



A Low Cost Educational Atomic Force Microscope ??????????

by **whoand** on April 27, 2014

Table of Contents

A Low Cost Educational Atomic Force Microscope ??????????	1
Intro: A Low Cost Educational Atomic Force Microscope ??????????	2
Step 1: Materials and tools ??????	2
Step 2: Assembling the AFM base ??????????	3
Step 3: Assembling the AFM piezo scanner ??????????	4
Step 4: Assembling the AFM head ??????	5
Step 5: Installing piezo scanner connectors ??????????	6
Step 6: Assembling a passive anti-vibration platform ??????????	6
Step 7: Sample preparation ????	6
Step 8: AFM evaluation and calibration ??????????	7
Step 9: Measuring the surface of an eraser ??????????	8
Step 10: Observing PM 2.5 particles in Beijing ??????????	8
Step 11: Prepare for making your own educational AFM	9
Related Instructables	11
Advertisements	11
Comments	11

Intro: A Low Cost Educational Atomic Force Microscope ??????????

Microscopes are awesome! They help us see things that are not visible to bare eyes. Optical microscopes can only see micro scale (1/1,000 millimeter) structures. However, you can explore nano scale (1/1,000,000 millimeter) world by Atomic Force Microscopes (AFM). Yet a stock-ready AFM usually costs hundreds of thousands of dollars to buy. Thus we are providing you a solution to make your own AFM optomechanical system out of daily used parts including optical pickup unit (OPU) in a DVD player and piezo buzzers in your watch. The total cost is between 500 to 1,000 dollars. Most of the traditional AFM systems use beam deflection method for monitoring the AFM probe, the low cost educational AFM directly use an OPU for the same purpose. This low cost educational AFM is originally designed and made by Dr. En-Te Hwu, Institute of Physics, Academia Sinica, Taipei, Taiwan. Idea of using circuit boards as structure: Sebastian Buetefisch.

??1/1,000????????????????????(1/1,000,000 ??)??
????????????????????DVD Rom??1000??
??Sebastian Buetefisch.

??1/1,000????????????????????(1/1,000,000??)??
????????????????????DVD Rom??
??Sebastian

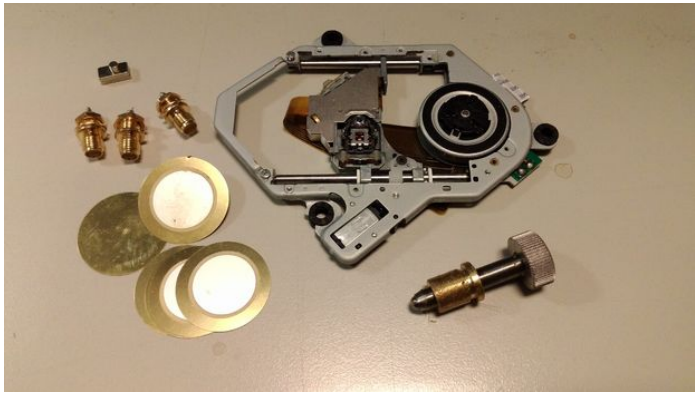
Buetefisch.

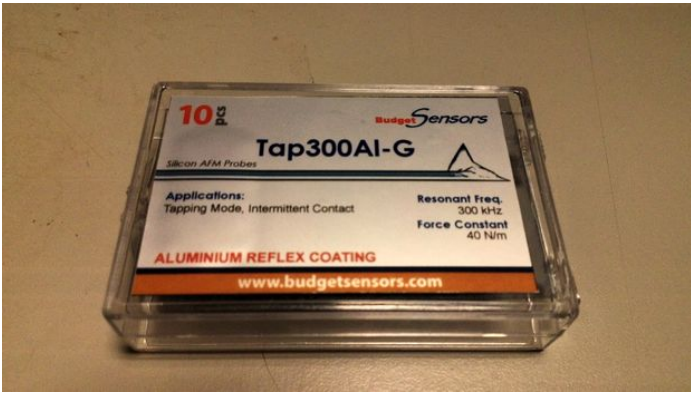


Step 1: Materials and tools ??????

Materials for the low cost AFM are: 1.OPU disassembled from a DVD ROM. 2.Piezo speakers. 3.Signal connector. 4.Precision screws. 5.Circuit boards. The tools needed are: 1.A soldering iron 2.Solder 3.Quick-dry adhesive 4.Epoxy 5.Magnets 6.Screw driver. The consumable is AFM probes (working frequency 300 kHz).

????????????????????1.DVD?????????? 2.????? 3.????? 4.????? 5.?? 6.???????? ?????1.?? 2.?? 3.??? 4.AB? 5.????????????????????????????????300k????
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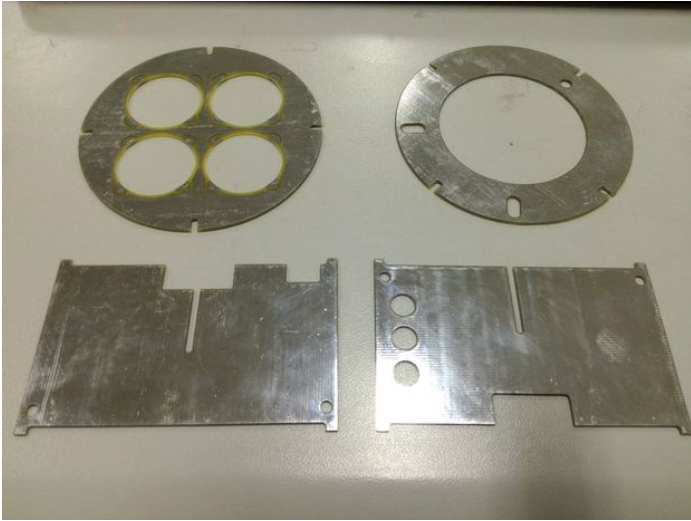


Step 2: Assembling the AFM base ??????????

The optomechanical part of the AFM system is assembled by students from junior high school attached to Tsinghua University. The AFM base is structured by 4 circuit boards which are fixed by solder.

??4????????????????????????

??4????????????????????????

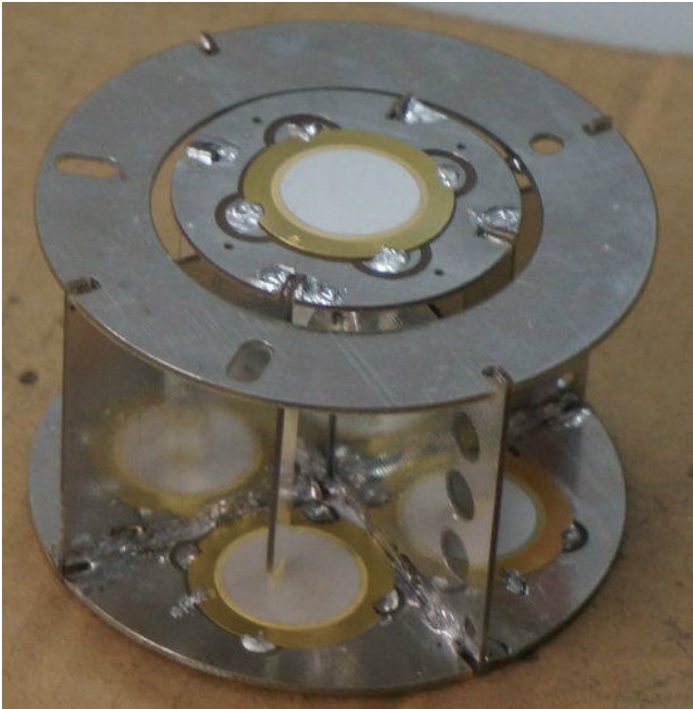
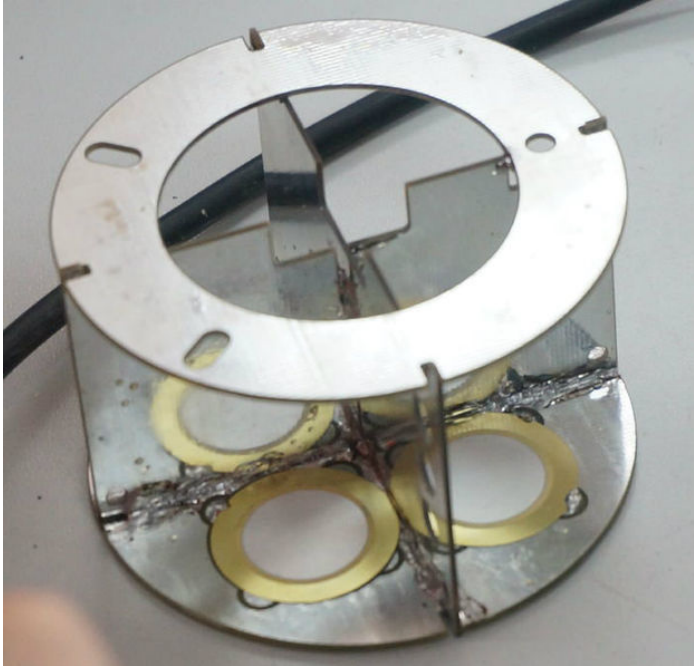


Step 3: Assembling the AFM piezo scanner ????????

Assembling the scanner structure and fix the structure on 4 piezo buzzers which are soldered to the base. The fifth piezo buzzer is fixed on top of the scanner structure.

????????????????????AB??

????????????????????AB??

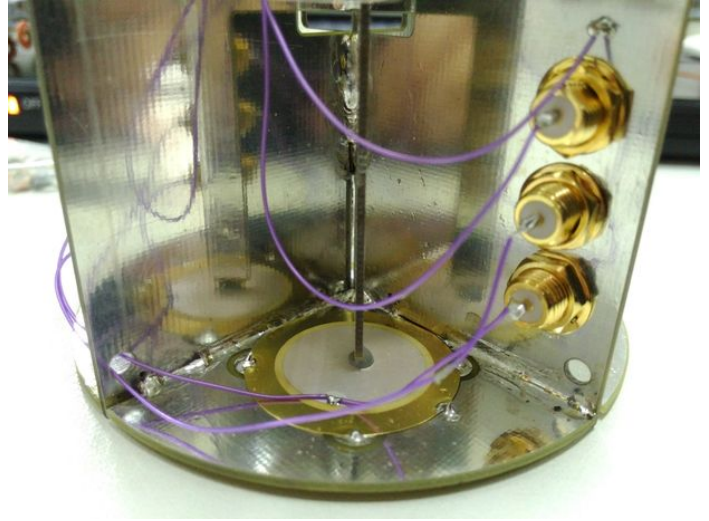
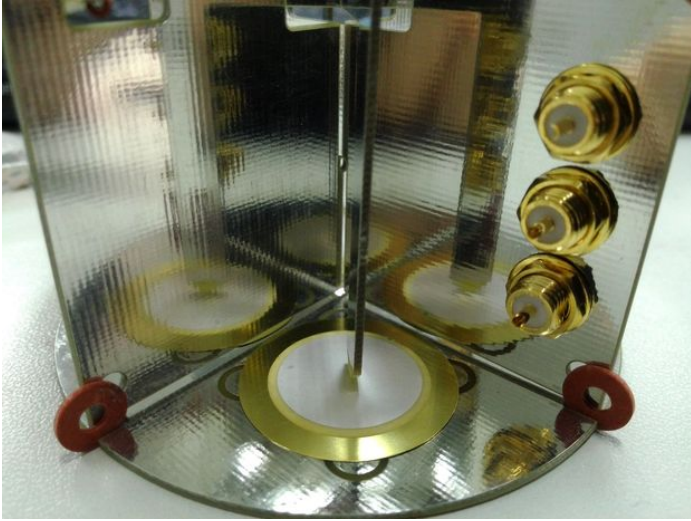


Step 5: Installing piezo scanner connectors ??????????

The piezo scanner needs 3 connectors for X,Y,Z signal input. Wire those 5 piezo speakers to the connectors which installed in the base.

????????????X?Y?Z????????????????????????????????

????????????X?Y?Z????????????????????????????????

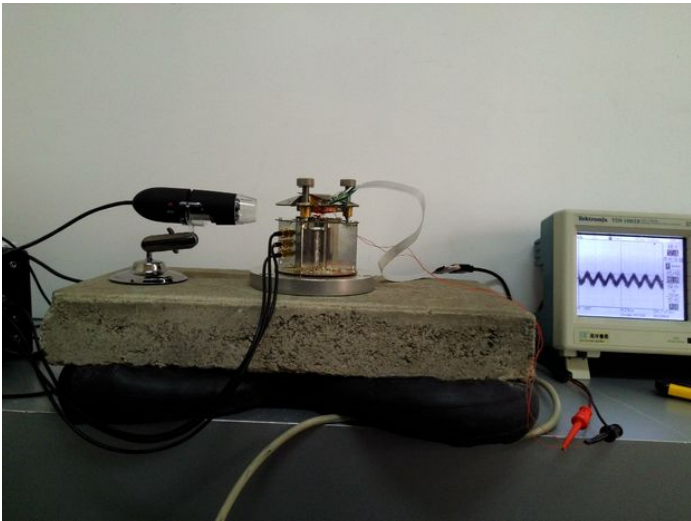


Step 6: Assembling a passive anti-vibration platform ??????????

Proper vibration isolation can ensure AFM measurement quality, good news is that the vibration table can be built by materials we can easily get:1.Bicycle tube(diameter 10-18 inch) 2.A stone, iron block or other heavy object (weight of 3-10 kg, size of approx. 20x50 cm) 3.Pump for pumping the bicycle tube. Place the stone on top of an inflated bicycle tube, this can be a very simple passive anti-vibration platform.

??1.????????????10-18????2.????????????????????????????3-10????????????20????50????????????3.????????????????????????

??1. ?????????????10-18??? 2. ?????????????????????????????3-10????????????20????50????????? 3. ?????????????

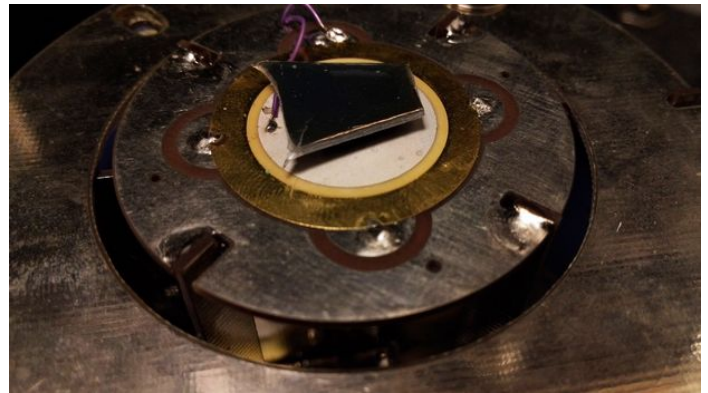
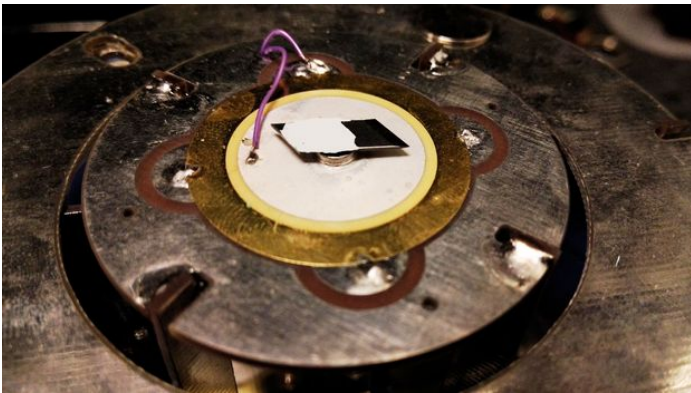
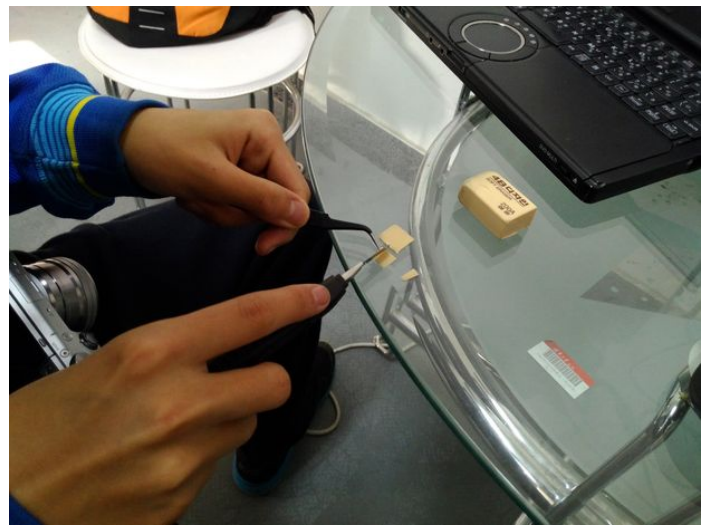


Step 7: Sample preparation ????

Like normal AFM systems, the low cost AFM also needs simple sample preparations. Here we use data tracks on DVD and Blu-ray disks (protection layer are torn out) for AFM system evaluations and calibrations. The DVD and Blu-ray data tracks have pitch of 740 nm and 320 nm, respectively. Besides, the students are very interested in measuring surface nano structures on an eraser. We cut one piece (approximately 1x1 cm) of the sample glued on an iron sample holder (piece of paper knife). The sample holder can be fixed by a magnet glued on the piezo scanner.

??DVD?Blu-ray??(???????)????????????????????????????DVD????????740??Blu-ray????????320????????????????????

??DVD?Blu-ray??(???????)????????????????????????????DVD????????740??Blu-ray????????320????????????????????



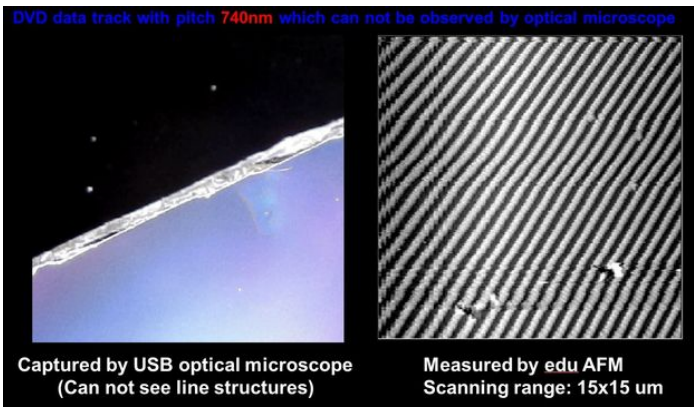
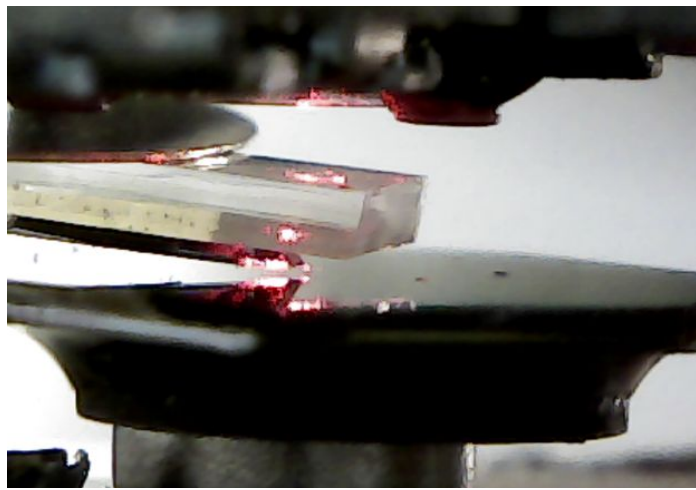
Step 8: AFM evaluation and calibration ????????

Students use the AFM they assembled for measuring the DVD data tracks (pitch 740 nm), measurement result shows that the actuation area of the scanner is 15x15 micron. Students also compare the AFM measurement result (right image) with optical image captured by a USB microscope (left image). The low cost AFM can easily measure the DVD data tracks which can not be observed by the optical microscope.

????????????????????????????DVD?????????????740?????????????????????????????X?Y??15?????AFM?????????????USB??????????????????????????????
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????????????????????????????DVD?????????????740?????????????????????????????X?Y??15?????AFM?????????????USB??????????????????????????????
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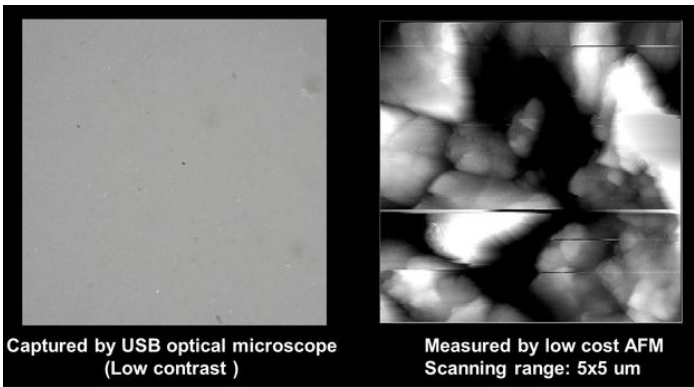


Step 9: Measuring the surface of an eraser ????????

Students are very interested in surface structures of an eraser that they use everyday. The surface of eraser is observed by the USB microscope (left image), we can not see clear structures. The same eraser is measured by the low cost AFM (right image), we found that the structures on the eraser surface are very big (several microns in all dimensions). The measurement area of the eraser is 5x5 micron.

????????????????????????????????????USB????????(??)??(??)????????????5x5???

????????????????????????????????????USB????????(??)??(??)????????????5x5???



Step 10: Observing PM 2.5 particles in Beijing ??????????

Students like to measure Blu-ray data tracks that the pitch is 320 nm. We can get the high density data tracks in a scanning area of 10x10 micron. Besides, we can find several particles (size approx. 1 micron) on the data tracks. Those particles are PM 2.5 in Beijing.

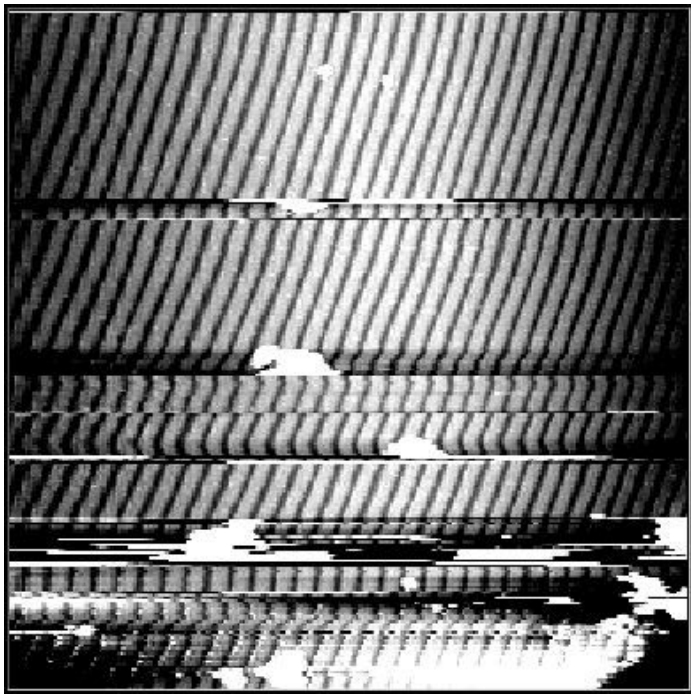
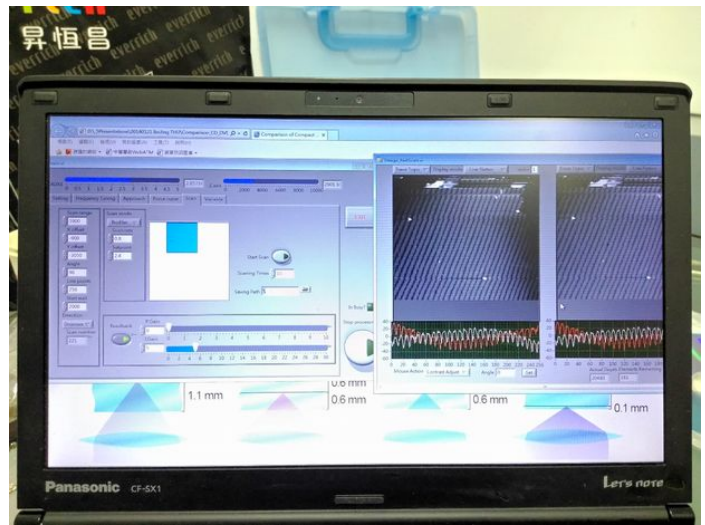
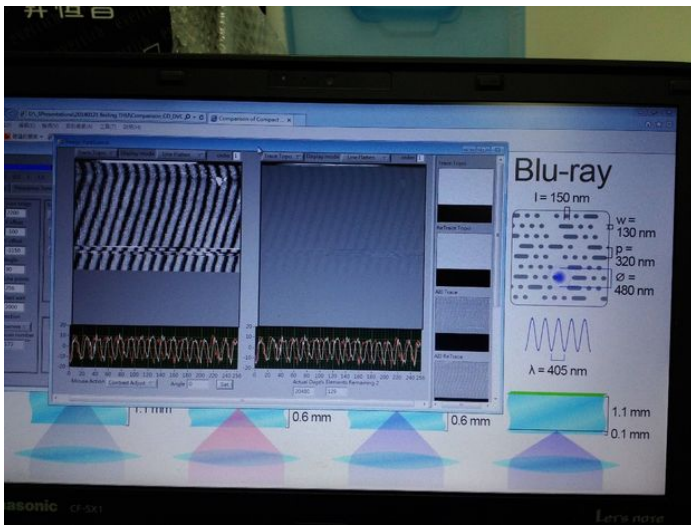
Due to some probom in the instructables, here is a link of the step by step process in PDF: <http://ppt.cc/bEsH>

?????????????Blu-ray????????????320?????????????????????Blu-ray????????????????10x10??PM 2.5???

?????PDF????????????PDF??? <http://ppt.cc/bEsH>

?????????????Blu-ray????????????320?????????????????????Blu-ray????????????????10x10??PM 2.5???

?????PDF????????????PDF???<http://ppt.cc/bEsH>



Step 11: Prepare for making your own educational AFM

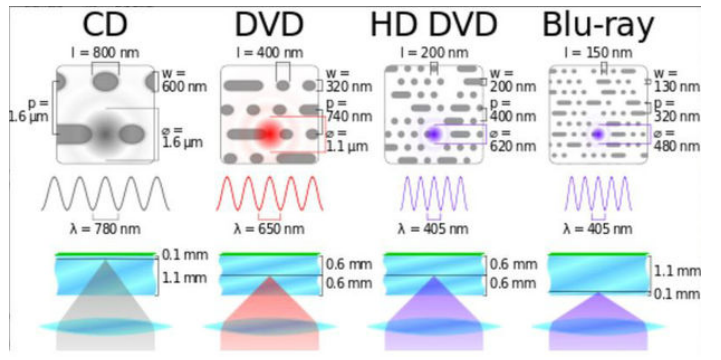
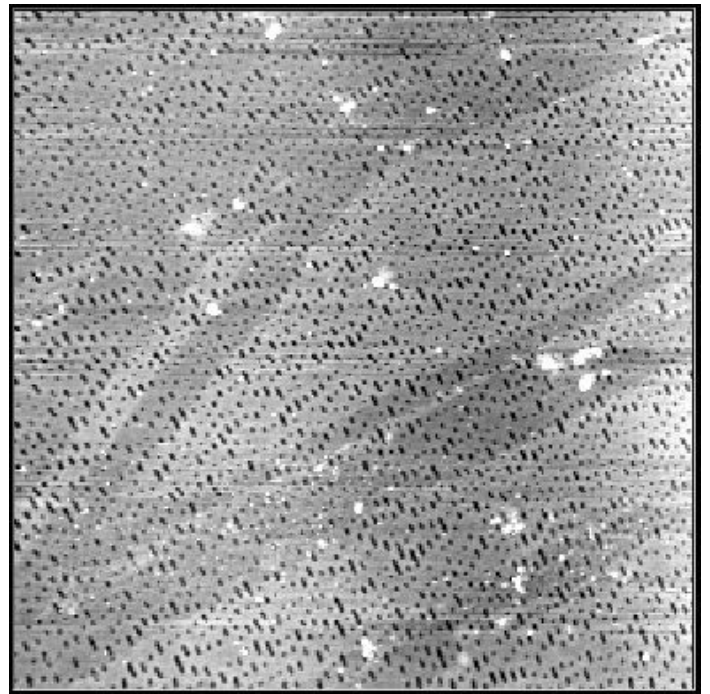
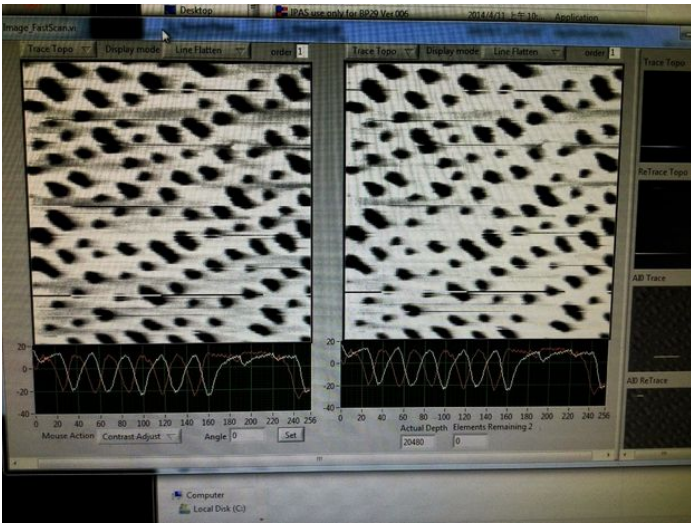
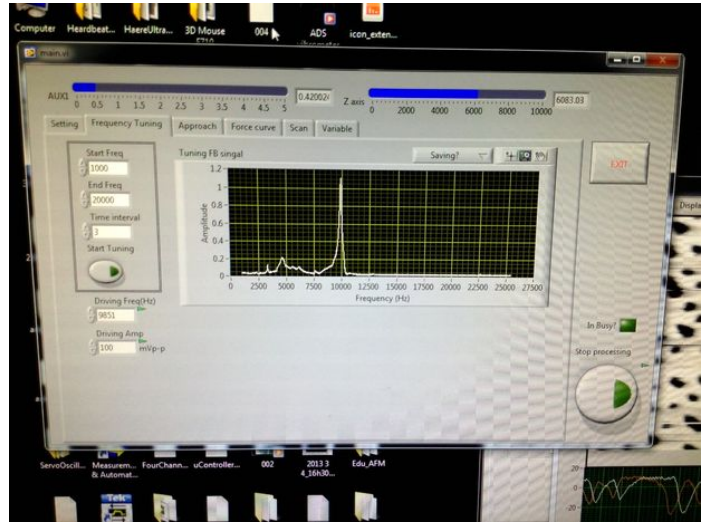
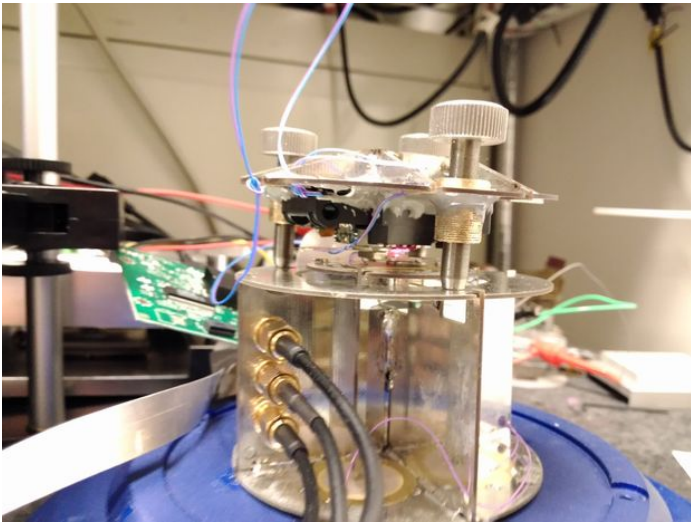
One working system in Taiwan runs 24-7 for stress test, this system is continuously scanning for more than one week. I am using contact mode AFM probe now (still use that probe in tapping mode). The sample is a Blu-ray disk of mass produced PS3 game (I think the game is Front Mission Evolved). There are no data tracks on the disk, we can find data pits on the surface. The size of one data pit is about 150 nm.

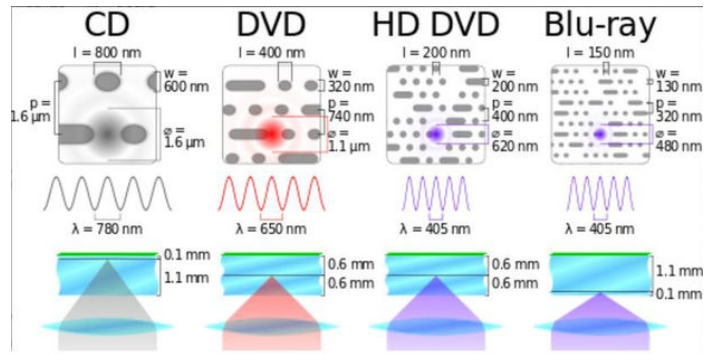
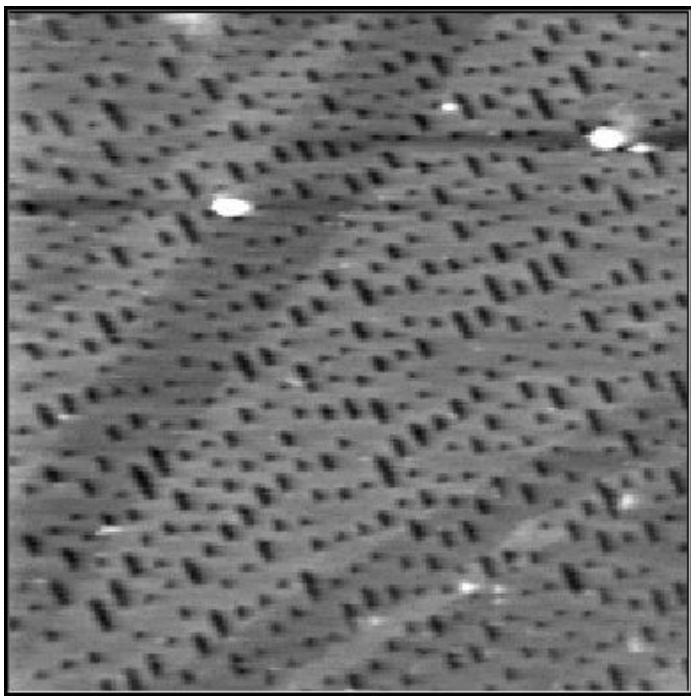
Actually I work with OPUs for 10 years already....the OPU based AFM paper published long time ago (<http://nanotechweb.org/cws/article/tech/33346>) It's still fun to play with OPUs.

Using OPU for AFM application seems very easy, but actually there are a lot of tricky parts. One may need to know fundamentals of the OPU, then it would be easier to start working with OPUs. Here is a document about background knowledge of the OPU:

<http://ppt.cc/lN~N>

I am preparing another document which gives all dimensions of optical, mechanical parts, pin assignments of the OPU and example circuits for driving the OPU of the educational AFM. Those details can not be found in published journal papers.





Related Instructables



????????? A Low Cost Atomic Force Microscope (by Hwu En-Te) by woodyme



How to make a batch file upload another batch file by stinkfly62



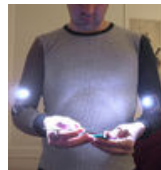
Drive by wire go kart by 765mj



Lego Transformer: Aegis by edward32214



little K'NEX car by grantskier



Hand Lights by Grathio

Comments

50 comments

Add Comment

view all 109 comments



kidharris says:

Is the bicycle inner tube wrapped in a figure eight? Low pressure?

Apr 30, 2014, 12:22 PM [REPLY](#)



mhb says:

Is there a description of the electronics to drive the piezo actuators and sensor?

Apr 29, 2014, 7:09 AM [REPLY](#)



whoand says:

You can find more details in my paper here: Low-voltage and high-performance buzzer-scanner based streamlined atomic force microscope system.

Apr 29, 2014, 7:51 AM [REPLY](#)



kidharris says:

Come on, that pdf paper costs \$33 U.S. and we don't even know if it contains a detailed parts list or cad drawings or just a bunch of high tech talk that would just fly over most of our heads. This site is for showing how to make things, and I know lots of people would love to make this awesome gadget, but, I personally don't know the first thing about how to build this from your instructions. Maybe I'm just too stupid, but to me, this reads more like a public announcement than an Instructable. Detailed parts list and drawings, please.

Apr 30, 2014, 12:14 PM [REPLY](#)



darktwilite says:
(removed by author or community request)

Apr 30, 2014. 10:00 AM



whoand says:
Hi, if you carefully use AFM probe and not to break 2 probes then you can read complete AFM fundamentals! Good luck!

Apr 30, 2014. 10:23 AM [REPLY](#)



darktwilite says:
any details of the electronics?

Apr 30, 2014. 11:48 AM [REPLY](#)



darktwilite says:
yo.I understood the working after a while.but is there a more detailed version of how this was built?

Apr 30, 2014. 11:47 AM [REPLY](#)

bearinv says:
Awesome... May I please receive the additional paperwork?

Apr 30, 2014. 10:46 AM [REPLY](#)



chicomar says:
Amazing!!! I am a Professor of computer art at Federal University of Minas Gerais (UFMG), Brazil. It would be great to do some "micro & nano art"! May it be possible to see more detailed instructions? Could you be so kind to send me an e-mail with the detailed info?

Apr 30, 2014. 9:36 AM [REPLY](#)

My e-mail is fccm@ufmg.br

Thanks!



whoand says:
Sure, and I would like to introduce you to my German friend. He is a nano metrologist who is also crazy for micro & nano art! This is his video:
https://www.youtube.com/watch?v=_gKPu_ygzU

Apr 30, 2014. 10:21 AM [REPLY](#)



thor.stormlord says:
amazing application of knowledge im sure your students will become great under such tuition. can i have the documents to make this also??

Apr 30, 2014. 8:57 AM [REPLY](#)

my mail is b02e6569@opayq.com

thanks in advance



whoand says:
Done, welcome!

Apr 30, 2014. 10:15 AM [REPLY](#)



Bizarro Super Dave Osborne says:
WOW!!! This is amazing!!! Thank you so much for posting this info. May have to do this one with my Boy Scouts.

Apr 30, 2014. 8:06 AM [REPLY](#)



whoand says:
Welcome! Actually the educational AFM system needs AFM probes which are still costly....I still need to figure out how to solve this issue....

Apr 30, 2014. 8:15 AM [REPLY](#)



Bizarro Super Dave Osborne says:
10 for \$200 USD here: <http://www.nanoandmore.com/USA/AFM-Probe-ContAI-G.html>
Not bad considering the rest of the hardware can be had pretty cheap.

Apr 30, 2014. 10:03 AM [REPLY](#)



hotcheezy says:
I am really interested in this can you send me more detailed info about this?
My email is peterleng1234@gmail.com


Apr 30, 2014. 8:06 AM [REPLY](#)

Really awesome project by the way.




whoand says:
Thanks! The papers are sent.


Apr 30, 2014. 8:11 AM [REPLY](#)


 **davidgrm** says: Apr 30, 2014, 7:33 AM [REPLY](#)
Hi
Thanks for fantastic work. There were some things like how the OPU fits in that was not clear.
I would like to make one. Can you please send me more detailed information about this build?
my email is david@southtrader.com

 **whoand** says: Apr 30, 2014, 7:51 AM [REPLY](#)
Sure!

 **th3boy** says: Apr 30, 2014, 7:16 AM [REPLY](#)
Great work! Could you possibly send me the paperwork for this marvel? th3boy@yahoo.com thanks!


 **whoand** says: Apr 30, 2014, 7:25 AM [REPLY](#)
Enjoy!


 **erastotene** says: Apr 30, 2014, 4:09 AM [REPLY](#)
Dear Dr. Whoand,
Great Work!!!
May it be possible to see more detailed instruction? Do you think this would be a nice master thesis project?
My e-mail is erastotene83@yahoo.com
Thank you
Marco


 **whoand** says: Apr 30, 2014, 5:40 AM [REPLY](#)
?r2....
Delivery to the following recipient failed permanently:
erastotene83@yahoo.com
Technical details of permanent failure:
Google tried to deliver your message, but it was rejected by the server for the recipient domain yahoo.com bymta5.am0.yahoodns.net. [66.196.118.240].
The error that the other server returned was:
554 delivery error: dd This user doesn't have a yahoo.com account (erastotene83@yahoo.com) [-5] -mta1551.mail.bf1.yahoo.com

 **erastotene** says: Apr 30, 2014, 6:40 AM [REPLY](#)
sorry! The mail was erastotene83@yahoo.it , my fault!!!!

 **whoand** says: Apr 30, 2014, 6:43 AM [REPLY](#)
OKOK!

 **whoand** says: Apr 30, 2014, 5:39 AM [REPLY](#)
I think this project fits master thesis very well, however you may need to know the fundamentals of the OPU.
I've send papers ;) Enjoy!


 **Marvin042** says: Apr 29, 2014, 10:53 AM [REPLY](#)
Great project, I would like to know what software is used to see the images. Also was wondering if I would be able to get a copy of the PDF file?
I would like to try and build this myself using more cost effective control.


 **whoand** says: Apr 30, 2014, 6:09 AM [REPLY](#)
The software is written by one of my student, we use fully digital signal processing for dealing with the AFM signals. The software is LabView.
Here is a link of the step by step process in PDF: <http://ppt.cc/bEsH>
This <http://ppt.cc/In-N> is a document about fundamentals of the OPU based AFM.


 **rodrigo G** says: Apr 29, 2014. 10:55 AM [REPLY](#)
0: Fantastico. Me encantaria armar uno.


 **whoand** says: Apr 30, 2014. 6:05 AM [REPLY](#)
Grazas!


 **Klappstuhl** says: Apr 29, 2014. 11:42 AM [REPLY](#)
Favorited. I mean, how can I not, come on, this is incredible!

 **whoand** says: Apr 30, 2014. 6:05 AM [REPLY](#)
Thanks, actually I work with OPU for a long time already.....but I still like to play with OPUs ;p

 **screwrules** says: Apr 29, 2014. 12:40 PM [REPLY](#)
i have worked with AFM previously, i am defiantly going to try to make this.. Can you please share the software used? And the cut files for the circuit board if possible.
Big ups guys for making this!! Great job

 **whoand** says: Apr 30, 2014. 6:04 AM [REPLY](#)
I am preparing another document which gives all dimensions of optical, mechanical parts, pin assignments of the OPU and example circuits for driving the OPU of the educational AFM. Those details can not be found in published journal papers.

 **bear benami** says: Apr 29, 2014. 2:05 PM [REPLY](#)
Sir,
Congratulations for a remarkable application of current technology! I would like to make one of these units. Do you have the CAD files for cutouts and a parts list? I would very much appreciate your posting those items!
Again Sir, kudos.


 **whoand** says: Apr 30, 2014. 6:03 AM [REPLY](#)
Actually, using OPU for AFM application seems very easy, but actually there are a lot of tricky parts. One may need to know fundamentals of the OPU, then it would be easier to start working with OPUs. Here is a document for basic knowledge about the OPU: <http://ppt.cc/lN~N>

 **nwlaurie** says: Apr 29, 2014. 2:35 PM [REPLY](#)
Quite, quite remarkable. I salute you and your students!

 **whoand** says: Apr 30, 2014. 6:01 AM [REPLY](#)
I always let my students try weird ideas ;p

 **phoe** says: Apr 29, 2014. 3:56 PM [REPLY](#)
This looks absolutely amazing !

 **whoand** says: Apr 30, 2014. 6:00 AM [REPLY](#)
Thanks!

 **maniac3d** says: Apr 29, 2014. 4:11 PM [REPLY](#)
Hi
Really really great project!. I am going to make one. please could you help me with the paper and other instructions? my email address is
maniac3d@naver.com
Thank you.



whoand says:
Done, enjoy!

Apr 30, 2014. 6:00 AM [REPLY](#)



XTL says:
Brilliant work. What does the electronics look like ?

Apr 29, 2014. 5:11 PM [REPLY](#)



whoand says:
With low voltage buzzer scanner, no more high voltage amplifier.....

Apr 30, 2014. 5:58 AM [REPLY](#)



santilp says:
Any chance of releasing documentation for replicating this? Neither software or hardware details are specified here! :(

Apr 29, 2014. 4:52 PM [REPLY](#)



whoand says:
I am preparing another document which gives all dimensions of optical, mechanical parts and pin assignments of OPU, example circuits for driving the OPU of the educational AFM. Those details can not be found in published journal papers.

Apr 30, 2014. 5:57 AM [REPLY](#)

dmarusic1 says:
As someone who worked with an AFM for my Honours thesis I take my hat off to you.

Apr 29, 2014. 7:08 PM [REPLY](#)

I was working with a proper machine worth thousands of dollars, and that was difficult enough to get images with. To see what is possible with everyday materials is truly amazing.



whoand says:
Actually I work with OPUs for 10 years already....the OPU based AFM paper published long time ago (<http://nanotechweb.org/cws/article/tech/33346>).

Apr 30, 2014. 5:56 AM [REPLY](#)

I am working on high speed AFM now (cooperated with Prof. Ando's group in Japan) the scanning speed can achieve 20 frames per second with my OPU based AFM. The OPU has 250 nm laser spot that no AFM in the market can compete, also 160 MHz high working bandwidth (normal AFM has maximum 10 MHz).



jimmyas says:
whoand,
Can you send me the papers about this experiment?

militronica@gmail.com

Thank you!

Apr 29, 2014. 7:59 PM [REPLY](#)

[view all 109 comments](#)