



INTRODUCTION TO HiTUS* TECHNOLOGY OF PLASMA QUEST LIMITED



* (HiTUS = High Target Utilisation Sputtering)

This document has been prepared for the attention of personnel untrained in the sputtering technology with the purpose of introducing to them the HiTUS* technology of Plasma Quest Limited (PQL). The information given here is, as a consequence, insufficient to solve real problems. This document enables an outline understanding of the operation and the significance of this new technology. As a consequence, it is well understood that neither Plasma Quest Limited nor its employees, agents or any person capable of being implicated directly or indirectly in the present communication would be expected to have some committed responsibility for the inaccuracy or incompleteness of information, systems, products or processes revealed by any manner whatsoever. Similarly, particular attention has been brought forward as to not breach any rights of third parties, products, processes, brands, manufacturers or services of any nature whatsoever. However, despite our efforts, if there was any known problem, this could only be an error. In this case, we thank you for informing contact@plasma-quest.com without delay so that we could put a stop to this state of affairs as soon as possible. Should an error occur, Plasma Quest Limited, its employees, agents or any person capable of being implicated directly or indirectly in the present communication would be expected to have some committed responsibility for any cause whatsoever. In addition, the viewpoints expressed by the authors only involve themselves and do not necessarily reflect the viewpoint of Plasma Quest Limited.

*** (HiTUS = High Target Utilisation Sputtering)**

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Introduction

The purpose of this document is to present the operating mode and numerous advantages of the technology patented as HiTUS (High Target Utilisation Sputtering) of Plasma Quest Ltd.

The purpose of this technology is to deposit on a substrate a film with controlled characteristics : thickness, uniformity, morphology...

Being a major development of the traditional Magnetron technology, we have prepared this document by presenting this Magnetron technology, its operating modes and its limits: as covered in Part I of this document.

Once this has been explained, we have proceeded to describe the technical aspects of the HiTUS technology : see part II

This then helps to clarify and understand the numerous advantages of this unique technology: see part III.

I. Developments of the Technology

In part I of this document, we proceed to describe the cathodic sputtering technology and its developments : from the Magnetron to the HiTUS of Plasma Quest Limited (PQL).

The objective is to remove the constituent atoms⁽¹⁾ from a source material called the target in order to deposit them on a surface called the substrate⁽²⁾.

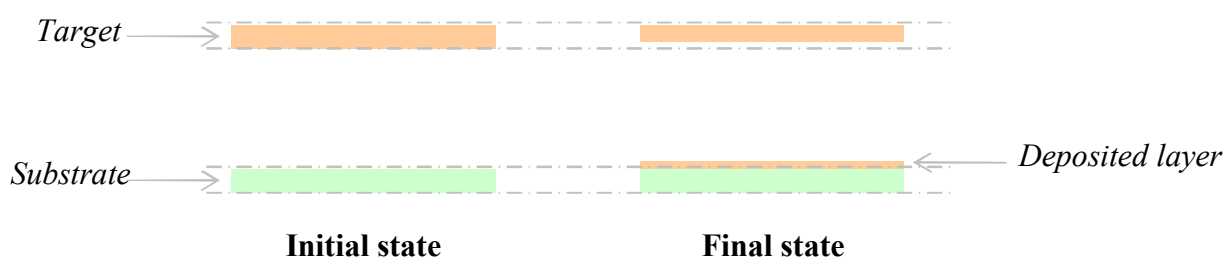


Figure no. 1 : The objective is to remove atoms from the target to deposit them on the substrate.

1. Diode Cathodic Sputtering

The target and substrate are set in a vacuum chamber

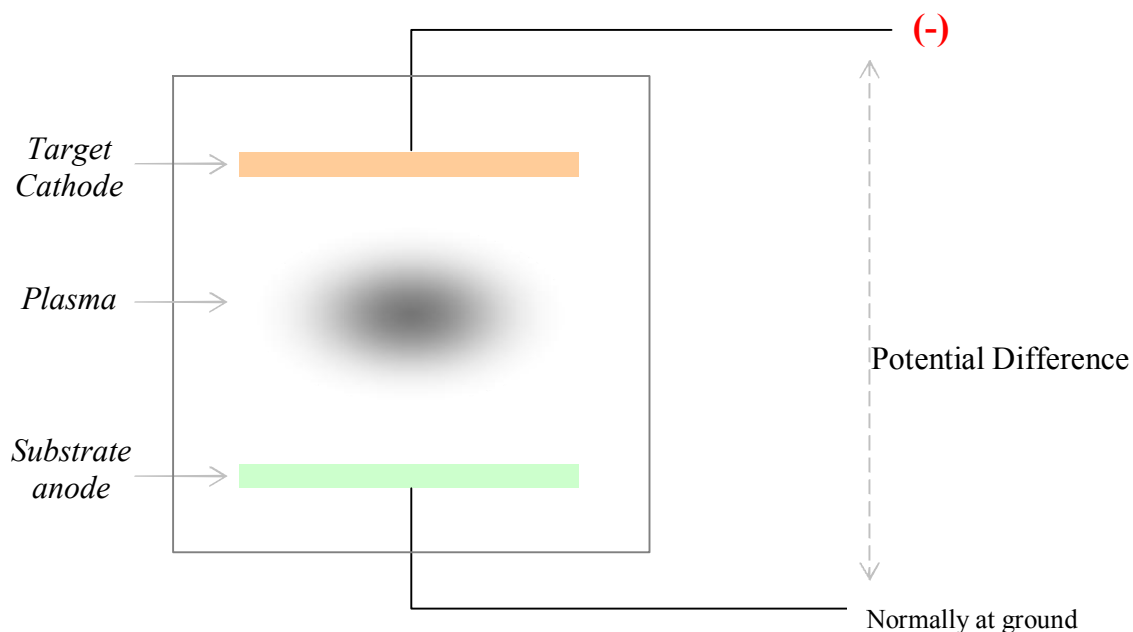


Figure no. 2 : General diagram of the diode cathodic sputtering

Argon gas is introduced into the chamber under low pressure. The target is biased negatively. Thermal electrons⁽³⁾ within the chamber are accelerated away from the target (due to the

applied field), and collide with argon atoms, thus releasing further electrons. The loss of an electron from the argon atom produces a positively charged argon ion. These argon ions are accelerated towards the negatively charged target, collide with the target and remove target atoms/ions/clusters in a “billiard ball” type collision process. Consequently there is a transfer of material between the target and the substrate⁽³⁾. Further electrons are produced by this collision process – these are known as secondary electrons

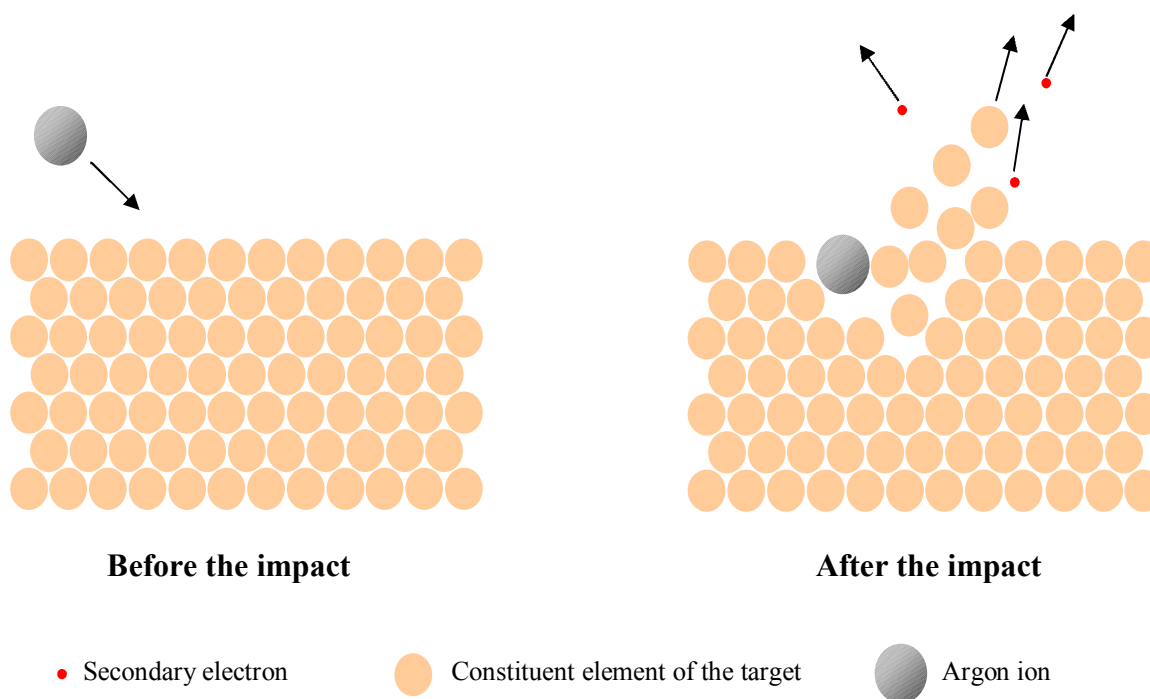


Figure no. 3 : Collisions between the argon ion and the target liberate, within the chamber, species composing the target (ionised or non-ionised atoms) as well as secondary electrons.

The secondary electrons collide with other argon atoms, ionise⁽⁴⁾ them and, thus, help to develop a self sustaining plasma⁽⁵⁾.

The detached surface atoms of the target are scattered within the vacuum chamber. Subsequently they are directed at high speed towards the substrate where they are adsorbed. Subsequently a thicker and thicker layer of the target atoms is formed on the substrate.

In this diode sputtering process, the plasma has a low argon ion density which results in a low deposition rate.

In order to remedy these problems the plasma is enhanced and densified as demonstrated in the Magnetron process – as described in Part II.

2. Magnetron Sputtering

a. Operating Principle

In the classical sputtering technology, an electric field is created between the target and the substrate. In the magnetron sputtering technology, a magnetic field is added. The combination of this (new) magnetic field and the electric field (existing) will communicate an helicoidal trajectory⁽⁶⁾ to the electrons. This results in trapping electrons within the vicinity of the target.

Electrons are trapped within the vicinity of the target, thus the number of electrons per unit volume increases within this location, and hence the argon ion density increases, thereby increasing the deposition rate. If the target is circular, the region of high erosion rate, induced by the local magnets, is called the racetrack.

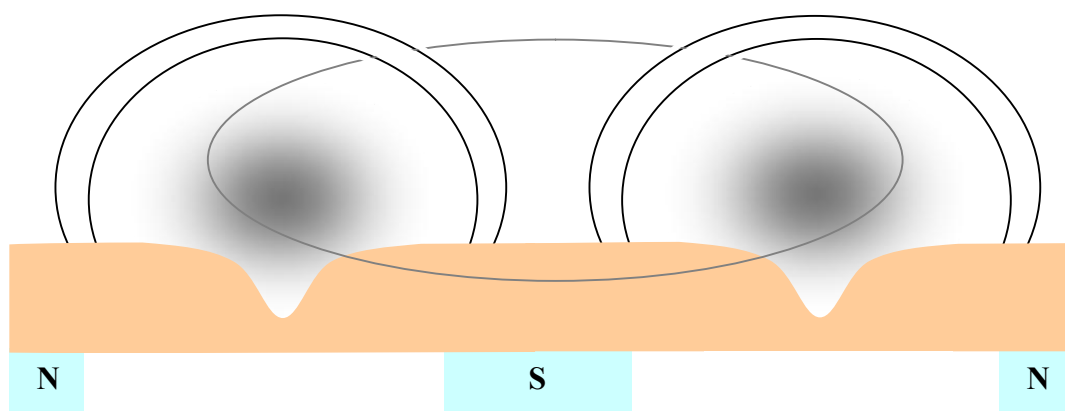


Figure no. 4 : The plasma has a higher density due to its localisation under the effect of magnetic field.

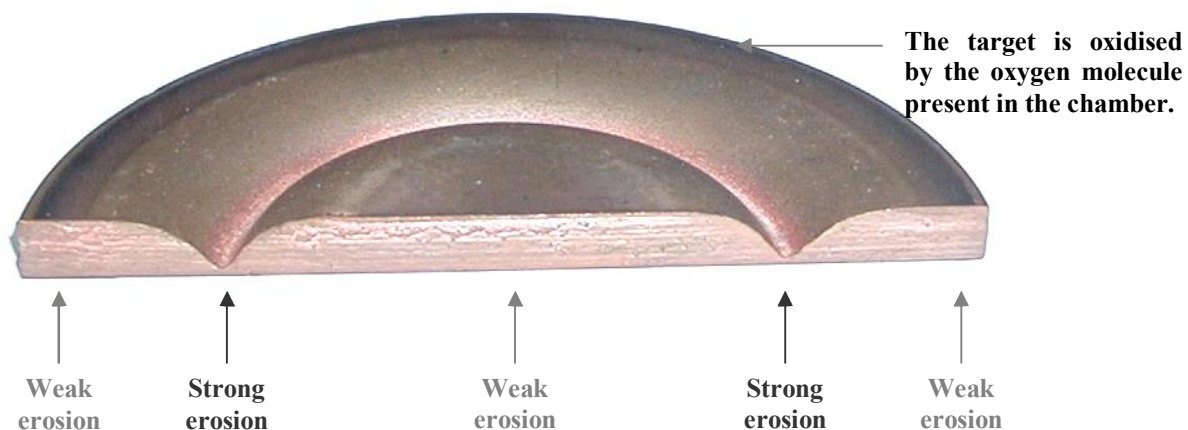


Figure no. 5 : The copper target is not consumed homogeneously. Therefore, it needs to be replaced when only it is used at about 30 -35%.

If this technology helps to increase the speed of deposition, it raises other problems. In fact, the target is not consumed homogeneously precisely because of the localisation of the plasma, leading to poor target utilisation (of the order 30% to 40%).

As a consequence, the target needs to be changed before being fully consumed. A disadvantage which necessarily affects the production cost.

The profile of the target erosion zone is shown in Fig. 6 ie the stronger the magnet field (closer to local magnets) the tighter the profile.

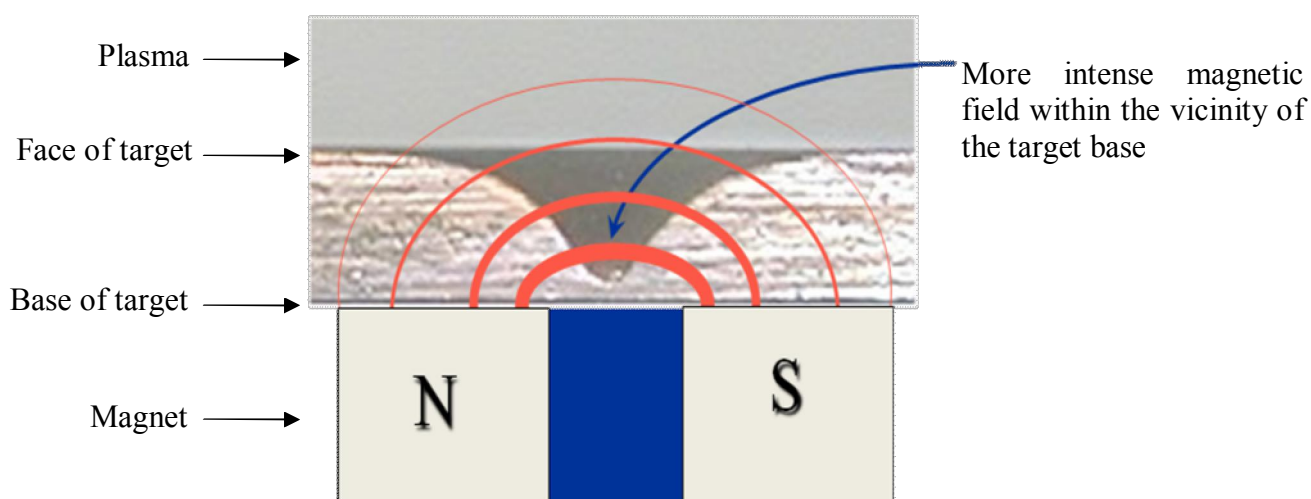


Figure no. 6 : The target is not consumed homogeneously, making the process non-reproducible.

b. Reactive Cathodic Sputtering

In this technique, the film deposited on the substrate is not formed only of the target atoms. It is the product of a chemical reaction between atoms expelled from the target and a reactive gas (O_2 ; N_2) introduced into the chamber. Unfortunately, regions of the target away from the racetrack can form an oxide or nitride on the target surface leading to target poisoning. This leads to plasma instabilities and hence variations in deposited material properties. This can be partially overcome using pulsed DC or plasma emission based technologies.

3. Disadvantages

- a) Low utilisation rate of targets (increasing the deposition cost).
- b) Contamination of substrates.
- c) Difficulty in maintaining the stoichiometry from multi-component (compound) targets (due to the racetrack formation).
- d) Difficulty in controlling reactive sputter processes due to target poisoning – requiring Pulsed DC or feedback controls (instability).
- e) Difficulties in depositing magnetic materials due to reduction in magnetic field strength at the plasma side of the target. Normally this requires thin targets and strong local magnets
- f) Complex methodologies to control the reactive deposition processes (process and reaction instability during the deposition).
- g) Deposition difficulties on heat-sensitive organic substrates.
- h) Low speed of deposition during reactive sputtering and when sputtering from ferromagnetic targets.

II. HiTUS technology of PQL

1. Operating Principle

In HiTUS technology, the plasma is generated outside the main chamber, in an adjoining chamber. It is possible to generate a stable plasma with a density reaching 5×10^{13} ions/cm³.

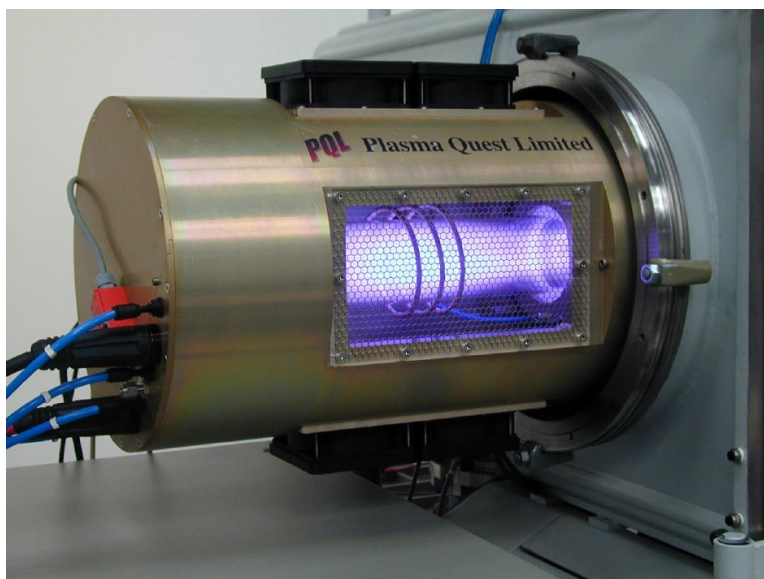


Figure no. 7 : In HiTUS technology, the high-density plasma is generated outside the main chamber. This plasma generator can generally be adapted to existing Magnetron machines.

Argon ions, generated in the sidearm are extracted by a combination of electron density diffusion and ambipolar diffusion, are introduced into the main chamber (see figure no. 8). The electric field present in the main chamber enables to control rigorously the speed, therefore the kinetic energy of the argon ions. The magnetic field (created inside the main chamber by two electromagnets placed between the exit of the adjoining chamber and the target) enables the argon ions to be orientated towards the target to control their trajectory.

Decoupling the actuators (electric field for speed, magnetic field for the trajectory) offers greater degrees of freedom and flexibility for this process.

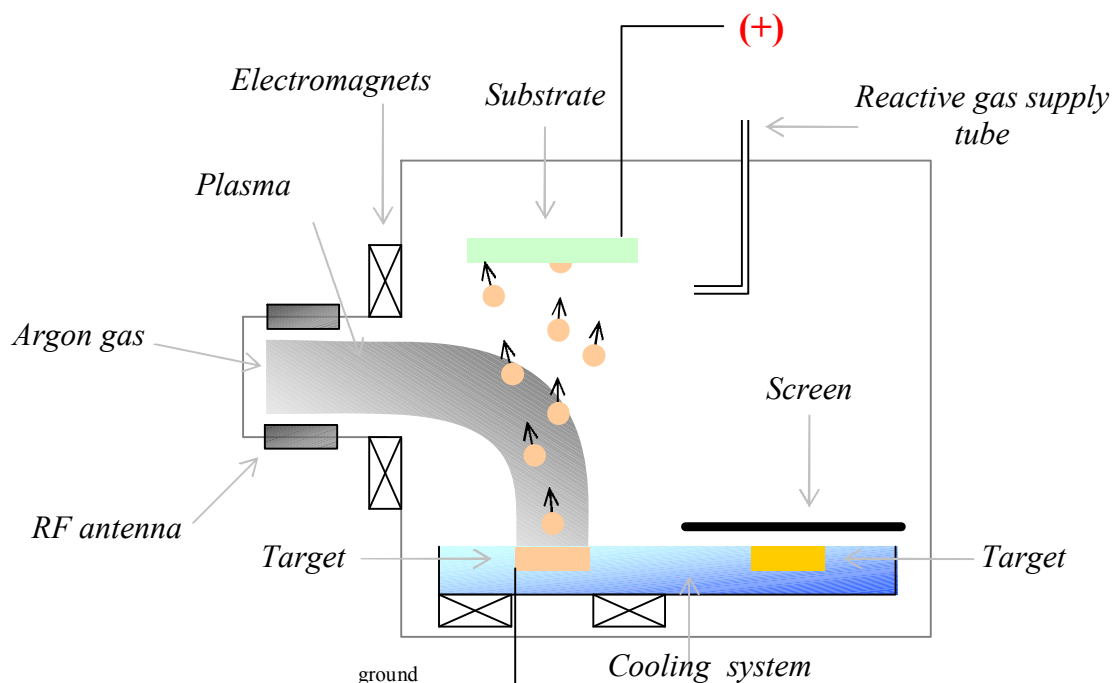


Figure no. 8 : General diagram of the HiTUS technology.

HiTUS Technology

Fig. 8 above is a schematic interpretation that demonstrates the HiTUS technology.

A high density plasma is generated in the side arm due to the forces on thermionic electrons caused by the interaction of the 13.56MHz rf electric field and the static magnetic field from the “launch” electromagnet. Activating the “steering” electromagnet placed behind the target results in a high density of argon ions localised to the region directly in front of the target surface. This is due to a combination of electron diffusion (due to electron density diffusion) and ambipolar diffusion. The energy of the argon ions is low (30eV to 50eV) and is not sufficient to sputter from the target directly. Applying a DC bias to the target accelerates the argon ions across the local sheath where they collide with the target, releasing target atoms/ions/clusters and secondary electrons. With the plasma being generated remotely, ie not from the target as in magnetron sputtering, there is no requirement for local magnets behind the target. This therefore means no racetrack development in the target surface. The result of this is:

- High target utilisation, due to full surface erosion
- Reduced target poisoning. Thus there is no requirement for pulsed DC or process feedback, which leads to a much higher deposition rates of reactively sputtered dielectric materials, especially when compared to magnetron processes.
- Enhanced repeatability when sputtering from compound targets

Furthermore, as the plasma generation is not dependant upon local magnets being placed behind the targets, the deposition rate is not affected by the ferromagnetic nature of some targets. Therefore high deposition rates from thick ferromagnetic targets are possible.

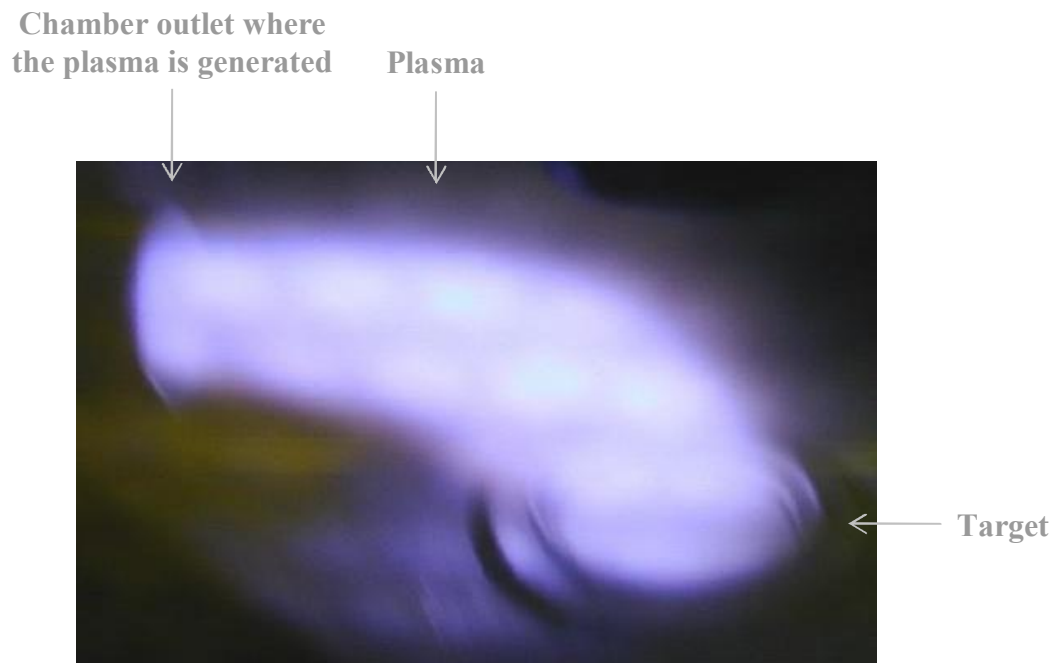


Figure no. 9 : At the adjoining chamber outlet in which the plasma is generated, the plasma beam is curved due to the presence of a magnetic field, and is directed to the target.

2. Substrate position Using HiTUS Technology

With the HiTUS technology, contrary to the magnetron technology, the substrate is normally placed at the top of the main vacuum chamber. Therefore, only the atoms of the target with sufficient energy to overcome the gravity will be adsorbed on the substrate. This helps to warrant the quality of the deposited film. In effect, the pollutants found in the chamber have not sufficient kinetic energy to reach the substrate and be adsorbed on it.

3. Abolishing the Magnetron

To improve the performance of the sputtering system, it was necessary to densify the plasma. Such was the reason of the Magnetron technology being. Thus, with PQL technology, a high-density plasma is generated outside the chamber. As a consequence, by using this new technology, this eliminates the need to use the Magnetron. Therefore, by abolishing the Magnetron, all difficulties inherent to its use are eliminated: the targets can be homogeneously consumed on their entire surface during the entire deposition cycle. Instability is no longer a problem. Substrate pollution problems are removed since the plasma beam is sufficiently intense to prevent the oxygen molecules from approaching the target and oxidise it at the surface.

4. Different Materials

a. Magnetic Materials

It is difficult to deposit efficiently magnetic materials using the magnetron technology. The ferromagnetic material has not got a magnetic field, it does, however, influence the magnetic field produced by the local magnets.

And even if the Magnetron technology uses thin targets, the problem still remains acute. In fact, in this case, the magnetic field of the target varies during the whole deposition process due to the target consumption. The deposition process is, thus, difficult to be reproduced.

As previously stated, in the HiTUS technology the plasma generation is not dependant upon local magnets being placed behind the targets, thus the deposition rate is not affected by the ferromagnetic nature of such targets. Therefore high deposition rates from thick ferromagnetic targets are possible, with the added benefit of increased plant uptime.

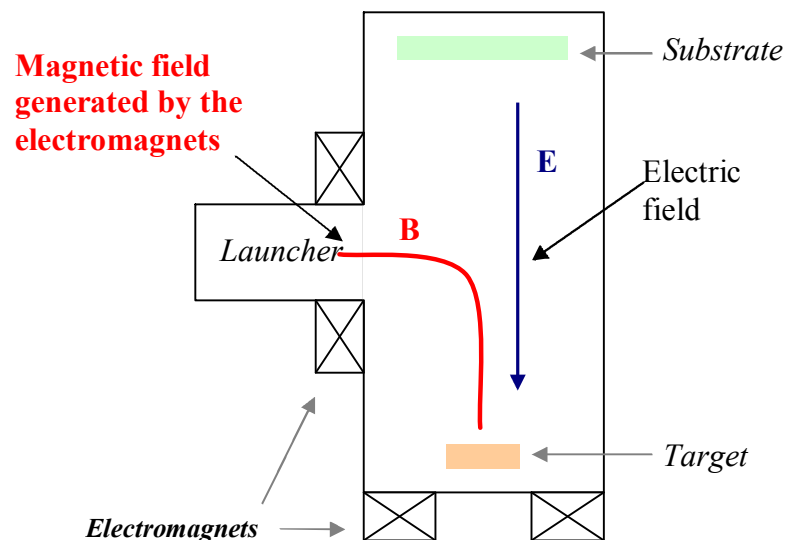


Figure no. 10 : The plasma beam is directed onto the target by means of electromagnets.

b. Insulating Materials

Magnetron

Clearly if the target is insulating, a DC bias will not work and is replaced with an rf bias. Consequently, the insulating target forms part of a capacitive circuit operating at 13.56MHz. Now, free (thermionic) electrons are able to follow the high frequency field and reach the target during the $\frac{1}{2}$ cycle and charge the capacitor (of which the target forms a part). Argon ions, which are much heavier and less mobile, are not able to follow the 13.56MHz field and effectively remain static. The net effect is that the surface of the insulating target acquires a negative potential from the light mobile electrons. With a negative bias on the target surface it is now possible to sputter the target from argon ions generated from the 13.56MHz electric field.

HiTUS

The same argument for the negative bias of the insulator surface applies with HiTUS based technology, but with the same advantages as with DC bias.

5. Substrate Cleaning : Electrostatic Materials

a. Surface Cleaning

To improve adhesion and to prepare the substrate, volatile contaminants must be eliminated. To achieve this, the plasma beam is directed onto the substrate. This is made possible by simple reversal of the magnetic field of the electromagnet placed beneath the target.

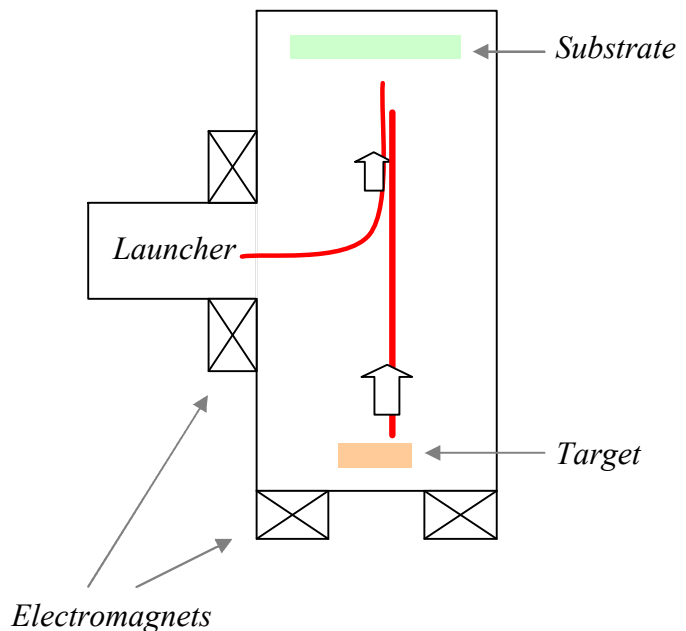


Figure no. 11 : The plasma beam is directed onto the substrate by means of electromagnets.

b. Deep Etching

To ensure perfect cleaning, the intensity of the plasma beam can be tuned in order to remove the first atom layers at the substrate surface. This requires the substrate to be biased negatively.

The use of a RF source is well adapted to the cleaning of insulating substrates which present electrostatic problems. In effect, the fact of being able to neutralise the charges accumulating on the substrate by means of this RF⁽⁹⁾ source helps prevent the accumulation of attracted particles with opposite charges. And the fact of being able to carry out the cleaning in a single machining cycle avoids substrate re-contamination when they are introduced into the chamber after having been etched elsewhere. Plasma Quest Limited also has other solutions to handle this problem during the same per batch or continuous handling.

6. Co-deposition / Co-sputtering

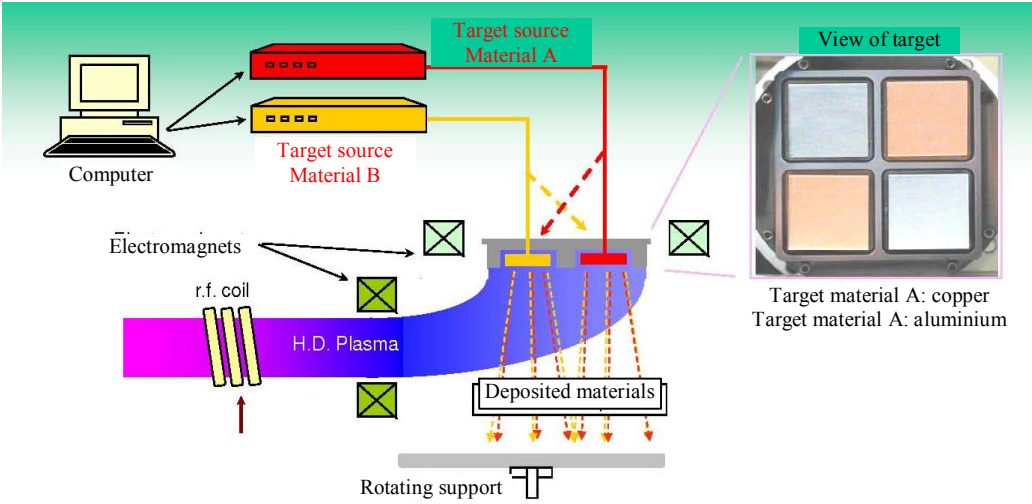


Figure no. 12 : Diagram of the co-deposition.

It is possible to deposit alloys made from different metals by using our Co-deposition (Co-sputtering) technology. In this case, the plasma is directed onto a target containing 4 targets of smaller sizes (2 materials A and 2 materials B). The targets formed from material A are connected to a supply source and those formed from material B to another one. Emission spectroscopy of the plasma helps to tune the relative power to the targets A and B independently, and hence, obtain real-time control of the stoichiometry of the film deposit. Plasma Quest Limited has had significant success using this system for the deposition of a Cu/Al (copper/aluminium) alloy with this technology.

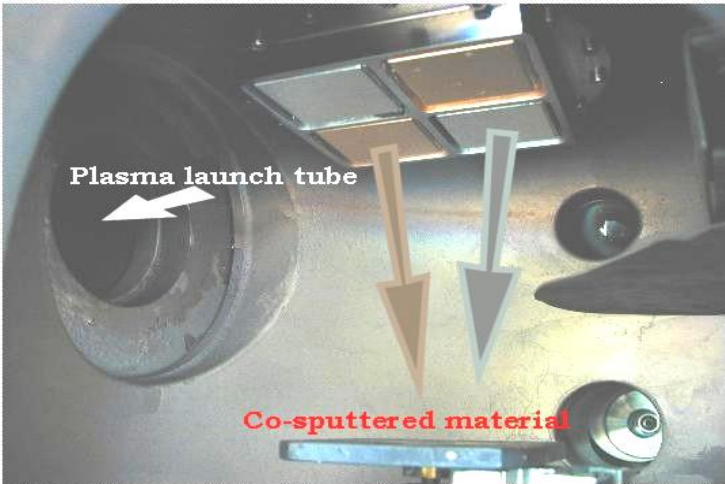


Figure no. 13 : The co-deposition enables alloy deposition, in which the stoichiometry is rigorously controlled.

7. High Throughput Production.

Scale Up Issues

The HiTUS technology provides a more efficient plasma generation process for sputter deposition than more conventional processes. The systems are well suited R&D applications and batch processing. To increase the throughput of HiTUS there are several important issues that have to be overcome:

- Larger targets require a greater diameter plasma launch tube, the PLS must be at least 75% larger than the diameter of the target.
- The rf power supply to the PLS must also scale with bias power
- Larger targets with higher bias are required to increase throughput

b. Linear Systems

Plasma Quest limited has developed a new geometry for the plasma launch tube see Fig 14. In this geometry the same plasma launch tube of the conventional HiTUS system is used, but a cylindrical target is placed in the plasma “beam”. This geometry has many benefits including a more efficient use of the plasma, no requirement to scale the source with the target, increased coating area and higher deposition rates.

The plasma beam generated by the PQL technology consists of a tubular generation region where the electrons are magnetically confined (and is responsible for the glow discharge). This generation region cannot be interrupted, but placing the target inside this critical region has no effect on the propagation of the plasma. This region has a high argon ion density and results in a very efficient sputter process.

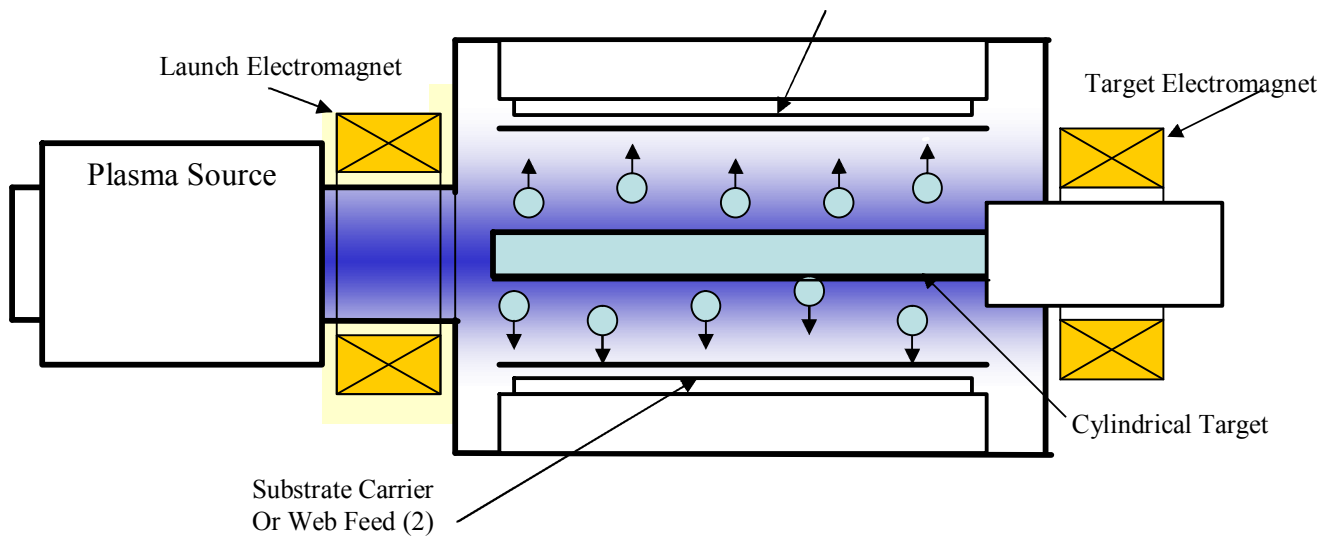


Fig. 14 Linear System Schematic

This chamber offers deposition rates even greater than the HiTUS, up to 200nm/min for many materials having been experienced. It also facilitates the handling of substrates with larger dimensions than conventional HiTUS. For a 50 cm long target, the system can provide a high uniformity over 30cm range.

In the linear system, several plasma generators can be positioned next to each other in independent chambers, allowing the deposition of multilayer materials (see Fig. 15)

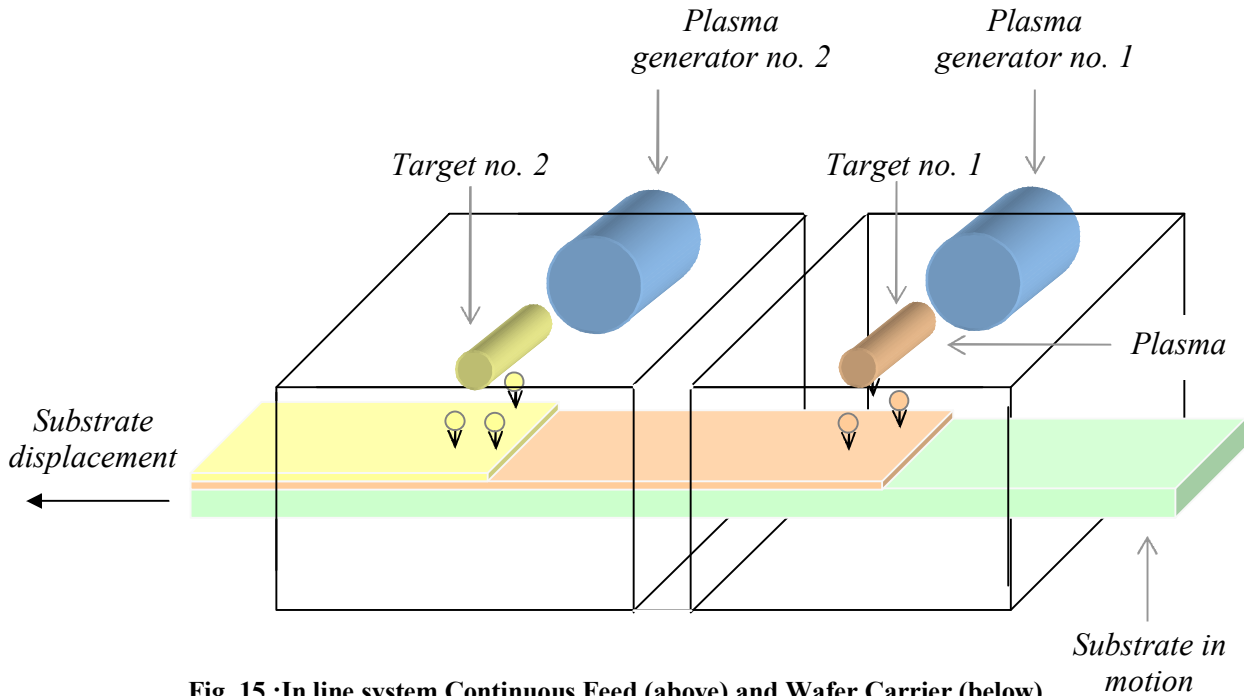
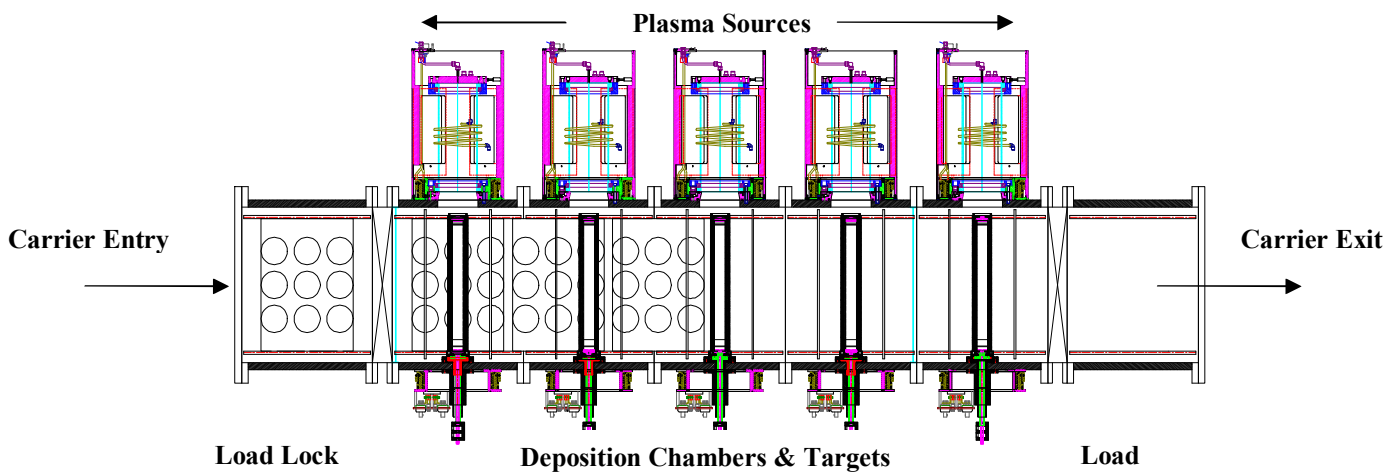


Fig. 15 :In line system Continuous Feed (above) and Wafer Carrier (below)

Fig 16 Alternative Configuration



c. Roll to roll

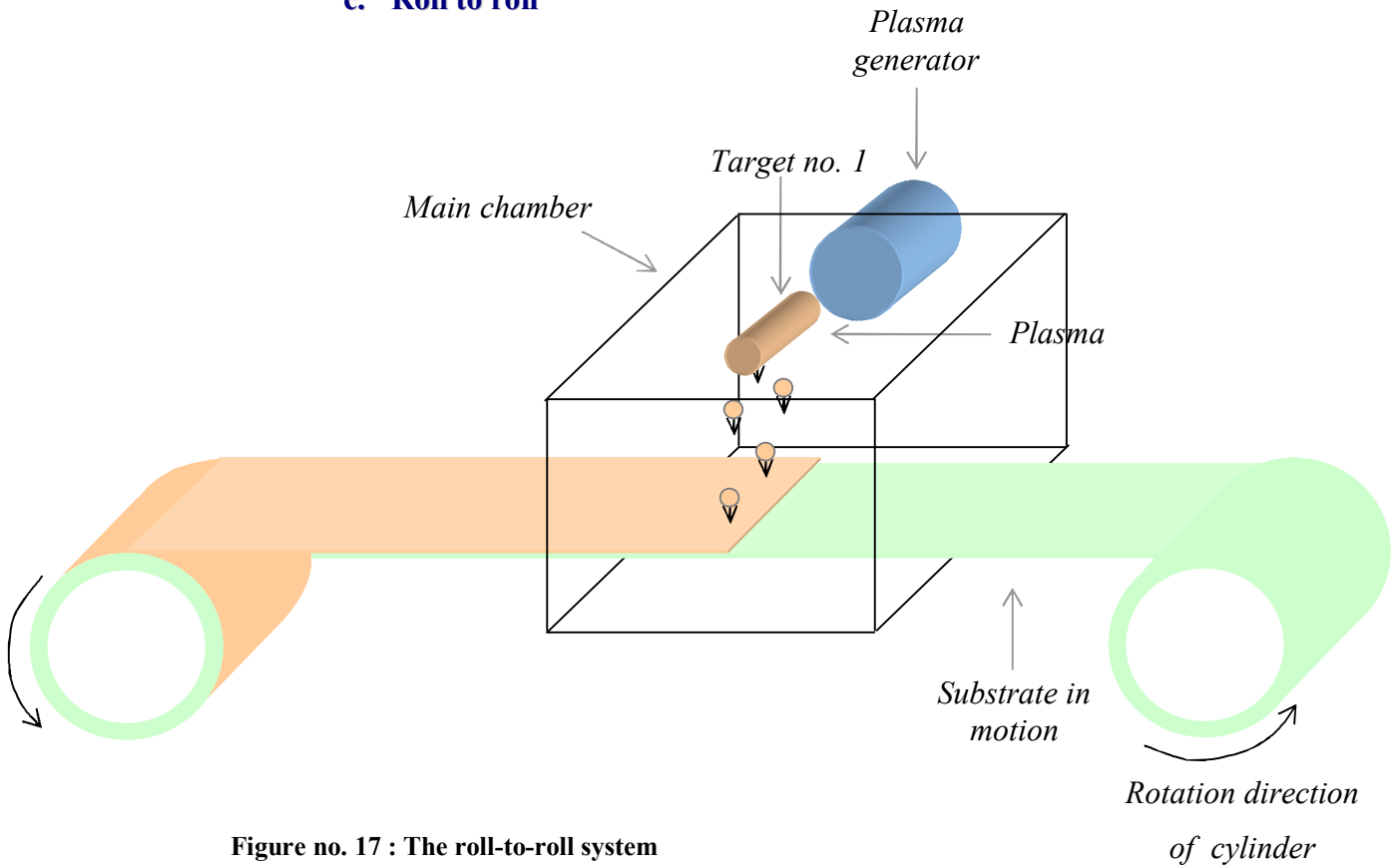


Figure no. 17 : The roll-to-roll system

When the substrate is flexible enough to allow it to be wound around a cylinder, the roll-to-roll system can be suitable.

III. Competitive Advantages of the HiTUS technology of PQL

1. Technical Performances

a. The Deposited Film

- HiTUS enables the controlled deposition of thin or thick layers
Because the generation of the plasma is separate from the target bias, it is possible independently to vary both. This gives PQL's technology the ability to control the deposition rate over five orders of magnitude whilst maintaining the film properties.
- High stability during the deposition process
The full target erosion inherent with PQL technology results in no poisoning of the target during reactive sputtering, unlike the race track in magnetron sputtering
- Thickness Uniformity
Using a rotating substrate it is possible to achieve +/- 0.2% over an 8" wafer from the linear technology, and +/- 0.25% over 4" diameter wafer from a 4" target from the conventional HiTUS process
- Excellent Adhesion
The interaction of the released target materials and the plasma results in an activation process that promotes adhesion. An example of PQL's superior adhesion is seen with its gold deposited onto PET® without the need for a seed layer:

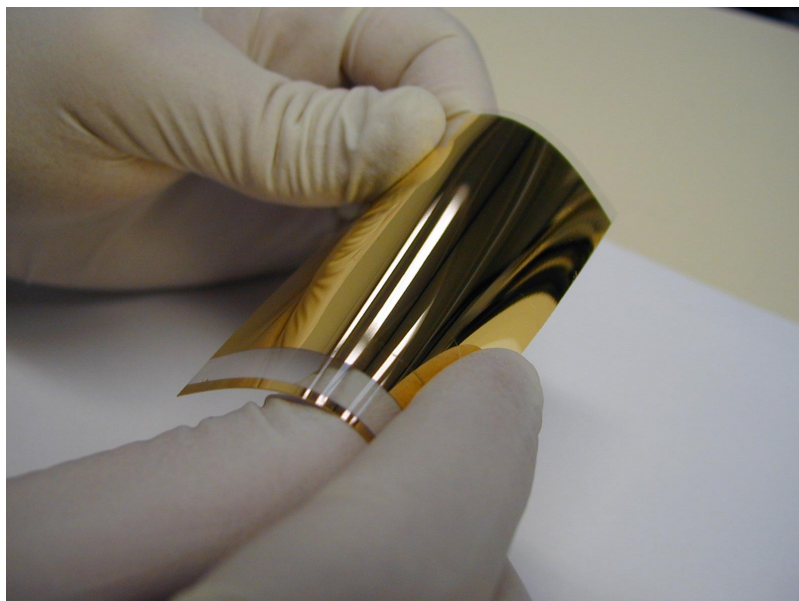


Fig 18 – 100nm gold deposited onto PET®

- Stress Control

The decoupling of the plasma and bias results in the ability to control the chamber pressure independently of the plasma generation. The control of the pressure enables control of the kinetic energy of the target atoms on arrival at the substrate, leading to a direct control of stress. It is possible for PQL to deposit films with tensile, compressive or stress free properties (<10MPa)



Figure no. 19 : it is possible to deposit within compression or tension through a zero stress.

- Near to Bulk Properties

The densification of the films inherent to the PQL technology results in near bulk properties, such as refractive index and resistivities. The RI has been independently confirmed by work done with Lawrence Livermore National Laboratories:

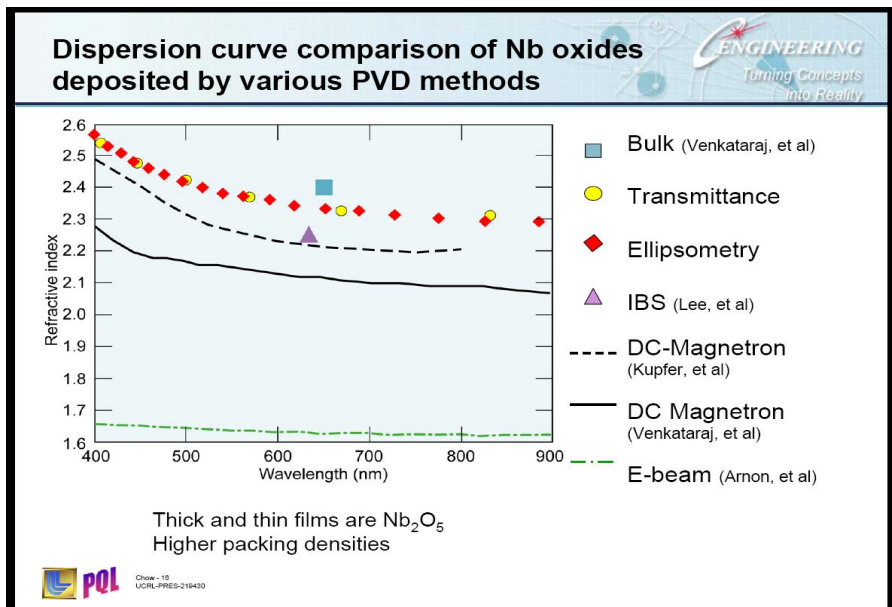


Fig no 20 : Demonstration of near bulk properties

- **Low Argon inclusion**
The plasma generation and high deposition rates, especially with reactive sputtering, can result in very low argon inclusion. Independantly measured films of aluminium oxide reactively sputtered from an aluminium target showed <1% argon inclusion in the film when compared to >5% for magnetron sputtered material.
- **Low temperature deposition**
Although the plasma is high energy, the confinement of the plasma and the separation from the substrate result in very little heating of the substrate during deposition, typically <100°C. PQL have successfully deposited films onto organic materials such as Kapton®, PET®, and PEN.

2. Production Costs

a. Investment

The plasma launch is generally retrofittable onto traditional Magnetron machines. As a consequence, the upgrade cost is low for the manufacturer who wishes to be equipped with this new technology : it is not generally necessary to replace the vacuum chambers.

The multi-target and multi-substrate systems enable the deposition of multi-layers and the semi-continuous batch processing.

b. Target Consumption

The PQL technology leads to better utilisation of the targets : greater than 90 % compared to 30 % to 40% for the Magnetron technology.

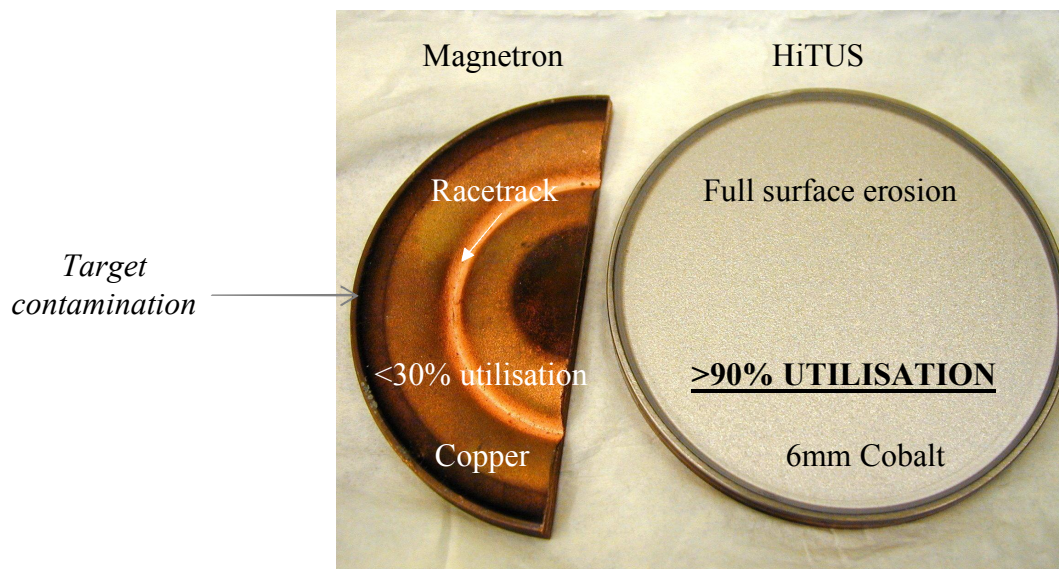


Figure n°21 : PQL technology allows a better utilisation of the target : above 90 % versus 30 % the best with the Magnetron technology

c. Operating Costs

The generation of this high-density plasma enables considerably increased deposition rates, especially for reactively sputtered materials. The high speed of deposition is a major asset of the PQL technology. In some cases, it can be ten times greater than the magnetron technology, especially with regard to reactive deposition of dielectric materials.

The reproducibility and strength of the process allow to reduce considerably the costs related to rejections and quality control of the finished product.

The PQL technology offers greater flexibility and utilisation. The simplicity of the process optimisation, due to the decoupling of the deposition parameters, enables a more rapid and easier change from one production run to another.

3. Summary of the Advantages

In the market of thin-layer production technology, the Plasma Quest Ltd technology eliminates problems associated with Magnetron technology. More precisely :

The Plasma Quest Ltd technology affords :

- An elevated ratio of target consumption (HiTUS): > 90% compared to < 40 % for the magnetron technology
- No means to contaminate the targets.
- Rapidity of deposition is significantly higher (up to 10 times greater, especially with regard to reactive deposition of dielectric materials)
- Control of the deposition process is simple : no retroactive control systems required
- Significantly greater precision of deposition
- Better control of the characteristics of deposited film. Layers properties are very close to the target ones.
- The characteristics of the deposited thin layers are currently only achievable using technologies, which are significantly more expensive and generally use at much lower speeds of deposition.
- Very high reproducibility ratio
- Unit price of production is considerably reduced
- Possibilities to produce roll-to-roll, on line systems or those with jutting targets with the possibility of multi-layer deposition.
- Stresses of the internal layers are readily controllable, ranging from compressive to tensile, with zero stress in between.
- Low-temperature process enabling the deposition on organic substrates.
- This technology can easily be integrated in the majority of existing vacuum production systems ; therefore, investments in improvement are considerably reduced.

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V. Glossary

(1) Atom : originates from the Greek word *ατομος*, atomos “indivisible”. It is the smallest part of a simple body capable of being combined chemically with another. Its characteristic size is ten million times smaller than the meter, that is 10^{-10} m.

The atomistic theory, which supports the idea of a matter composed of "grains" (versus the idea of an indefinitely divisible matter), is known since antiquity, and was particularly defended by Democritus, a philosopher of ancient Greece. The atoms constitute the elementary building blocks of the matter.

The atom is an electrically neutral species.

(2) Substrate : to remove an atom from the target and give to it a velocity, the argon ion needs to possess an energy greater than the energy which binds this atom to other atoms of the target : $E_c^{\text{Argon}} > E_{\text{att}}^{\text{target atom/substrate}}$. The residual energy will serve to provide a velocity to the

removed atom : $E_c^{\text{target atom}} = E_c^{\text{Argon}} - E_{\text{att}}^{\text{target atom/substrate}}$

(3) Electrons : the atom is made of a nucleus and electrons. If the nucleus is the heart of the atom, the electrons are found around the nucleus.

Electrons are electrically charged species. Each electron carries a negative charge with a value of : $q = -1.6 \times 10^{-19} C$.

The electron mass is negligible versus that of the nucleus : $m = 9.11 \times 10^{-31} kg$. Therefore, the atom mass is comparable to that of the nucleus.

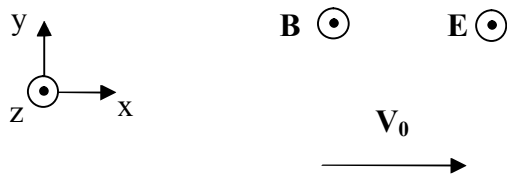
(4) Ionised : when an atom (with a neutral electrical charge) loses at least one electron (a negatively charged species), it becomes a positively charged species called cation. When an atom gains at least one electron, it becomes a negatively charged species called anion. The anions and cations are both electrically charged species: the ions.

(5) Three states of the matter are usually known: the solid, liquid and gaseous states. They share one common point: the constituting atoms are neutral. A fourth state of the matter called the plasma exists, in which neutral particles, ions⁽⁷⁾ and electrons⁽³⁾ are simultaneously present.

One of the significant features of the plasma state in the context of our interest is that if electrically uncharged particles exist, they can be made to move in an electric and/or magnetic field.

(6) Helicoidal movement. A charged particle placed in a chamber, in which both a magnetic and electric fields exist, acquires an helicoidal movement.

System : charged particle with a charge of q , propelled by an initial velocity V_0 .



Fundamental relationship of the dynamics :

$$\frac{d\vec{v}}{dt} = q(\vec{E} + \vec{v} \wedge \vec{B}) \Rightarrow \begin{vmatrix} \dot{v}_x \\ \dot{v}_y \\ \dot{v}_z \end{vmatrix} = q \begin{vmatrix} 0 & v_x \\ 0 + q & v_y \\ E & v_z \end{vmatrix} \wedge \begin{vmatrix} 0 \\ 0 \\ B \end{vmatrix} \Rightarrow \begin{cases} \dot{v}_x = qBv_y \\ \dot{v}_y = -qBv_x \\ \dot{v}_z = qE \end{cases}$$

After integration :

$$\begin{cases} v_y = V_0 \sin(qBt) \\ v_x = V_0 \cos(qBt) \\ v_z = qEt \end{cases}$$

(9) Deposition using a RF supply: in this case, it is about to use a combination of a continuous supply source with an alternative-current one (Radiofrequency “RF”)

Under the effect of the plasma ions bombardment, the positive charges accumulate on the target when this is non-conducting. An alternative high-frequency voltage is then applied. Thus, the electrons contained in the plasma are accelerated during part of the cycle in the direction of the target. Once on the target, they neutralise these positive charges.

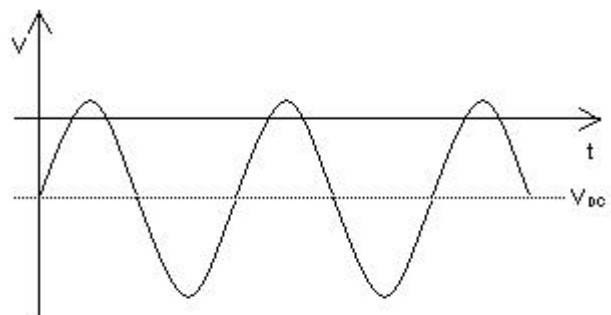


Figure no. 20 : Development of the voltage as a function of time : high-frequency signal.

If the electrons are sensitive to the high-frequency variation of the voltage, it is due to their low mass. The ions with a much higher mass are, for their own part, insensitive to high-frequency variations : they only react to the average RF voltage and DC.

The same principle is utilised for deep etching of insulators which pose electrostatic problems.

Other Useful terms

Anode : two electrically opposite charges [(+) and (-)] are attracted by each other, whereas two identical charges [(+) and (+)] , [(-) and (-)] repel one another. As a consequence, the positively charged anode attracts all negatively charged species.

The kinetic energy of an object is defined as half of the product of this object mass with the square of its velocity. $E_c = \frac{1}{2}mv^2$. As a consequence, an object which has a velocity of null value will have a kinetic energy of zero. If the velocity of an object is to be doubled, its energy is to be multiplied by four.



The HiTUS Technology as a Pioneer in Cathodic Sputtering

The purpose of the technology presented in this study is to deposit on a substrate a film with controlled characteristics: thickness, uniformity, morphology ...

The technology patented by Plasma Quest Ltd (HiTUS : High Target Utilisation Sputtering) is a major development of the traditional Magnetron technology.

It is a process founded on the remote generation of a high-density plasma. The plasma with perfectly controlled characteristics is generated first in an adjoining chamber opening onto the main chamber of the process, which contains the target and the substrate to be coated.

Since the plasma is generated from a distance, and not from the target itself (as it is the case of Magnetron technology) the ionic current of the target is independent of the voltage applied to the target. This provides additional degrees of freedom in the deposition of the layers, leading to develop new processes and new structures. In particular, this enables the deposition of thin layers possessing properties only reached with the deposition by ionic beam with a very high rapidity that is offered by the high-density plasma generator. Although all materials experience an increase in their quality, speed and precision of deposition, the benefits of the technology are particularly demonstrated with regard to the deposition of dielectric and magnetic materials.

Additional properties brought by the utilisation of a high-density plasma generator in the process of thin-layer deposition are the densification of the materials deposited and the control of their morphology, internal stress and adhesion.

The combination of the high speed of deposition, the characteristics of the materials deposited and possibilities of tuning opens the opportunity of creating new materials and processes not only in the field of nanotechnology, which is particularly appropriate for flexible semi-conductors, but also in many other applications.

As of its very conception, all the advantages brought forth by this process make it a pioneering technological tool for research and industry.