Internship report

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Abstract

This report is about the internship I did at Mantis Deposition this summer in the Master Nanotech course framework. Mantis is a company developing high quality deposition components and systems for the thin film coating community. One can find basic information about the company organization, its nomenclature and advantages over some competitors. The next part of the report is devoted to my particular role in the company: testing and internal commissioning of the instruments. It describes what goals and tasks I had and what kind of issues had to be solved. Then I will tell you about the techniques used to do the testing. Finally some results will be discussed.

Contents

Introduction

Mantis Deposition is a specialist instrumentation company developing high quality deposition components and systems for the thin film coating community. Mantis products are used in a range of academic and research applications at the forefront of thin-film coating technology.

My position at Mantis was a challenge for me, because I had never worked with vacuum equipment. I had to turn my theoretical knowledge into practice. Fortunately during the Master Nanotech course at Politecnico we studied the basic principles of thin film coatings as well as the required instruments.

There were just ten weeks to sort things out. My duties were to perform the operational testing of the instruments. It involved collection and interpretation of data while operating the instrument and comparing the results against the theoretical performance targets for the instrument. It gave me an understanding of vacuum practice and provided an introduction to a number of vacuum deposition processes from the practical point of view. There is a report below about the issues I had to solve to achieve this result.

Mantis Deposition Profile

Company organization

Mantis Deposition was established in 2003 by scientists who have the winning combination of deep understanding of nanotechnology, instrumentation and thin film deposition in the United Kingdom. That is why the head office is located in Thame, Oxfordshire. There are about 20 employees there. However Mantis Deposition has a worldwide team of sales and application experts. As Mantis Deposition is not a university or a national research centre its structure is completely business-oriented.

Fig 1. Thame location

Assembly of all the instruments and systems is done in the head office. Mantis does the design of all the devices, then the purchasing department orders necessary spares from different suppliers mostly located in the UK and finally people in the production section assemble and test the instruments.

There is also R&D department in the company. The most interesting cutting-edge scientific investigations are done there. The aim for the department has been changing during the company’s growth. Nowadays all the efforts are concentrated on nanoparticle applications. The company’s strategic goal is to sell nanoparticle sources for industry. To do it a nice application of interest to the market should be found.

The R&D department collaborates with different institutions and research centres all over the world. During my stay there were visiting researchers from Athens University (Greece) doing some experiments at Mantis. R&D organizes some workshops for all interested researchers but mostly among former customers. I attended such a workshop. There were people from all over Europe including CEA (Grenoble, France).

Besides the instruments themselves Mantis produces the control electronics for them in house. During the instruments design some computer modelling is normally done. The designers try to model the behaviour of magnets, ion flow, plasma, etc.

The company is growing quite fast producing more and more systems and separate instruments per year. That leads to the necessity of more workers. So, I had an opportunity to do an internship at Mantis Deposition.

Nomenclature

There are two main areas for the company: deposition systems and coating services. At the beginning of the company's history it produced separate instruments only. Nowadays huge complicated systems with different instruments inside become more popular. I cannot say anything special about coating service, because I was not involved in it. But normally companies can ask to deposit something on their substrate without buying the instrument. Thin films are produced by physical vapour deposition (PVD).

The most advanced apparatus in Mantis nomenclature is the *nanoparticle source* (NanoGen). The NanoGen source produces nanoparticles by a "terminated gas condensation" method. The resulting nanoparticles tend to possess one additional electronic charge and this allows them to be electrostatically manipulated either through deflection, focusing or acceleration. The acceleration towards the substrate allows the particle impact energy to be controlled precisely. At low acceleration (< 1eV per atom) the particles soft-land without deformation. At higher energies they undergo a small degree of interface mixing and form a layer of bound nanoparticles. At high energy the particles fuse into bulk material.

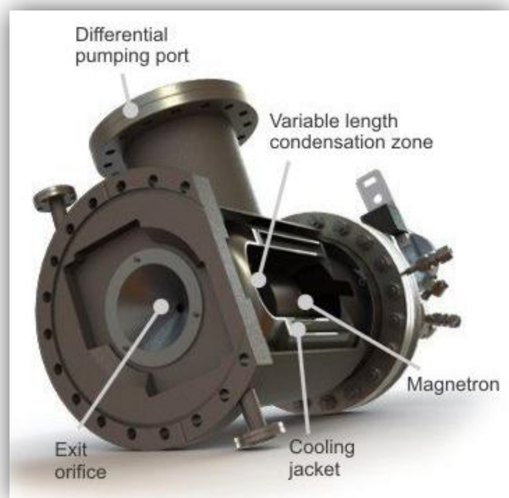

Fig 2. NanoGen structure

Such nanoparticle manipulation produces a wide variety of coating morphologies from nanoparticle powder, through porous films to crystalline structures.

Besides the NanoGen, Mantis produces a lot of other components for deposition:

- *E-Beam evaporators*. There is the unique device in this category called QUAD-EV. These evaporators use independent filaments, flux-monitoring plates and high-voltage connections to allow each material to be evaporated independently of the other three. This is employed to allow independent co-evaporation of up to four materials. Since each material uses an independent high-voltage connection, the evaporator will still function if there is a short-circuit due to accidental overheating of material in one of the pockets.
- *Atom sources*. The MATS sources deliver high volume flux of electrostatically neutral atoms that are excellent for epitaxial growth of nitrides and oxides. The radicals are highly reactive and have a low kinetic energy and will not damage the epitaxial structure.
- *Thermal gas cracker*. They are used to dissociate molecular gases, most commonly hydrogen, to atomic form, thereby increasing their reactivity by many orders of magnitude. In contrast to plasma-based atom sources (such as the MATS series) there is no intrinsic minimum in the gas flow requirement, which makes these sources suitable for low-flow applications such as surface science.
- *Ion sources*. Beams of accelerated ions are used to modify and erode surfaces under vacuum conditions. By carefully selecting the energy and composition of an ion-beam, this can be used, for example, to improve significantly the characteristics of a growing film by both densifying the film and modifying the chemical composition of the film.

- *Sputtering sources*. The CUSP magnetron sputter sources are the only commercially available sputter sources that are full UHV ($1 \cdot 10^{-11}$ Torr) compatible sources. All sources can be used for DC or RF sputtering.
- *K-Cells*. The Mantis Comcell effusion cell series are designed for high-purity, high-precision evaporation of materials in MBE or hybrid UHV applications.
- *Thermal Boat sources*. One of the simplest instruments in terms of background theory. They are designed for light thin film metal evaporation. The sources are not directly water-cooled, however, the design of the sources allows to introduce minimal thermal load to the chamber. They are connected to a high-current power supply with a 100A current limit.

Particular Market Position

Mantis is a global company having customers from all over the world. There are specialists who are ready to go almost everywhere for system installation or support. All the systems and instruments are always fully tested before shipping to the customer.

Mantis has some unique instruments like Quad (E-Beam evaporator) and nanoparticle source. The last instrument should be described in more details to underline its advantages. Nanoparticles (NPS) are produced by a "terminated gas condensation" (TGC) method. In this technique, a DC magnetron is used to sputter target material. The sputtered atoms enter the high pressure condensation zone where their mean free path becomes very small and they quickly thermalize. Nanoparticles are formed as these thermalized atoms migrate towards the expansion zone (Fig. 3).

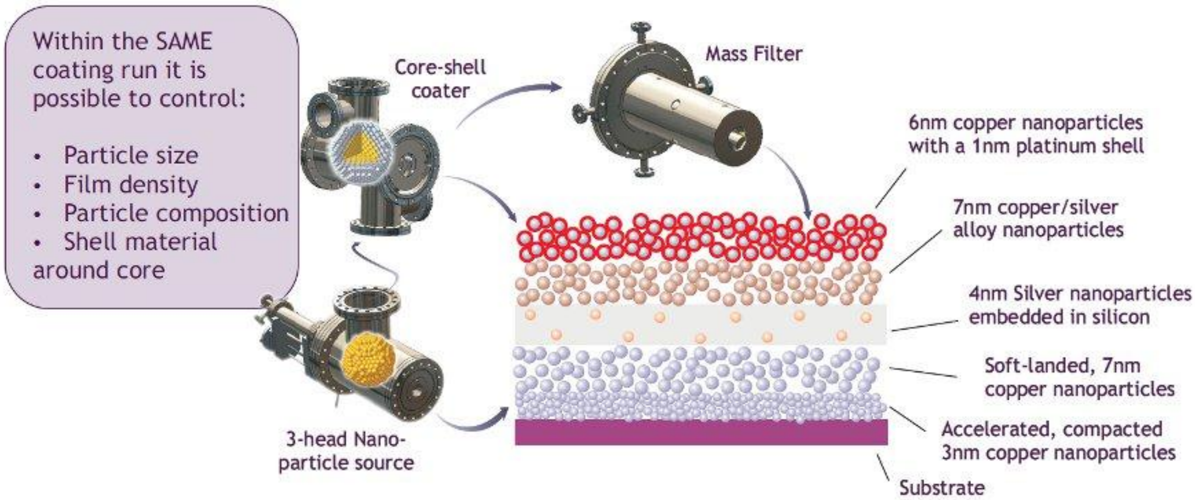

Fig 3. Nanoparticle Source schematic

The comparison to the traditional chemical synthesis is given in the table 1.

Terminated Gas Condensation (TGC)	Chemical Synthesis
Nanoparticles are of semiconductor purity. No solvent or gas-based contaminants.	Contamination problems.
Fast development cycle.	Slow development cycle.
Close to 100% beam ionisation allows controlled acceleration => controlled adherence and density of nanoparticle films.	Difficult to apply to surfaces.
The particle size may be designed over a wide range of sizes.	Difficult to design particle size.
Controlled cluster stoichiometry.	

Powdered films to single crystal.	One sort of nanoparticles.
Deposition onto plastic or other insulators.	
It is possible to make porous structures by semi-embedding nanoparticles followed by an etch process.	
Difficult to produce free nanoparticles.	Good for bulk production in solution or powder form.

Table 1. The comparison of TGC to the traditional chemical synthesis

Mantis Deposition has recently begun offering the new Nanogen Trio (Fig. 4) that is specifically engineered to develop alloy nanoparticles. The unique design is an evolution of the Nanogen50 where the head of the sputter source now contains three individual 1” magnetron sputter sources. By integrating the three targets, the researcher is now able to develop multimaterial nanoparticles.

These features provide Mantis with special, unique position in the global market.

Fig 4. NanoGen Trio

Test procedures

General approach

Inspection of every single bit is an essential part of the process flow. To assemble an instrument designers prepare step by step guides noting the most critical stages. Once an instrument is made it gets the unique serial number. Normally all the instruments belong to the specific customer orders (projects). Thereby the first test sheet appears. It is called the mechanical test sheet.

There are some people in charge of mechanical testing. They have to make sure that all the screws are tightened up and no gaskets on flanges are missing. Each instrument has its own test sheets with specific checkpoints. The tester signs his initials next to each item if the instrument passed the test. The most important points are checked several times during the different tests.

The second stage is functional testing. Normally it is done with operational testing. My job was mainly to do this phase. The tester should check some basic mechanical parameters; make sure there is a lack of leakages and measure the coolant flow rate. If everything is fine, there are two possible scenarios of what to do next. In the case of a stand-alone instrument the operational testing has to be done: the tester installs the targets, sets up all the electronics and checks the deposition process. But when the instrument is part of a system it is normally checked there.

The same approach is suitable for the electronics part. All the power supplies, different controllers, everything is checked using the test sheets I described before. A computer is the link between the instruments and the electronics. Mantis can provide customers with user-friendly software developed within the company. It is a good idea to order it because in this case you can log all the events and write small programs. It is especially important for the complicated systems when you want, for example, to deposit multilayer material. I do not know how the software is tested but Mantis regularly does new releases fixing bugs.

In fact, sometimes it is not enough to fill the test sheet in. If something goes wrong it can be necessary to write down some notes to the logbook (Fig. 5), especially if the computer was not used. It is very useful to monitor such basic parameters as pressure, coolant flow rate, deposition rate, etc. All the test sheets have a special field called “Comments” for such information, but in a lot of cases use of a notebook is more convenient.

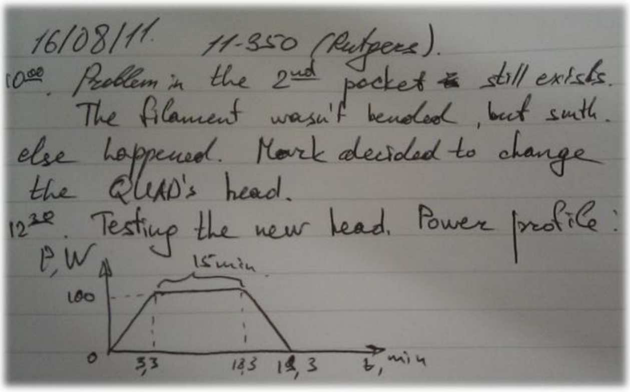

Fig 5. Some notes from my logbook

If all the tests have been passed the instrument is ready for shipping to the customer. All the test sheets are stored in the special folder labelled with a project number to provide good quality support to the customer in case of necessity. It is interesting that the systems are shipped fully assembled and with the chamber under vacuum.

Multitasking job

My main goal during this internship was to get familiar with different types of instruments used for the deposition process. To achieve it I joined the company as a tester. My duties were to do the functional and operational testing of the devices.

Mark Vaughan was my official supervisor but in fact I worked with almost all the people from the Production line. From the one hand Mantis has a great number of orders, from the other hand a lot of them are systems which means that the instruments will be tested installed on the system. By-turn it leads to the necessity of assembling the systems first.

It is a long multistep process. At the beginning you have to be sure the chamber itself is not leaking. At this point all the ports are sealed with blank flanges. If the chamber is fine you can start to put the instruments in. As I have already mentioned before, these instruments should have been functionally tested at this point. It means that they do not have any leakages and there is a proper water flow through them. Once the instruments are mounted to the chamber with copper gaskets the whole system should be checked for leak again. Then all the water lines should be connected and at this point the operational testing can be started. In the reality this sequence is more complicated, but this explanation is sufficient to get the main idea.

I helped to assemble the system, to do the leak check, to connect the water lines, etc. For large systems (Fig. 6) it may take a long time. That is why I worked with everybody from the Production line. Sometimes we had the situation when the system was ready for mounting the instruments in, but they were not ready yet. In this case I helped to build the instruments. It was a very useful experience because I could see all the parts and the process flow. It gave me a deeper understanding of working principles.

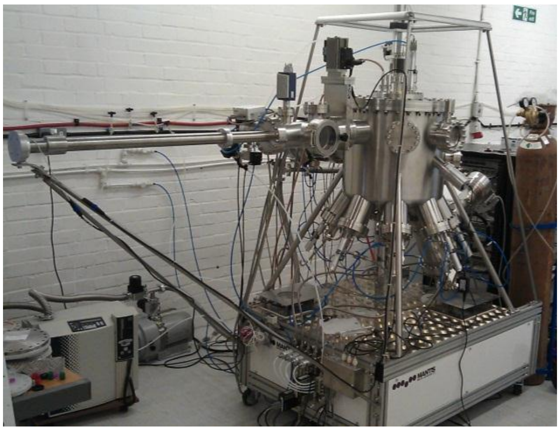

Fig 6. Example of the system

Mechanical assembling of the systems is not that much Nanotech internship, but it had to be done anyway. Let us switch to the topics more related with our course. It is the operational testing. In spite of a huge number of instruments produced by Mantis I tested few of them: magnetrons, e-beam evaporators, thermal gas crackers, nanoparticle sources. Some of them were brand new, others were returned for repair. Difficult to believe, but it is more difficult to determine the problem if the instrument is new.

One of the most successful instruments is the e-beam evaporator called Quad. Mantis has been selling it for seven years constantly improving the design of the instrument. In spite of this unexpected problems occur. The last serious issue was with the Quad for an American university. On the fourth of August I was asked to test it. Basically, the operational testing of the Quad includes filaments outgassing, crucibles or rods outgassing and the power handling ability test.

At first *tantalum crucibles* were installed to the Quad as they had been ordered by the customer. Quad successfully passed the filament degassing test. By the way, instrument *always* passed this test. Then the crucible degassing test started. In this test as well as in the rest of the power tests the applied power was 100W.

Strange behaviour was noticed (Fig. 7): the oscillations of the power were about 5W at 100W set point. This issue was resolved pretty fast. It turned out that the power supply unit had not been calibrated. Proper values of time constants, etc. were set up to fix the problem.

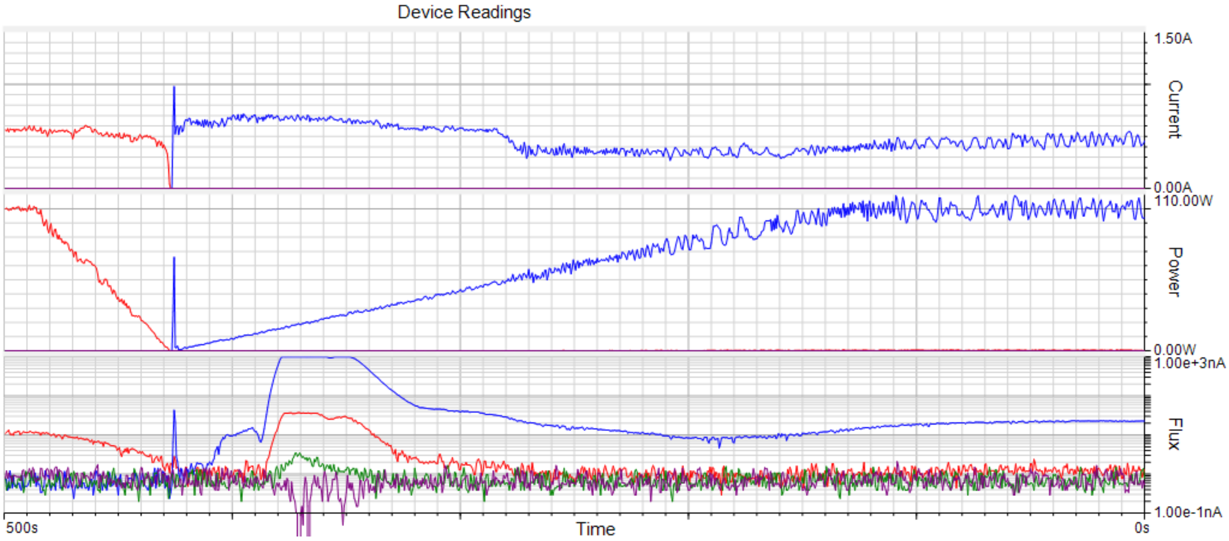

Figure 7. Oscillations around the set point

Then the crucible outgassing test was launched again. It took 5 minutes to reach the set point (100W) at *the second* pocket. After *1 minute* it failed with a quite common error: filament touched the head. The normal procedure in this case is moving it up a bit to avoid short circuit with a head. It was done. To be sure everything is done right resistances from a grounded leg of the filament to another contact were measured (Table 2). As the filaments are equal the resistance of all of them should be more or less the same.

	Resistance before moving up, Ω	Resistance after moving up, Ω
Filament 1	0.342	-//-
Filament 2	0.219	0.347
Filament 3	0.363	-//-
Filament 4	0.321	-//-

Table 2. Filaments' resistances

Once again the test was launched. Quad *passed* the test successfully. It was ramping up for 5 minutes and then 100W power was applied for 5 minutes as well. The maximum power test was launched. *The second* pocket failed at 10W. The chamber was vented and the Quad was taken away for examination.

The filament in the second pocket was bent because the *brazing melted* and the free leg moved down due to gravity. The hypothesis about the new filament batch was put forward. Three days later this filament from the second pocket was replaced with another one from previous supplier.

And again the test was started. The filament at the *second* pocket failed at the very end of the test: it withstood 5 minutes at maximum power and its *brazing melted* again during the ramping down. The test was carried on to test the third and the fourth pockets. There were no problems there.

One week after the tantalum crucibles were changed to *tungsten rods* and the broken filament was replaced as well. All the pockets passed the test in such configuration. To be sure everything is fine with the second pocket 100W power was applied during 30 minutes. Everything was stable.

There was a feeling that the proper filament was found. T*antalum crucibles* were installed again. Quad did not pass the test. The *second pocket* caused the problem again. As one can see from the Fig.8 the behaviour was slightly different. It failed after about 8 minutes but not because of the brazing issues. In this case the *filament was evaporated* and cracked.

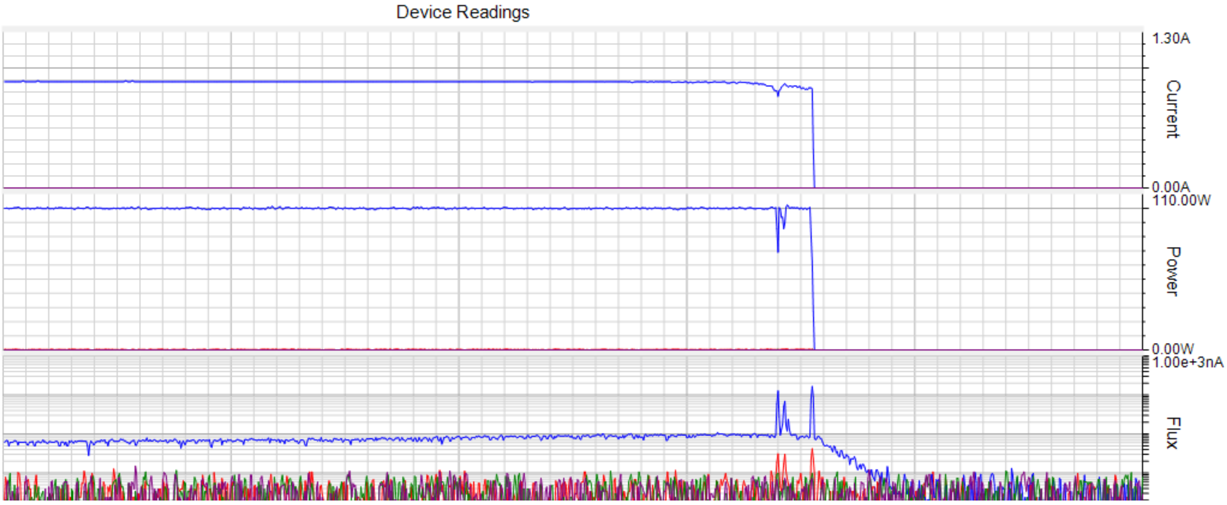

Figure 8. The second pocket fail

The drastic decision was made. The head of the quad was changed. The test was launched again. Surprisingly, the problem appeared at *the first* pocket. The behaviour was almost the same as in Fig.8. It ramped up to 100W and failed after 12 minutes. So, the *filament was evaporated* again.

The power supply was suspect. It was replaced with another one. It did not help because the problem appeared at *the second* pocket after 7 minutes of testing. The *filament was evaporated* again.

The next couple of tests were done with the *tungsten crucibles* inside. It helped. Quad passed all the long-term tests. It was running for 30 minutes with a poor water cooling (flow rate was about 0.2 l/min). In spite of these stern conditions it passed all the tests.

It seemed to us the problem was solved. Tantalum should be replaced with tungsten. We decided to do the final operational testing with *tungsten rods*. As we were sure it was the end, the Quad's lid was mechanically cleaned from all the previous coatings. The Quad failed at the very end of the test during the power handling test. The problem was at the second pocket. It was different from the previous issues. A small piece of copper fell into the pocket shorting the filament to ground. Maybe it was there after cleaning. But suddenly we observed a strange phenomenon.


Figure 9. Silver coating

The lid was covered with a shiny *silver coating* (Fig. 9). We did not notice it before because the lid had been dirty. It was an extremely important observation. It became clear there was evaporation from the filament. It was less intensive in this case than with the tantalum crucibles. I checked the material properties and noticed that the thermal conductivity of tantalum is three times less than the tungsten. Basically a tantalum crucible worked like a heat accumulator causing the filament to become very hot.

It was still not obvious why this problem had appeared. Once again the broken filaments were replaced and test run again. Suddenly, there was no silver coating above the first pocket. The detailed inspection revealed that the tungsten rod in this pocket was slightly *shorter* than in the others. All the rods were cut to the same length. The test of the first and the second pockets was run again. There was a coating only above the first pocket. So the length of the rods was not the major parameter influenced the test.

There were some problems with the filaments adjustments in the head in the past. The tolerances were too strict. Then the design had slightly changed and the openings for the filaments became larger in size. The issue with mounting the filaments disappeared. However the filaments were not in good contact with the copper head and so were no longer being cooled sufficiently. To check this hypothesis very thin copper plates were inserted in these gaps clasping the filaments to the head.

The test of all the pockets finished successfully. The further development of this idea was to make a hole in the head and clasp the filament with a grub screw. It was done for one of the pockets and the test passed without any errors again.

On this stage I had to finish my internship but we were pretty sure that this lack of thermal contact was the problem. The basic solution was proposed to solve the issue and it worked fine. So, I am very satisfied with the result of this long testing.

Technical details

Mostly I tested the new Quads. As the Quad operational testing is a long process (due to the outgassing necessity) it was done in the special chamber (Fig. 9) even if the Quad was supposed to be installed as a part of the system.

This chamber is interesting because of the possibility to adjust for almost any purpose. There are a lot of flange adapters and extensions which allow you to plug different instruments in. This chamber has a viewport to monitor the processes, pressure gauge, and vacuum turbopump. The volume of the chamber is relatively small. Therefore the pumping process is very fast. It is especially important for the tester because he vents and pumps down the chamber several times per day.

Figure 10. The main test chamber

There is a Quad installed at the bottom of the chamber in Fig. 10. It is named this because there are four pockets available for deposition. There is a top view shown in Fig. 11. One can see four filaments and rods in the pockets. Quad has four independent flux monitoring systems (Fig. 12).

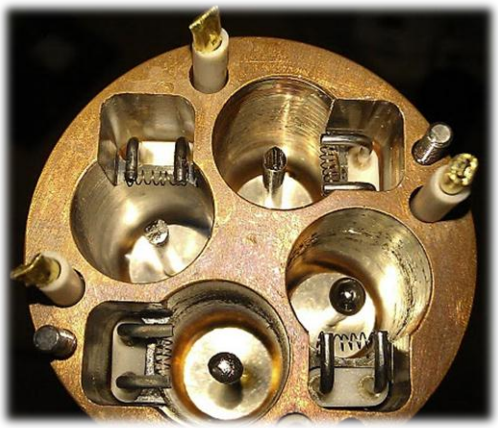

Figure 11. Quad. Top view

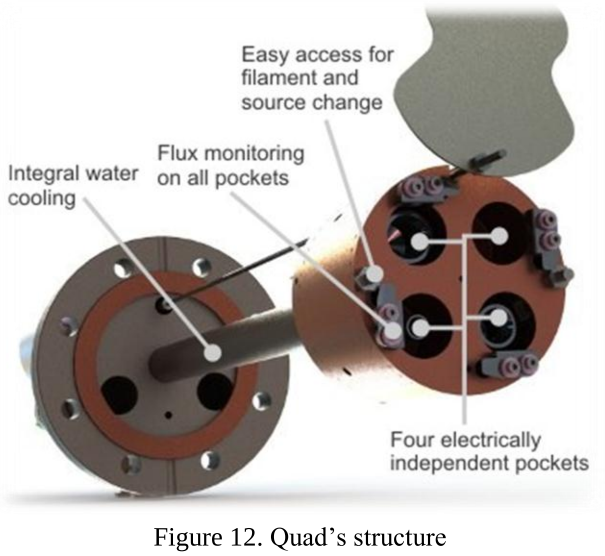

Figure 12. Quad's structure

The actual deposition rate depends on the material and some other factors so the flux current needs to be calibrated against deposition rate. All the data is transmitted to/from the power supply, which is linked to the computer.

Another chamber configuration is shown in Fig. 13. In this case the NanoGen is mounted horizontally. As it is a heavy device it is supported by the frame. There is also a separate turbopump for the NanoGen. A quartz crystal monitor (QCM) is installed at the bottom to measure the deposition rate in situ. Using a QCM is the most common way to control the process.

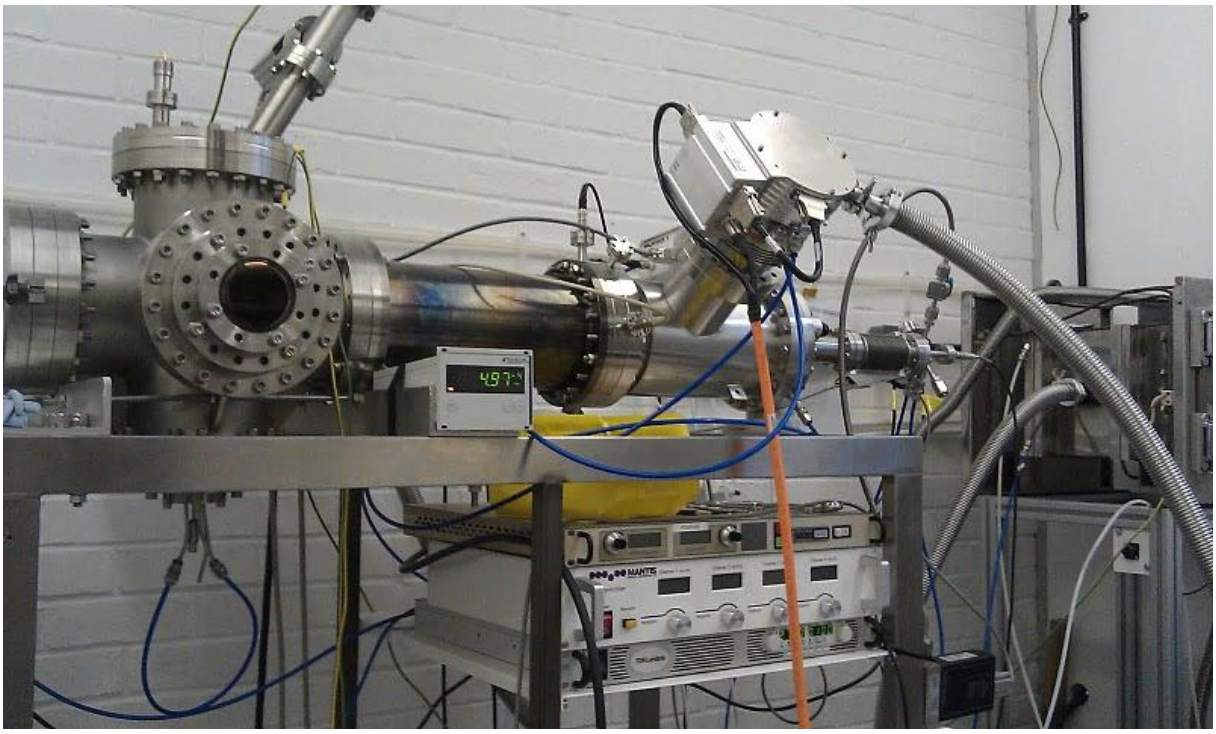
Figure 13. NanoGen in the test chamber

Here I will tell a few words about the NanoGen structure. The best explanation is given in the official manual. The following two figures (14 and 15) are taken from it. The main parts of the system are shown in the Fig. 14. It consists of a nanocluster source that includes a DC magnetron sputtering unit and a turbopump (300 l/s), a quadrupol mass filter, and the deposition chamber.

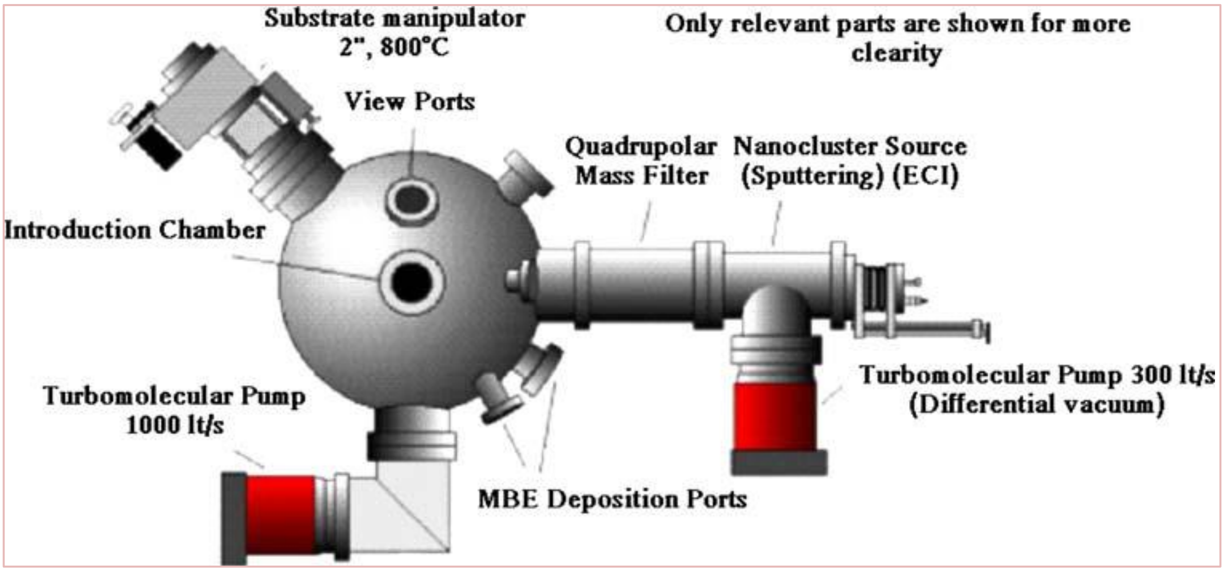

Figure 14. Integral system with the installed NanoGen

The nanocluster source is the heart of the system to obtain nanoparticles and consists mainly of a device called a NanoGen 50, where nanoclusters are generated and then channelled to the main deposition chamber to deposit onto a substrate as shown in Fig. 15. The size-selected nanoparticles deposition takes place through four main processes: Sputtering, aggregation, filtering, and deposition.

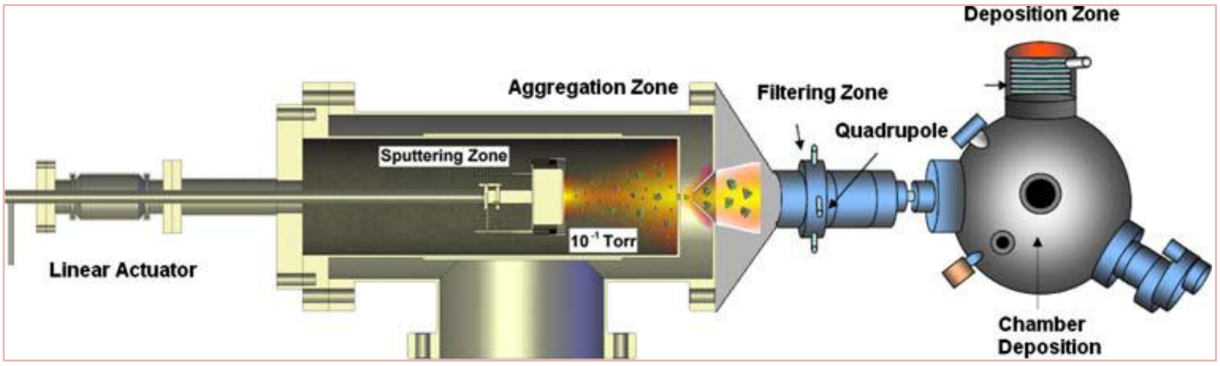

Figure 15. Schematic diagram of the nanocluster source

Sputtering

The DC magnetron type discharge is used to generate clusters from the target, connected to the magnetron assembly. The magnetron-based source has an advantage over all other types of cluster sources in terms of the wide cluster size range, which varies from fraction of a nanometre to a few tens of nanometres. DC plasma is ignited in a mixture of argon (Ar) and helium (He) gases and confined close to the target by the magnetic field.

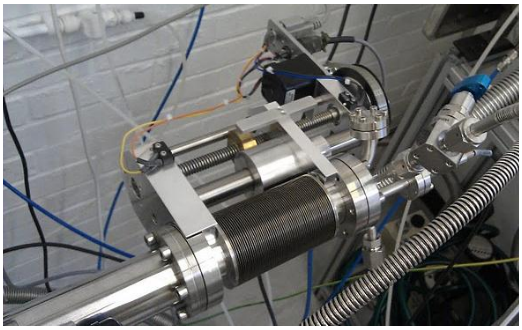

Figure 16. Linear transfer drive

For some purposes only argon is required. In the inert gas condensation process, a supersaturated vapour of the target's atoms is generated by sputtering a target in an inert gas atmosphere of Ar and He. The NanoGen system is kept at low temperature by a coolant mixture, and before the nanoparticles deposition, the system pressure normally is set at about 10^{-7} Torr. The cluster size can be adjusted by varying three main source parameters: the length over which the clusters aggregate (variable using a linear drive (Fig. 16)), the power to the magnetron, and the flow of the aggregation gases. In terms of the cluster size range, the magnetron-based source has the advantage over all other types of cluster source as it is the most flexible. For a large number of materials, the source is capable of producing clusters consisting of a few tens of atoms up to particles with diameters of around 20 nm. Due to the nature of the gas aggregation technique, narrow size distributions can be achieved.

Aggregation

Typically, sputtered clusters are swept through the aggregation region (10^{-1} Torr) by argon and helium gases, where these clusters nucleate to form a distribution of nanoclusters of various sizes as represented in Fig. 15. The nucleation of these small cluster 'seeds' is followed by the growth of the seeds into larger clusters. The growth of clusters is heavily dependent on interatomic collisions; this states the importance of Ar and He. Once the clusters grow in size to exceed a critical radius, large clusters grow from the cluster seeds at a faster rate than that at which new seeds are formed. The residence time within the aggregation zone can be varied by varying the length of the aggregation region with the linear motion drive. By controlling the residence time as well, one can control the distribution of the nanocluster size within the aggregation region. The nucleation and growth of clusters ceases after expansion through a nozzle where clusters expand into the filtering zone, which is maintained at a lower pressure (10^{-4} Torr).

Filtering

Along with the nanocluster source, the system may also consist of a quadrupole mass filter (MesoQ), positioned between the nanocluster source and the main deposition chamber. A large percentage of the clusters generated by the source are ionized which makes it possible to manipulate them electrostatically using the mass filter. MesoQ is used to filter nanoclusters of a particular size from the widely varied size distribution of nanoclusters present in the aggregation region. It allows acquiring mass spectrum. The electronics unit allows us to acquire a mass scan of the clusters from the source and filter the ionized clusters.

Deposition

The focused cluster beam is then mass-selected by a mass spectrometer and can be accelerated by a high-voltage pulse applied to a substrate in a high-vacuum chamber with a base pressure of 10^{-7} Torr. The system is capable of depositing at rates between ≤0.001 nm/s and ≥0.5 nm/s measured at a distance of 100 mm for Cu clusters. The deposition rate achieved depends on a number of parameters, which includes the material and the size of the clusters deposited.

Different targets can be used during the functional testing. The last test was done with a tantalum target. All the data is collected to the PC during the test. Using this data one can get the particle size distribution (Fig. 17). To get this data the MesoQ filter was swept in the range from 1 to 10nm particle size three times. It can be seen from the graph that the NanoGen source is pretty stable: three curves are very identical. It is possible to filter nanoparticle very precisely in terms of size.

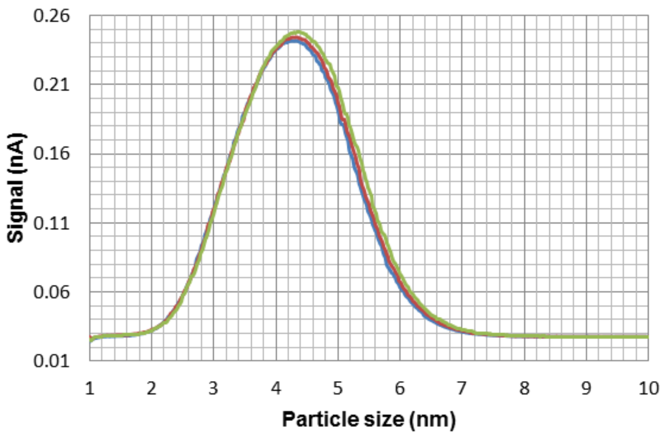

Figure 17. Tantalum particles size distribution

But it is a bit tricky, because influence of the parameters described above is not always predictable. The user has to adjust them in a way that the maximum of the Gaussian distribution corresponds to the desired particle size.

Basically the main idea of the operational testing of the NanoGen is to generate a set of curves with a standard target. Due to the magnetron in the NanoGen's structure it is necessary to strike the plasma. It can be difficult because the new target has to be outgassed for proper operation. Another issue to be solved is the balance between the parameters like gas flow, position of the target and power. The software for the NanoGen is more complicated than the Quad's one, because the tester has to control a lot of parameters. You can think at least about two turbopumps instead of one. As a conclusion I would say that the NanoGen test is the trickiest and the most interesting one. Of course, I am not talking about the whole system set-up.

Sudden tasks

The new chamber for a customer arrived at the end of August. The order included a couple of turbo pumps for the main and the load lock chambers. The manufacturer of these pumps was Pfeiffer. It is a German company producing a great variety of instruments for vacuum purposes. The first two devices mounted to the chamber are a pressure gauge and a pump. It is necessary to close all the other ports of the chamber with blank flanges to do a leak check of the chamber.

The load lock chamber was prepared for this procedure, all the required wiring was done as well. We switched on the power supply for the turbopump but instead of a constantly lit LED it was blinking. According to the manual it means that the turbopump is all right and it is waiting for the switch on signal.

The point is that there was no switch on/off button anywhere. The only one way to launch it was to send a signal from the computer. I installed all the drivers required for communicating with the turbopump but Pfeiffer has not supplied their customers with any software. I had to read the manual to understand the protocol using for communication with the turbo. Then I programmed basic software to send information to the turbo (Fig. 18).

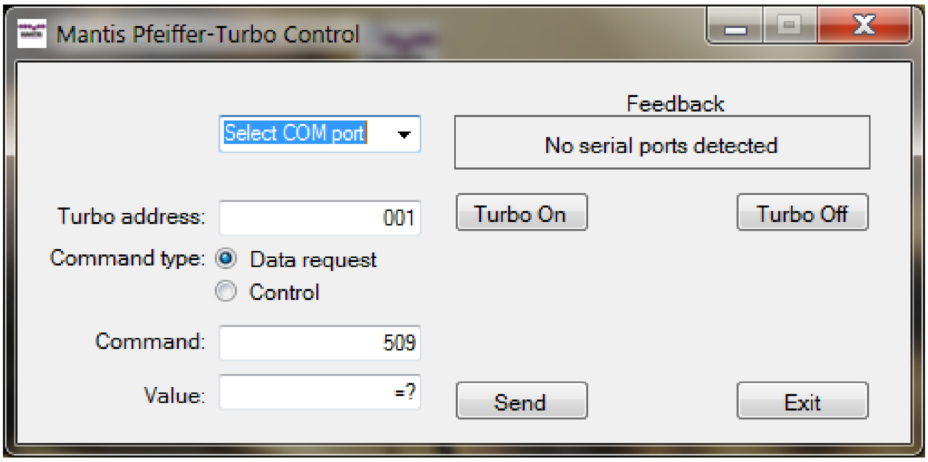

Figure 18. Pfeiffer turbo control software

Normally there is a specialist-programmer who does such a job. But he was on holiday at this time. So, I got some unexpected experience of programming the software to control instruments. I used a student version of Microsoft Visual Studio Express downloaded using Politecnico’s MSDN account. The programming language was C#.

Everyday life


Figure 19. Thame main street

Mantis Deposition is located in Thame. It is an old lovely market town in Oxfordshire. During my stay in France I tried to find an accommodation in Thame, but it was almost impossible to find something for a reasonable price. That is why I stayed in Aylesbury (Buckinghamshire). It took a bit more than half an hour to get to Mantis from my home by bus. The bus service between Aylesbury and Thame is very good. The bus intervals are about 20 minutes in peak-time. Aylesbury is not that far from London. It takes about one hour to get there by train. I cannot say I had any difficulties with public transport.

The official work day at Mantis is from 9:00 to 17:30 with one hour lunch break per day. This amounts to 37.5 hours per week. Normally I stayed at home after work during on days, but I tried to travel around South England during the weekends.

The closest to my home and well-known town was Oxford. That is why I went there few times visiting colleges, museums and just walking around the old town. The second place I went to was London. Due to the fact I worked at Thame I visited it few times like a tourist walking around and enjoying the neighbourhood nature.

During the lunch time half of Mantis staff stayed in office eating the food they had brought from home. Another part went to different shops and cafes to buy some sandwiches or traditional English fish & chips. In case of any important event like a birthday or another system shipping all the company went to the pub. So, I would say that the relations between the employees at Mantis are very good and kindly. It was a nice place to work.

Conclusion

The main goal of the internship was to understand the physical principles of operation of several types of vacuum coating instruments. They included but were not limited to mini electron beam evaporators and magnetron sputter sources.

This goal was achieved by performing the operational testing of the devices. It involved collection and interpretation of data while operating the instrument and comparing the results against the theoretical performance targets for the instrument. If an instrument did not perform to specification it was necessary to investigate likely causes and suggest options for improving the performance of the instrument.

The role developed knowledge of good vacuum practice, provided an introduction to a number of vacuum deposition processes that underpin numerous technologies (e.g. semiconductors, fuel cells, bio sensors) and enhanced problem solving skills in a challenging commercial environment. As a bonus the unique experience of working at an English-speaking company was obtained.

Annex A. Evaluation Sheet

Grenoble INP

Master Micro and Nano technologies
NANOTECH

2010 / 2011

EVALUATION FOR THE TRAINEE STUDENT

Training period concerning: Dmitry Yakimets a second year student in NANOTECH (2nd year of study)

Name of company: Mantis Deposition Ltd

Address: 2 Goodson Industrial Mews, Wellington Street, Thame, Oxfordshire, OX9 3BX, UK ☎ +44 1844 260 160

Department: Production Testing

Head of Department: Mark Vaughan

Subject: Operational testing of vacuum deposition instruments including fault finding, fault correction and suggestions for product improvements where necessary.

EVALUATION CONCERNING	EXCELLENT	VERY GOOD	GOOD	AVERAGE	INSUFICIENT
Integration of trainee in the company	✓				
Punctuality	✓				
Initiative	✓				
Technical level	✓				
Quality of the work furnished	✓				
Ability to assimulate new knowledge	✓				
Conscientiousness	✓				
Training period report	✓				

Other remarks: Dmitry showed great initiative and proved to be a very fast learner. It was a pleasure having him on the team.

Name and position of the person in charge of the trainee: Mark Vaughan, Product Test manager

Date: 9/9/11 Signature: M. Vaughan

IMPORTANT: This evaluation sheet should be returned to Mrs MORFOULI Panagiota, the person in charge of the master **at the end of the training period** – INP Grenoble MINATEC – 3 Parvis Louis Néel – BP 257 – 38016 GRENOBLE CEDEX 1