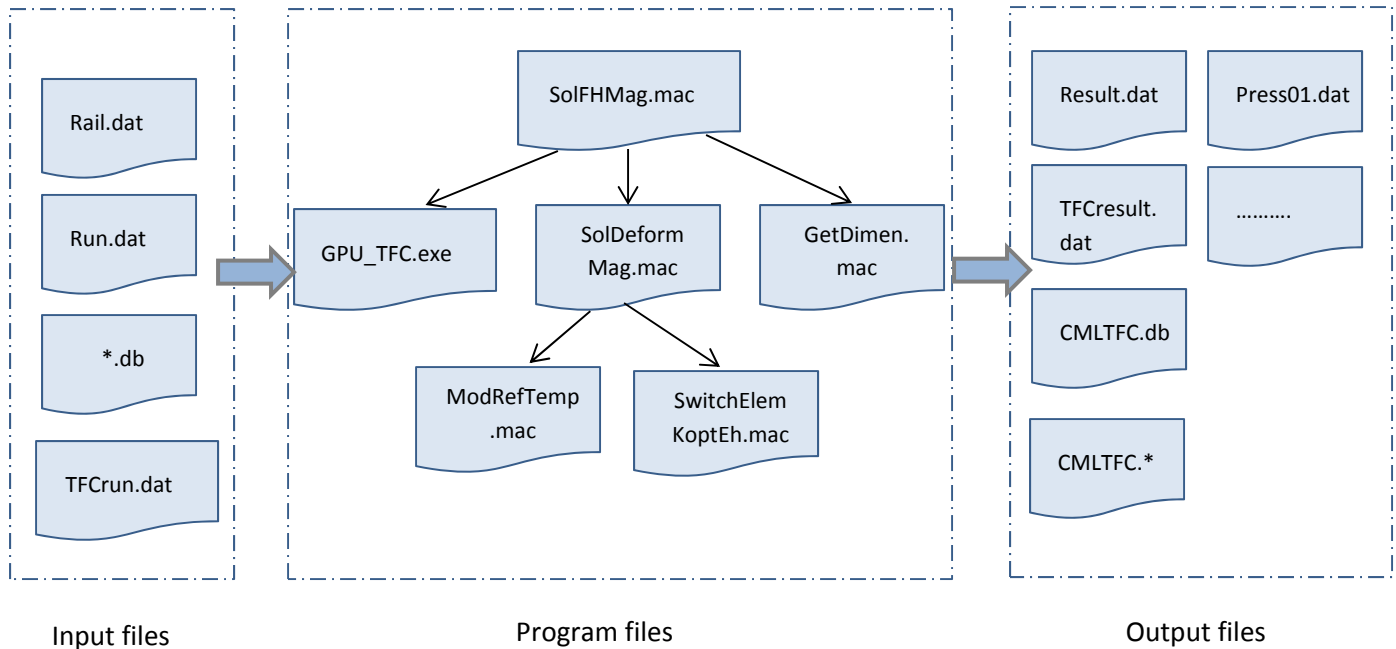


Figure 2. GPU TFC File structure

5. Computer system's requirements:

a. Hardware requirements

During the testing on the new GPU TFC v2.0, we used a Dell desktop computer model: XPS 8500. It has powerful core i7-3770 processors, 3.4 GHz (two processors on a chip), 16 GB of DDR 3 Ram and a PCI express slot version 3.0 where you attach the GPU to motherboard and get maximum speed transferring data in and out of the GPU. A decent power supply on board is required since the GPU, during calculations consumes a relatively large amount of DC power. Each GPU card has its rated max power that needs to be noted and accommodated. Inside the Dell XPS 8500 we installed the following NVIDIA graphic

card model: GeForce 680, which is a medium level GPU in the \$450 price range with powerful features that are used by many video game enthusiasts. The GPU card is shown in figure 3.



Figure 3. NVIDIA GeForce 680 GPU card

b. Software requirements

After obtaining the right hardware, a medium form factor desktop computer such as Dell XPS 8500 or equivalent computer and a GPU such as the GeForce 680 or above, you can directly and easily install the GPU and replace the already installed generic graphics card. Install the hardware into the desktop computer with the proper precautions such as discharging any electrostatic charges off your hands and trying not to apply too much pressure while installing

the GPU into the proper slot, since this might lead to damage to the motherboard and, of course, a malfunctioning GPU.

The GPU card comes with an installation DVD to install the card drivers, however, it is recommended to go to the www.nvidia.com website and download the latest GPU display driver software. This way you are sure of getting the best compatibility and bug free driver software. As of the time of writing this manual, the latest GeForce driver is version 332.21. This software driver was used when testing the new GPU TFC v2.0. The installation of the latest GPU driver is a straight forward process, just follow the installation instructions and it will take no longer than a few minutes.

If you would like to try a different GPU than GeForce 680, please let Dolf know. He will have the correct compiled GPU TFC v2.0 solver that fits the CC requirements for your GPU.

6. Installation of GPU TFC code and operation

Installation of the GPU TFC code can be done by downloading the GPU TFC package from the CML website. Unzip the package and copy the program files (APDL macros) to the current working directory. A complete set of program files includes: SolFHMag.mac, GPU_TFC.exe, SolDeformMag.mac, GetDimen.mac, ModRefTemp.mac, SwitchElemKoptEh.mac. Copy the input files (rail.dat, run.dat MyModel.db and TFCrun.dat) to the same directory. Modify TFCrun.dat to define the parameters for TFC analysis. Once you have all program files and input files in place, launch your ANSYS mechanical APDL launcher to the same working directory. Run the main program SolFHMag.mac. You can run the main program by two methods:

- I. Using the command line: type:
*USE, SolFHMag.mac
- II. Using the GUI interface: click on “Macro” tab, click on “Execute Macro”, then type: SolFHMag.mac and click ok.

7. Example sliders

During the testing of the new GPU TFC code version 2.0, we used three commercial TFC slider designs. Those sliders are in current products and have enough complicated designs to be good candidates to study and benchmark GPU TFC performance. Example 1 is shown in Figure 4 a, Example 3 is shown in Figure 4 b, and Example 2 is similar in design and complexity to examples 1 and 3.

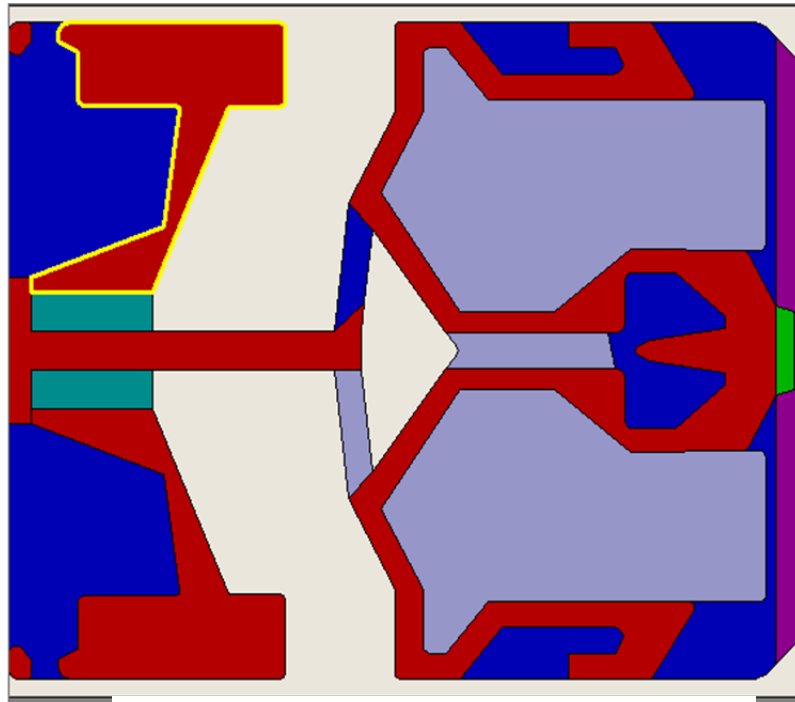


Figure 4 a. Example slider 1 ABS

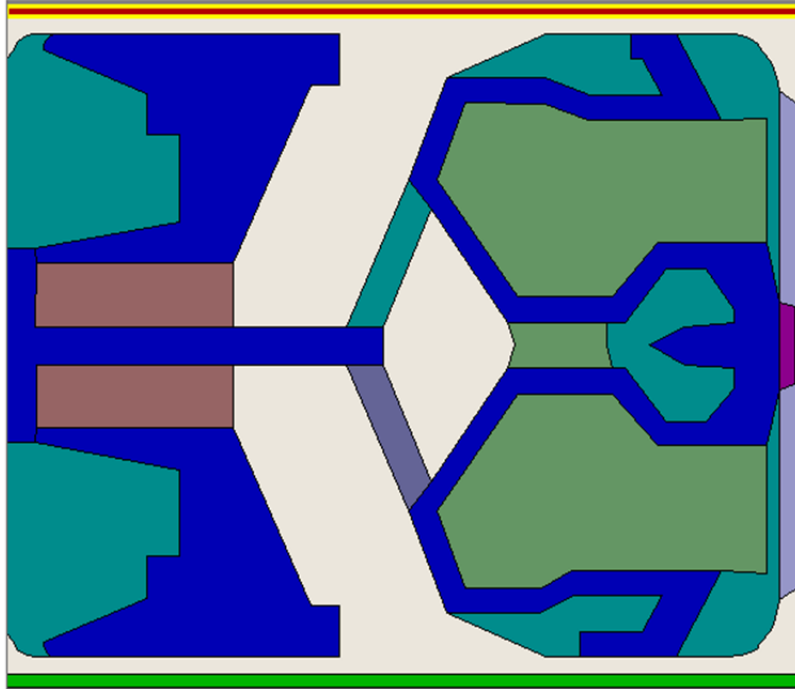


Figure 4 b. Example slider 3 ABS

8. Results and discussion

In this study of the GPU TFC code version 2.0, two factors were important: Speed improvement and accuracy of the results. To illustrate this, we used three different commercial slider designs to study the performance. The different slider designs along with different heater power setting gave different execution times and outputs. Speed improvements ranged from 16.67 % to 50.8 % over the TFC version 1.0. This achieved performance is expected due to the computational power of the GPU. The outputs for the example sliders used are illustrated in the below figures. Figures 5.a, 5.b, 5.c and 5.d show the following for example slider 1: execution time, maximum protrusion in the UZ direction, minimum FH (Flyheight) and change in FlyHeight from starting FH with no heater power to the converged FH versus heater power respectively.

For example slider 2 while measuring execution time, we took one power setting to emphasize the highest speed achieved rather than showing multiple power settings. In this case when 25mW heater power is applied, TFC v1.0 took 61 minutes to get the converged final Flyheight, while GPU TFC took only 30 minutes. This translates to 50.8 % speed increase over using CML TFC version 1.0 code. Figures 6.a, 6.b and 6.c show maximum protrusion in the UZ direction, minimum FH, and change in Flyheight versus heater power applied, respectively.

Example slider 3 results are shown in figures 7.a, 7.b, 7.c, and 7.d. Those figures show execution time, maximum protrusion in the UZ direction, minimum FH and change in Flyheight versus applied heater power respectively.

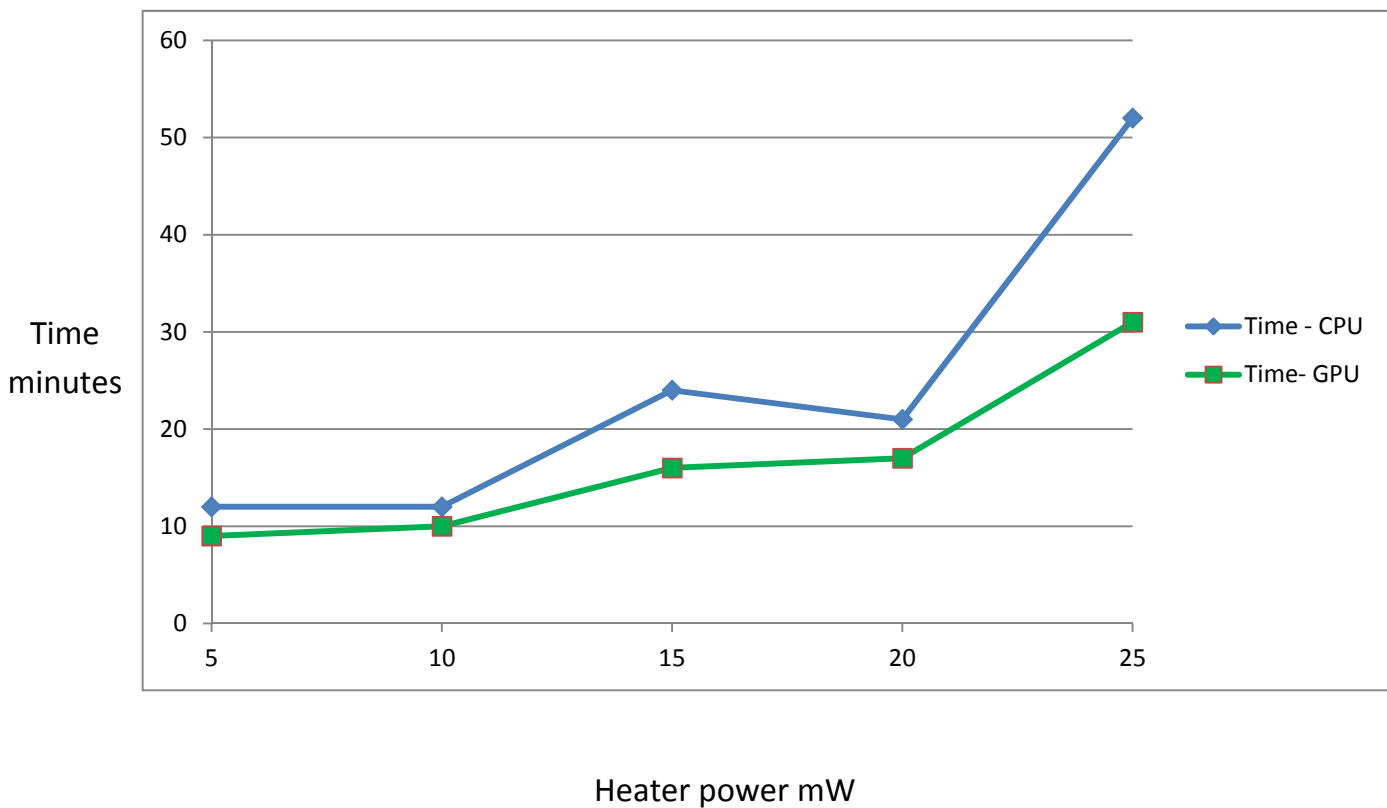


Figure 5 a. Example slider 1 execution time versus applied heater power

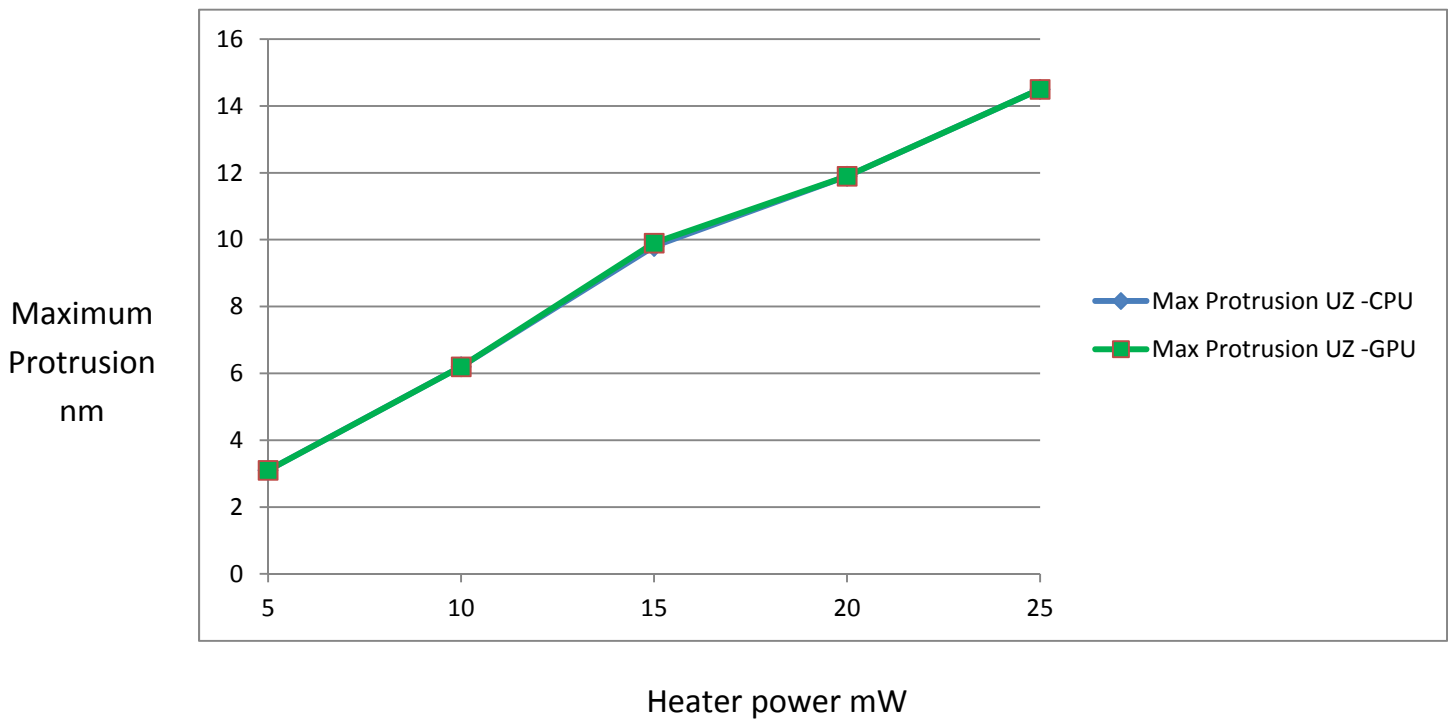


Figure 5 b. Example slider 1 Maximum protrusion versus applied heater power

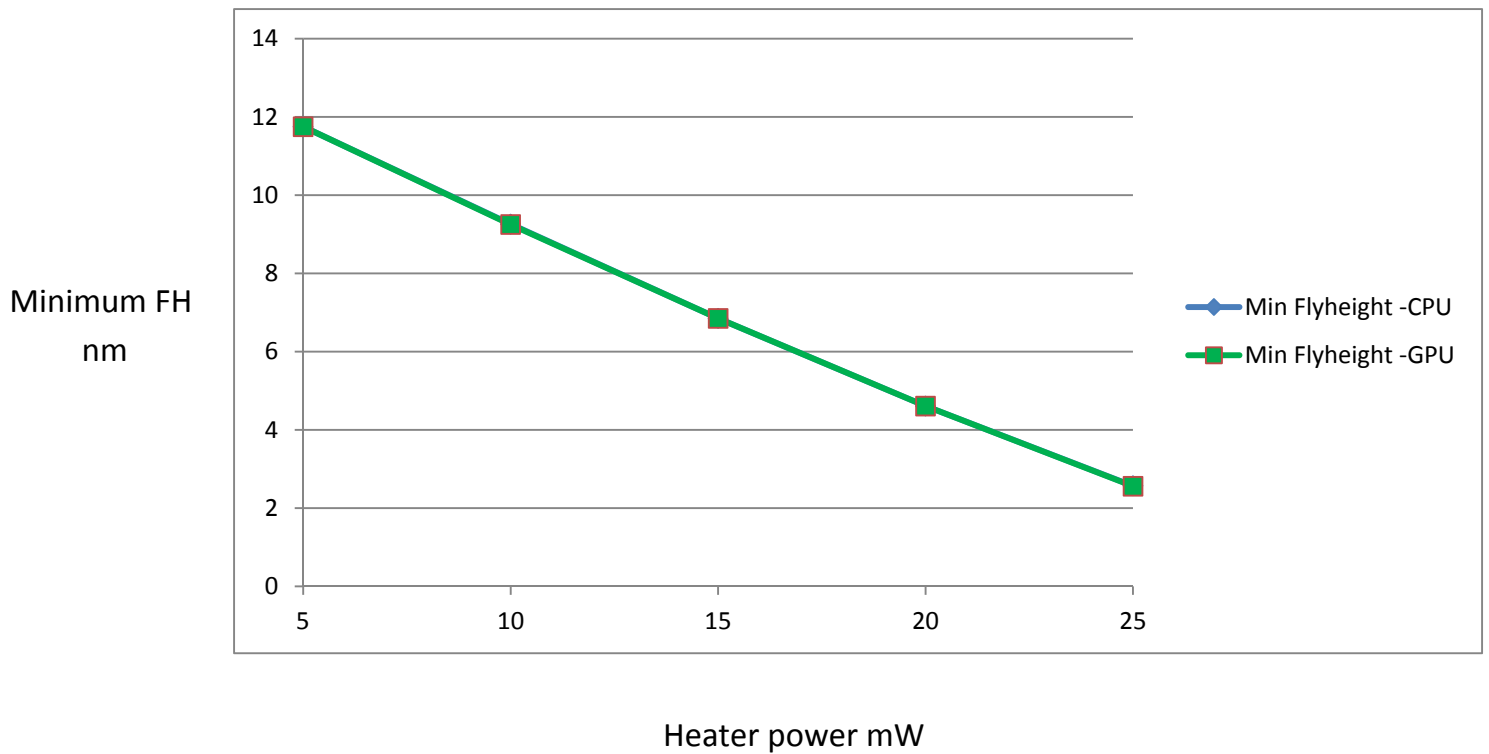


Figure 5 c. Example slider 1 minimum FlyHeight versus applied heater power

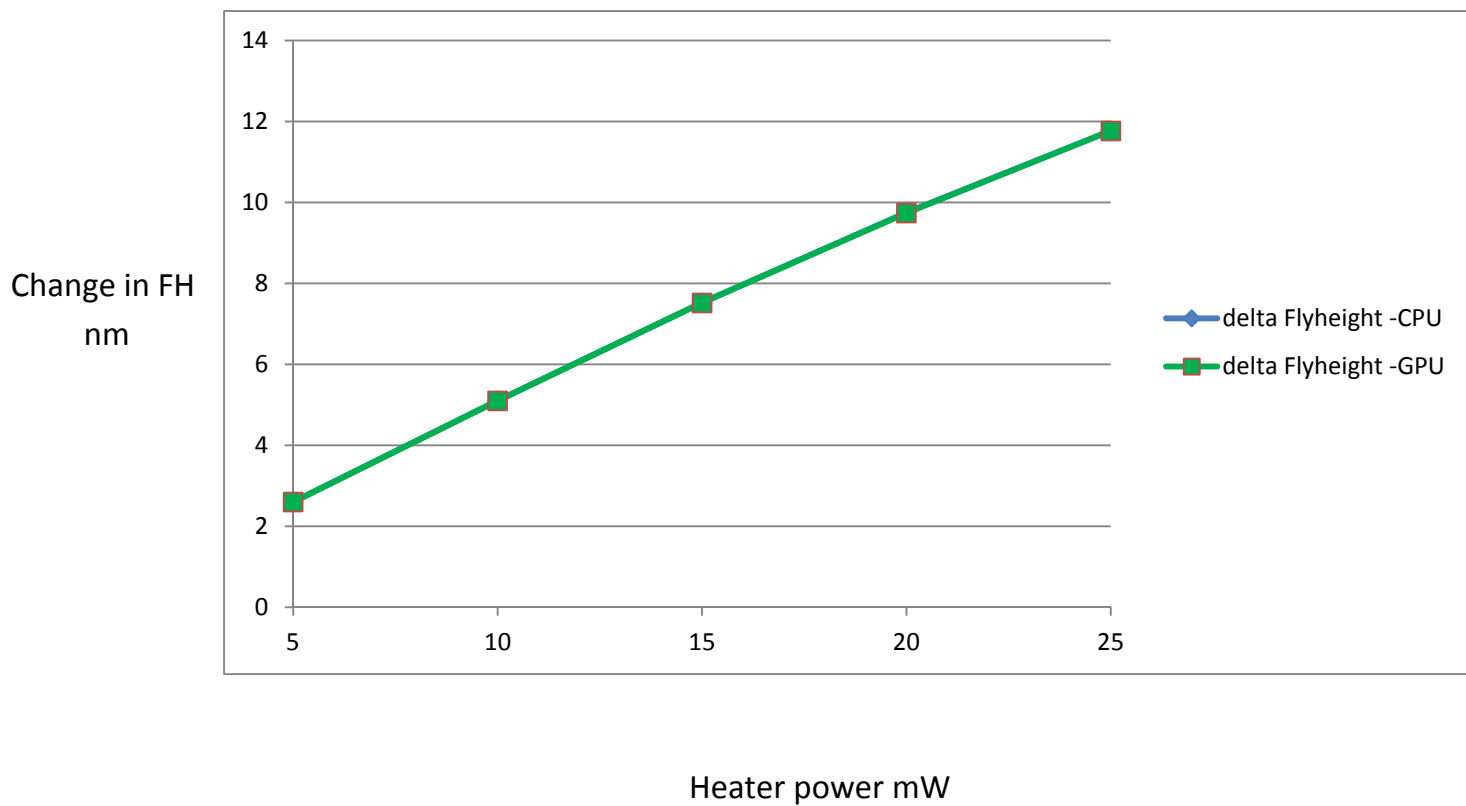


Figure 5 d. Example slider 1 change in FlyHeight versus applied heater power

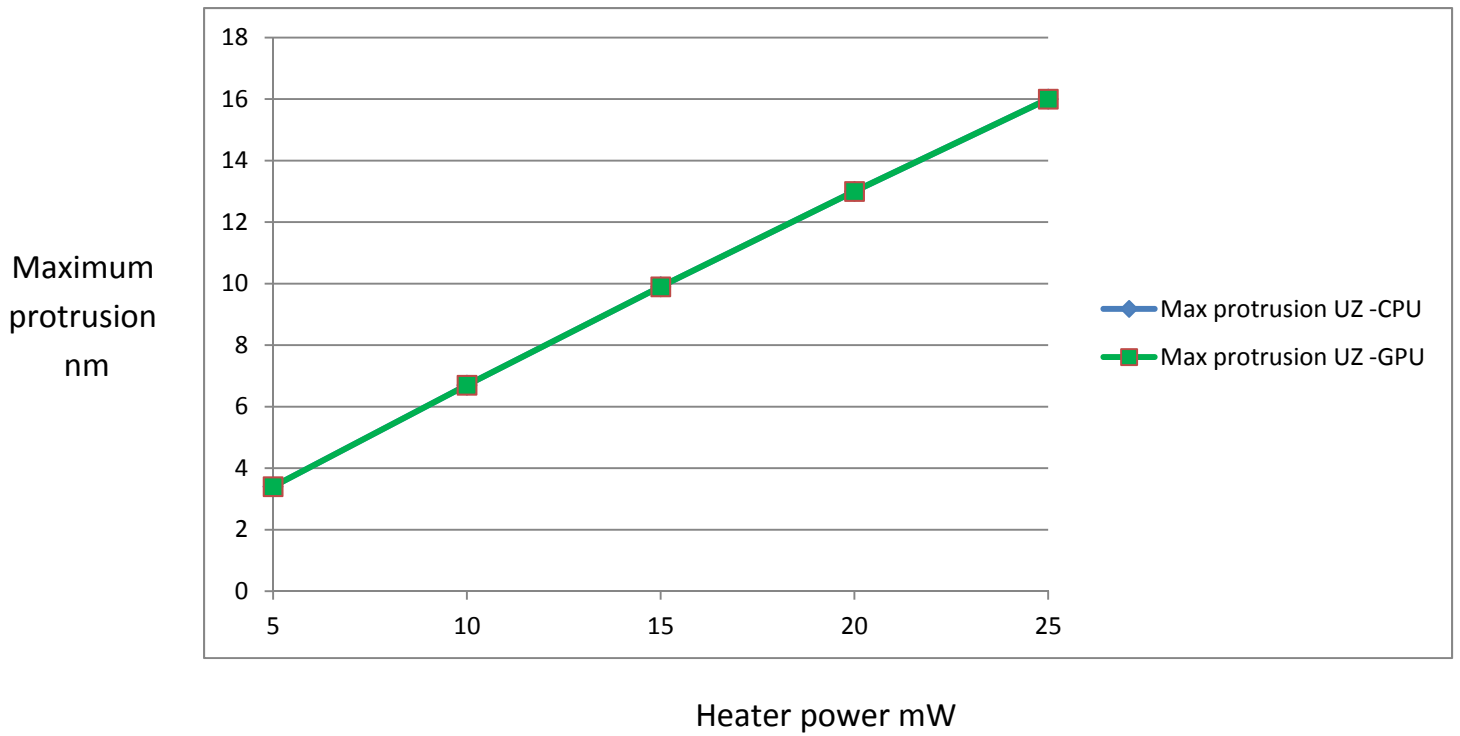


Figure 6 a. Example slider 2 maximum protrusion versus applied heater power

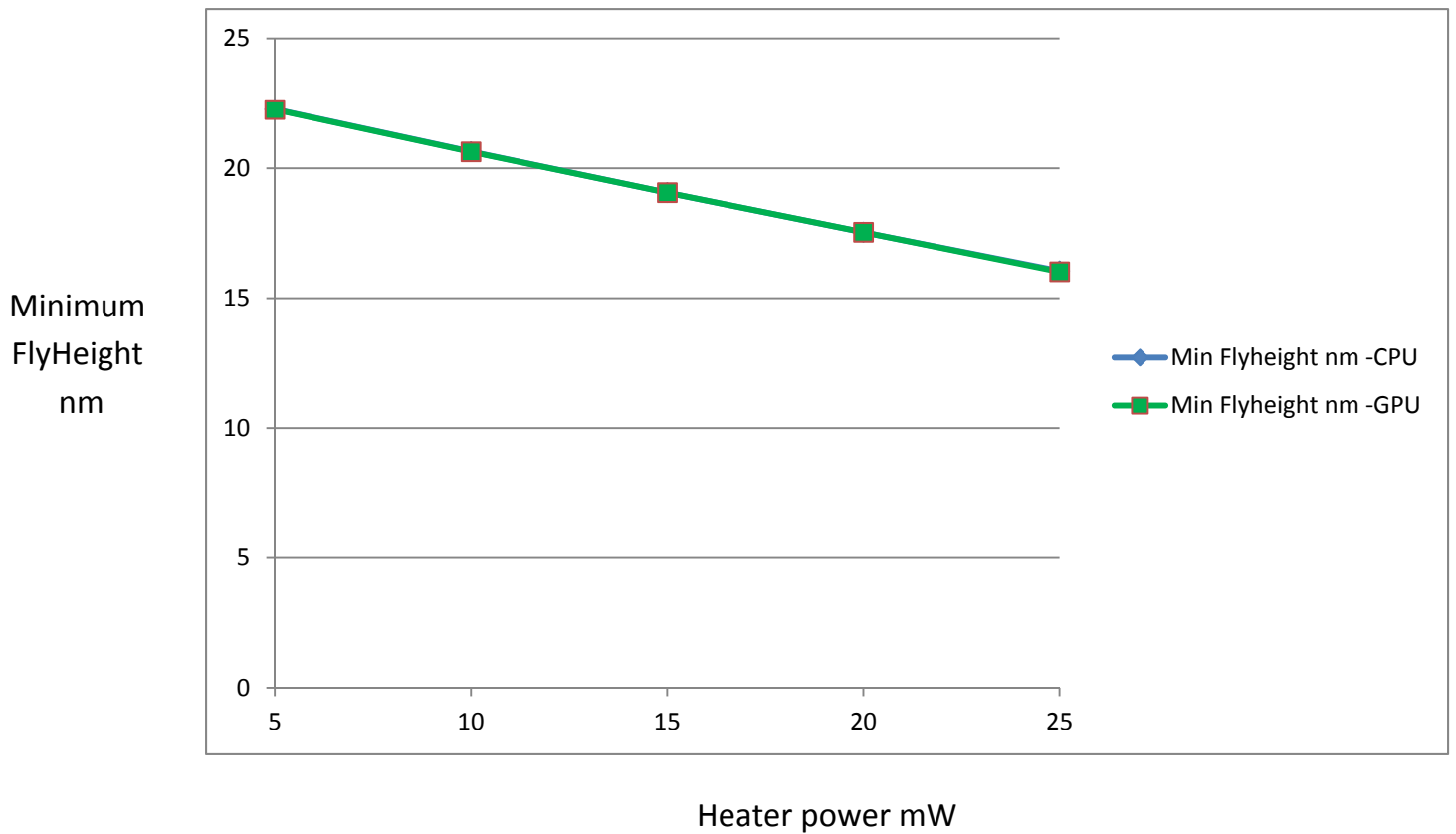


Figure 6 b. Example slider 2 minimum FlyHeight versus applied heater power

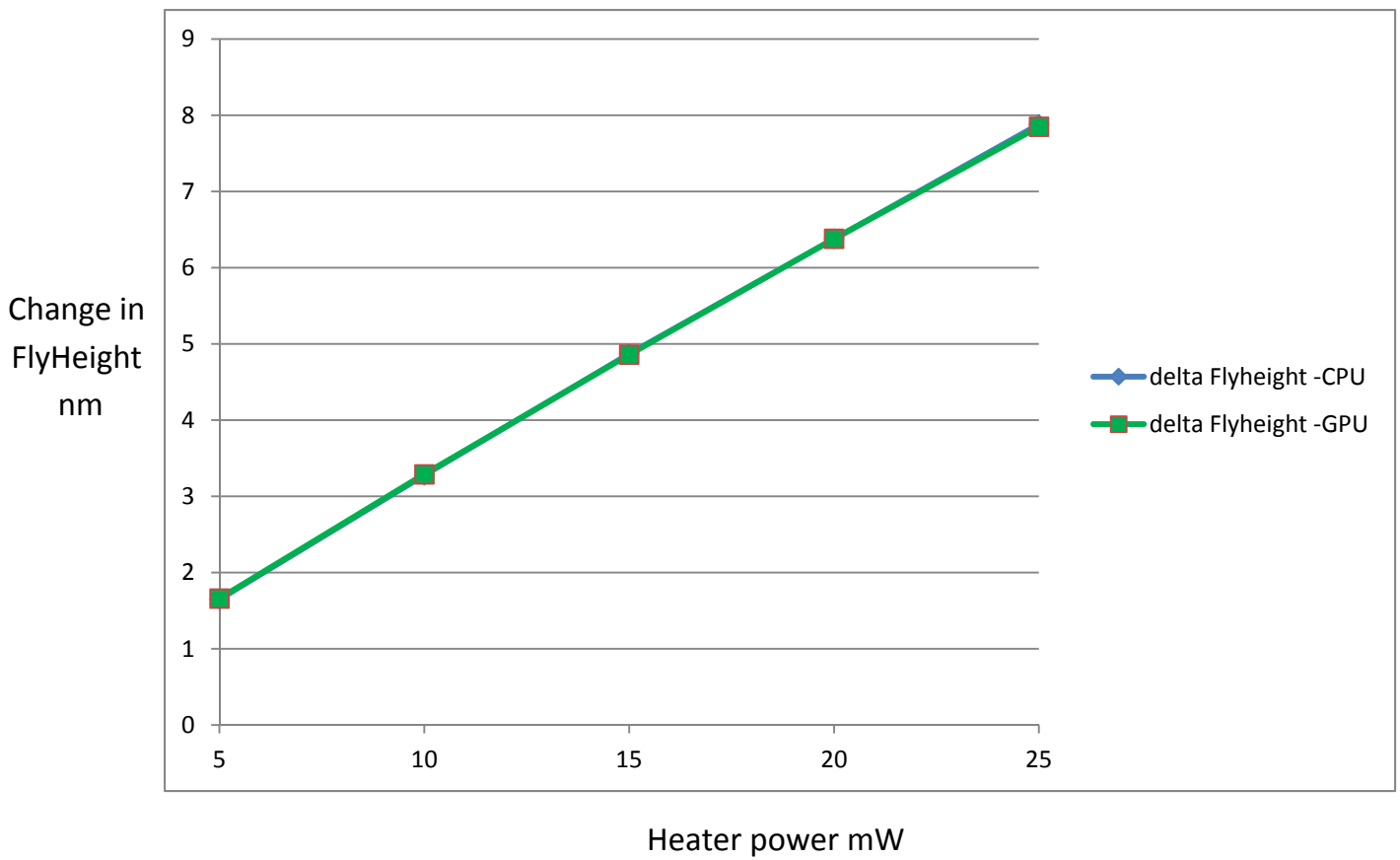


Figure 6 c. Example slider 2 change in FlyHeight versus applied heater power

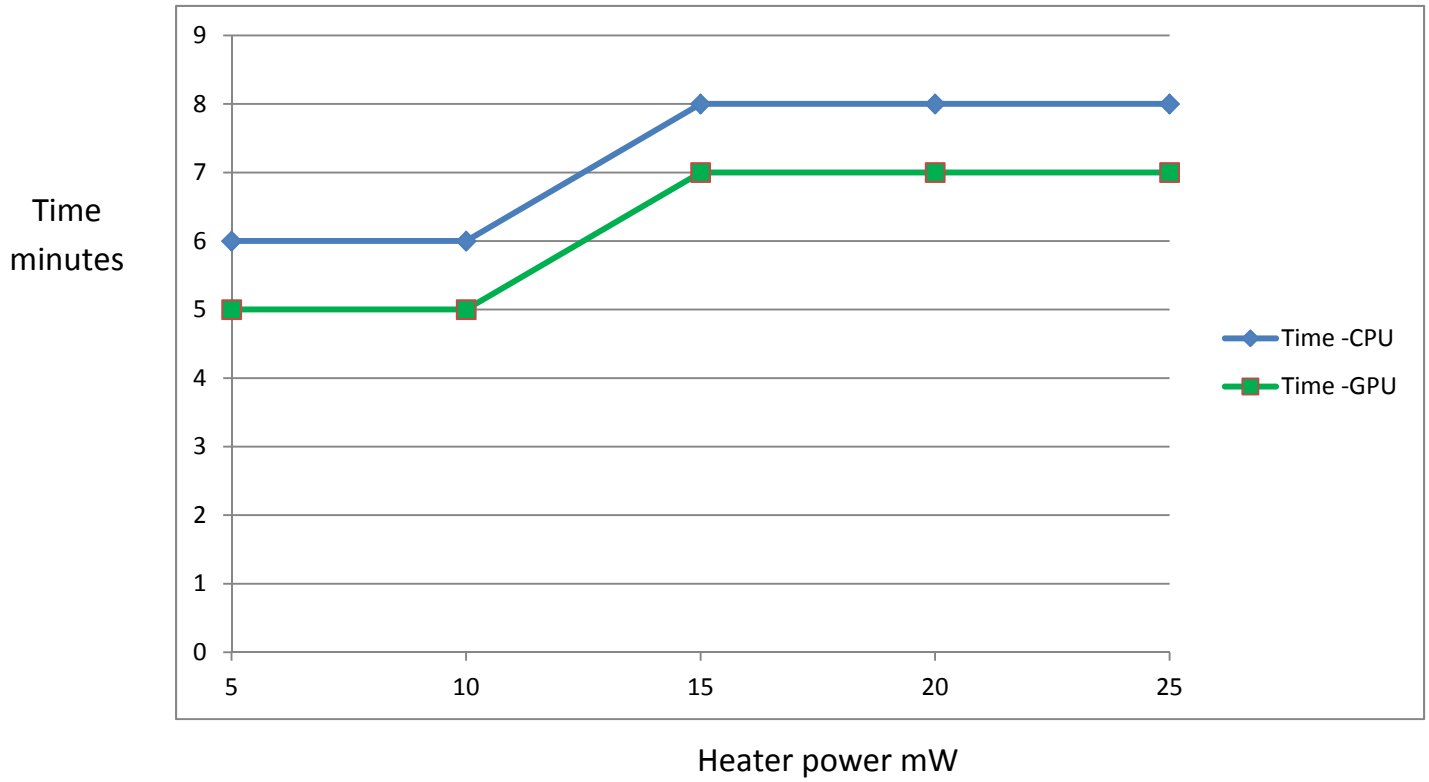


Figure 7 a. Example slider 3 execution time versus applied heater power

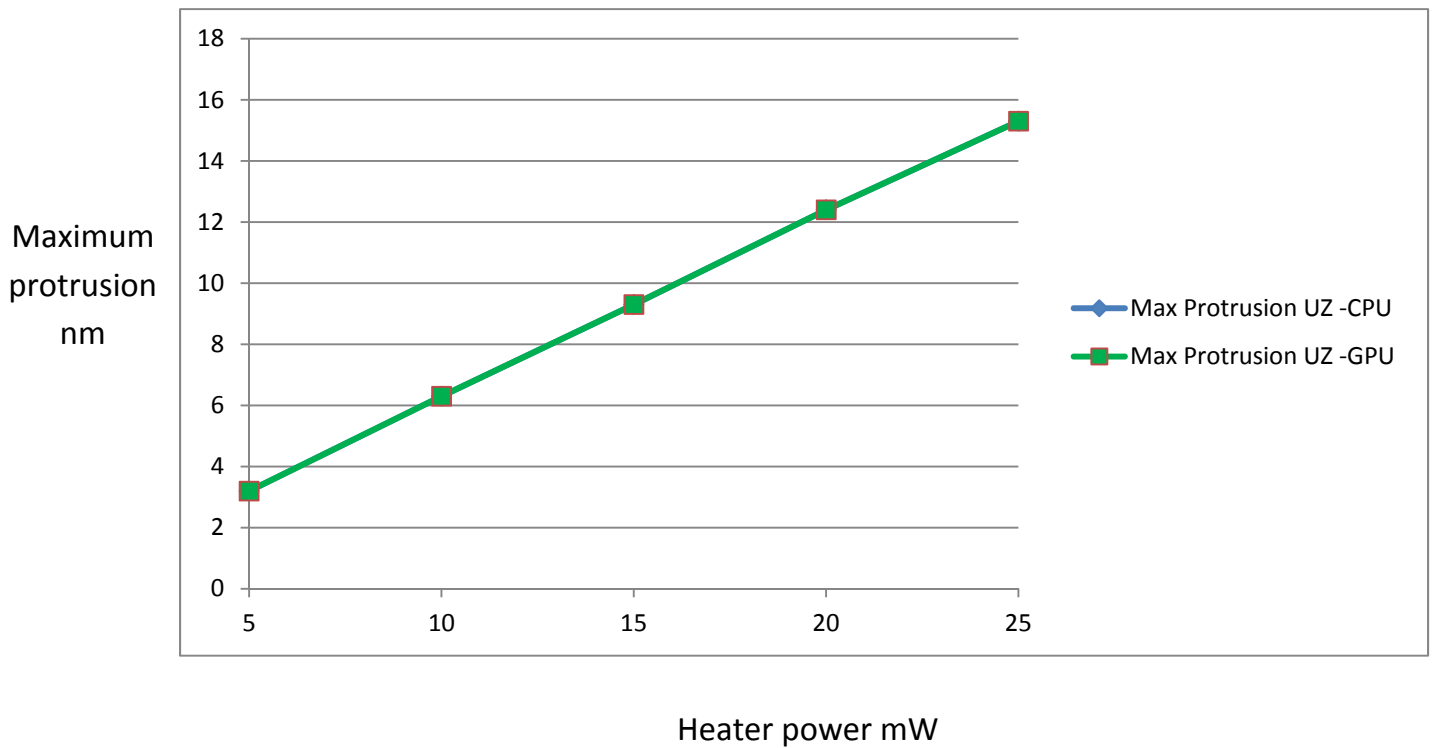


Figure 7 b. Example slider 3 maximum protrusion versus applied heater power

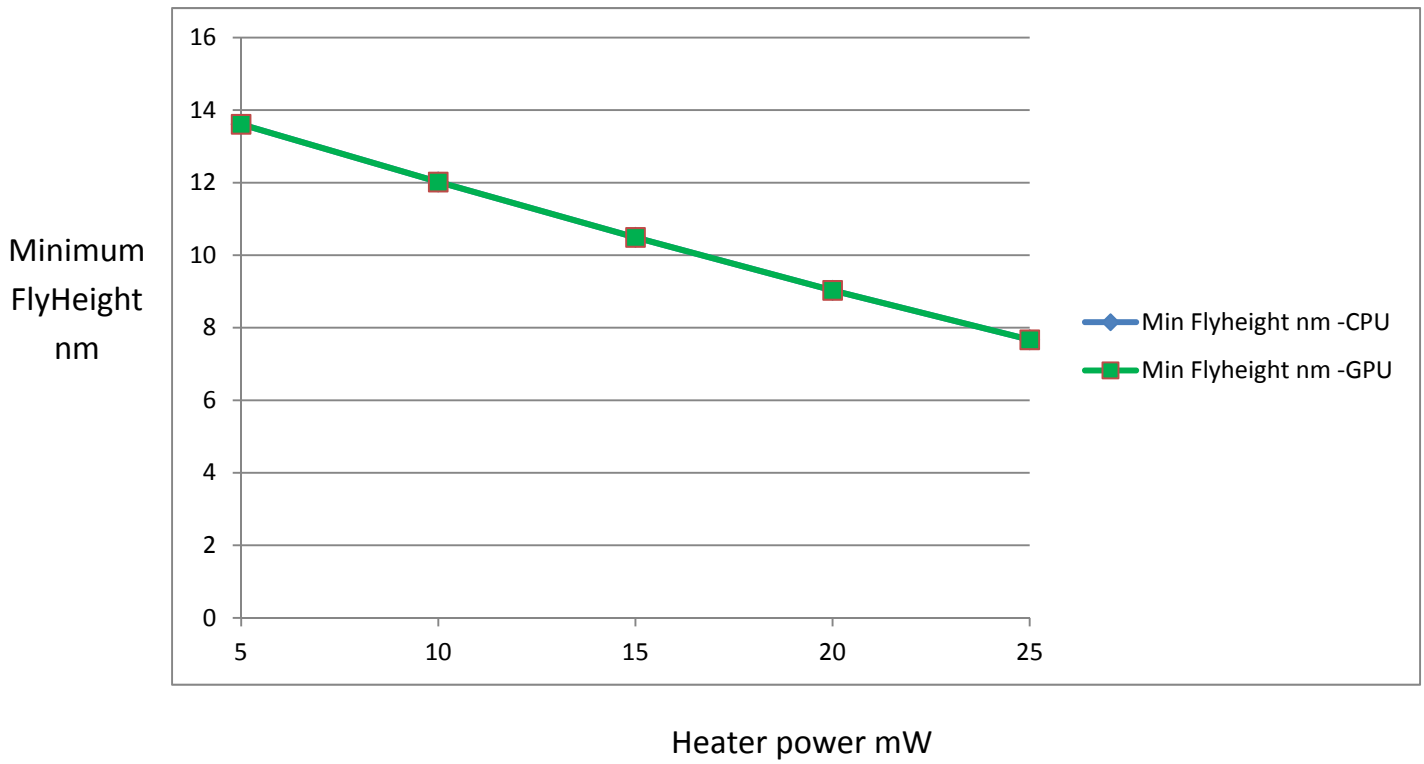


Figure 7 c. Example slider 3 minimum FlyHeight versus applied heater power

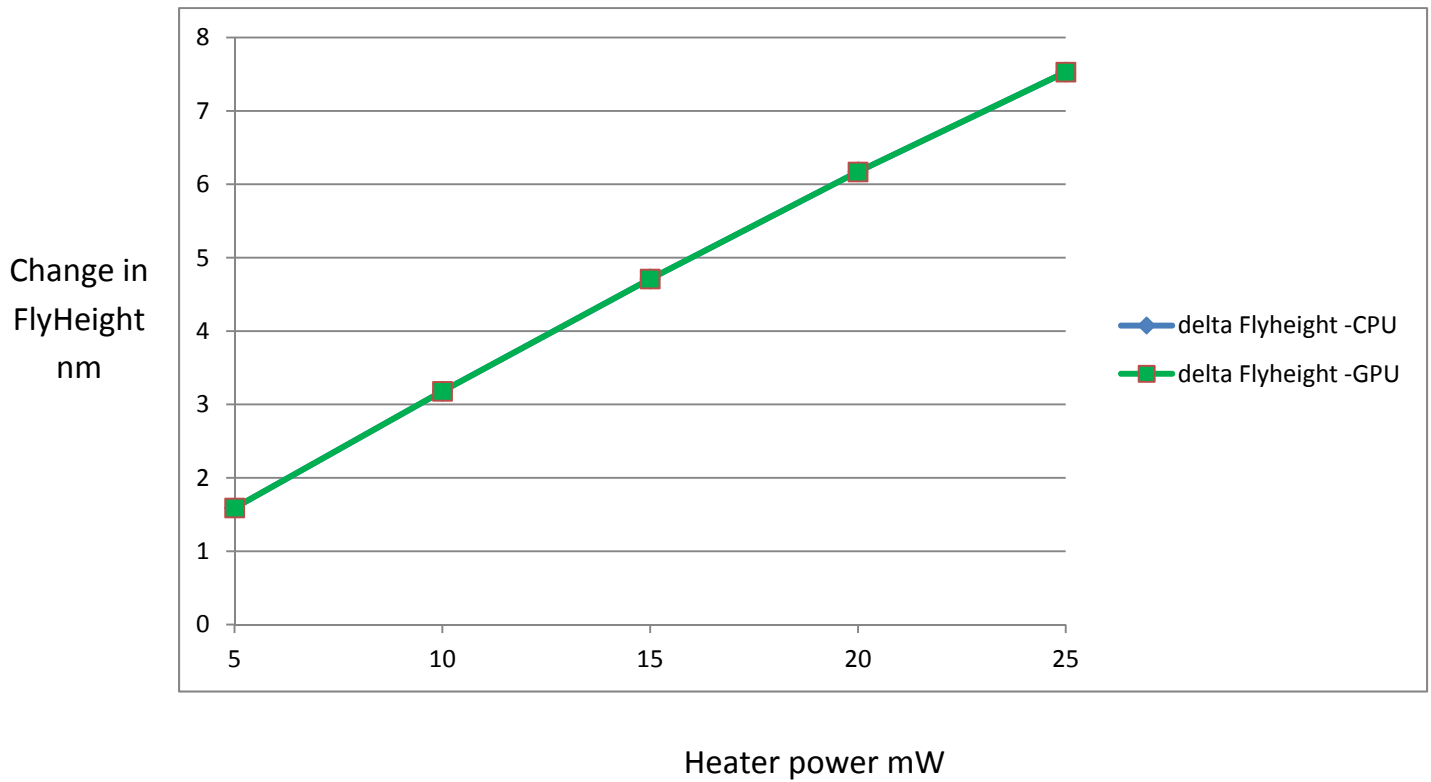


Figure 7 d. Example slider 3 change in FlyHeight versus applied heater power