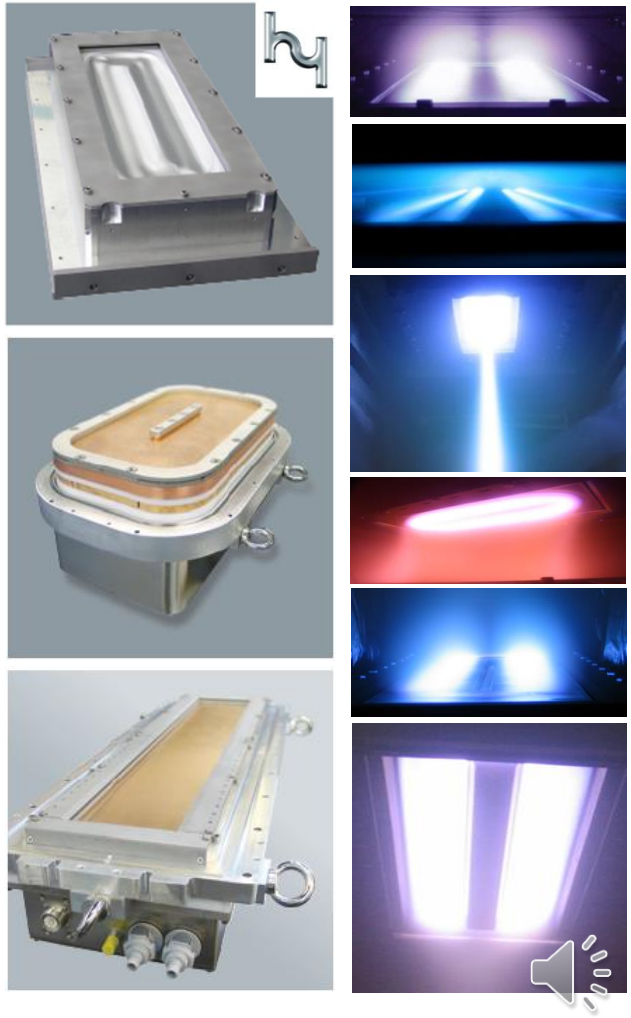
The Full Range of Magnetic Array Options for Planar Magnetrons – Too Much Choice?

Dr Dermot Monaghan, Gencoa Ltd,
plus 25 years of help from
Victor Bellido-Gonzalez & Robert Brown



SVC Society of Vacuum Coaters
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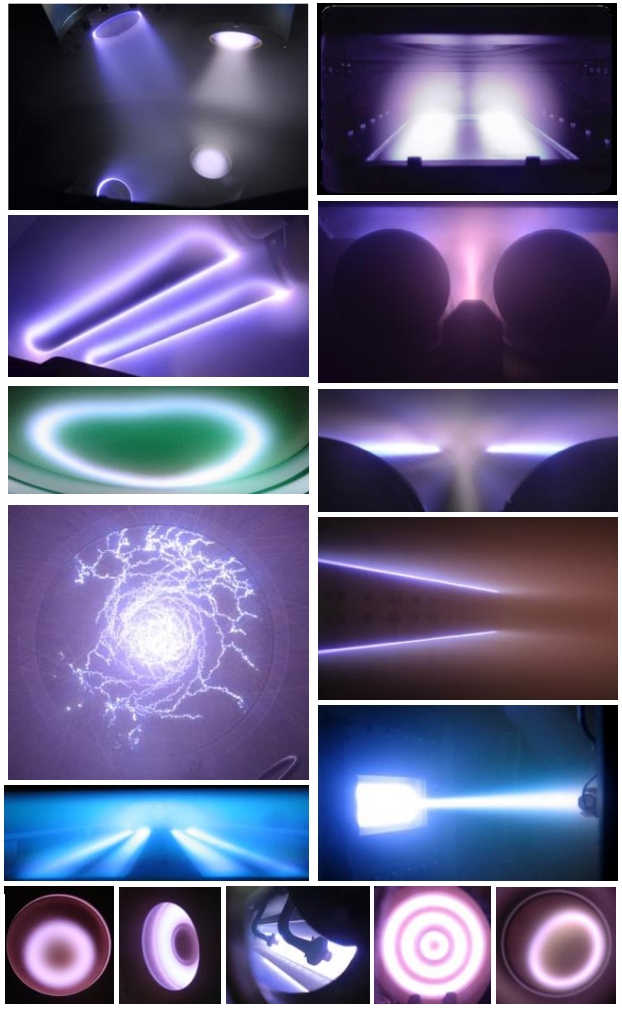
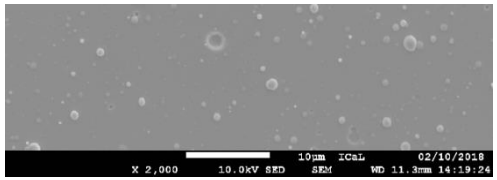
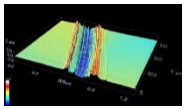
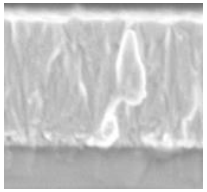
26 Years of of Products and Technology from Gencoa

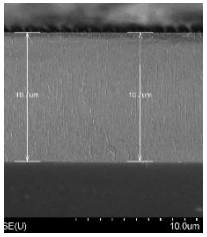
Rotatable & Planar Magnetron Sputter Cathodes • Retrofit magnetic packs • Plasma Treaters • Speedflo Reactive Gas Controllers • IM Ion Sources & power supplies • Arc MAX sources & power supplies • Active Anodes and Gas Delivery Bars • OPTIX Gas and Chemical Sensing • S and Se Sensor • PEC Pulsed Effusion Cell • V⁺DLC - Transparent DLC • IC Nano antimicrobial layer technology • Process implementation & tuning •

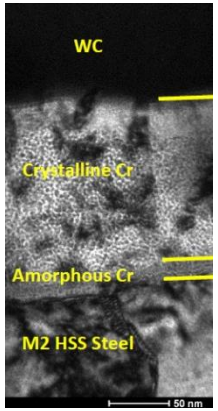


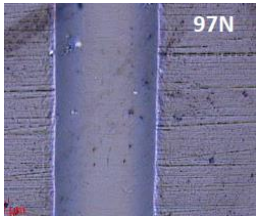


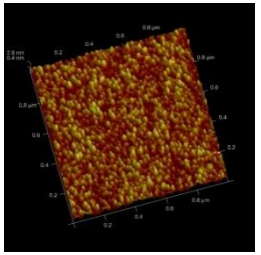


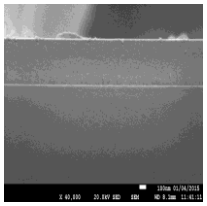


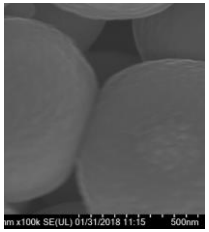


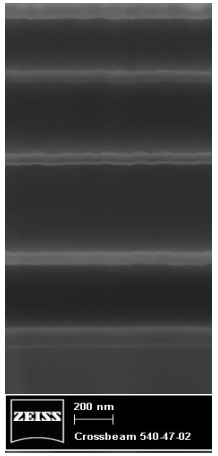


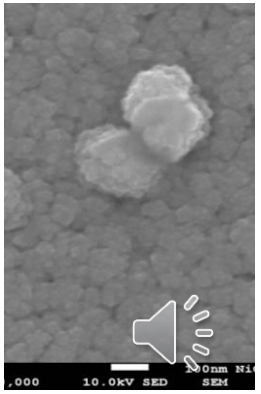










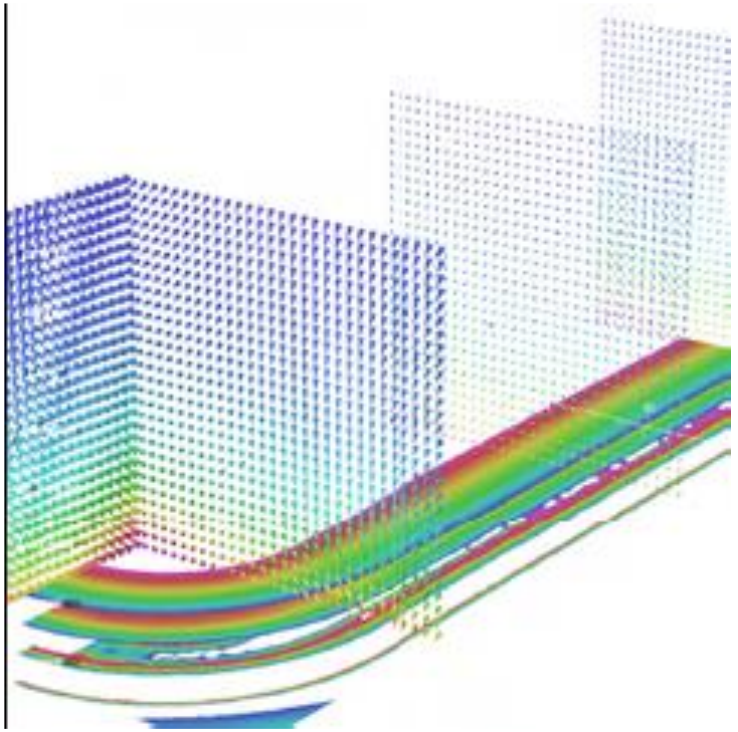


Rectangular planar magnetrons offer a wide range of magnetic array choices

All offer different process advantages – the 'devil' really is in the detail

- **Not just a case of offering *the highest target use*. Other important elements to consider are:**

- Target cleanliness
- Reduction in defects (within the coating)
- Power mode of operation (DC, MF, RF, Hipims)
- Pressure of operation (low or high)
- Desired voltage of operation (low or high)
- Layer uniformity
- Energy required for the growing film – extra impact for decorative and hard coatings
- Interaction of the magnetic field lines with the anodes, substrates and vacuum chamber components
- Heat tolerance of substrates
- Is the target ferromagnetic?
- Budget



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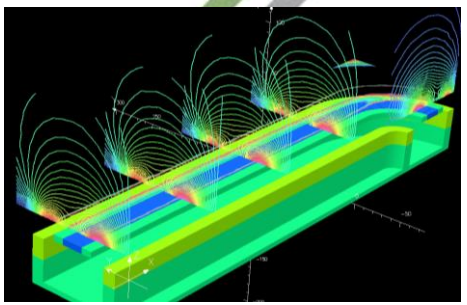
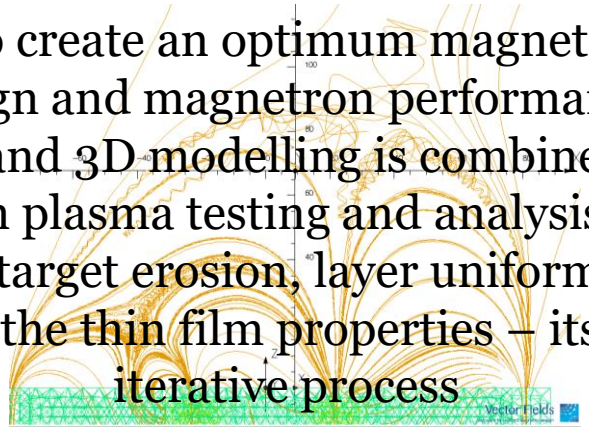
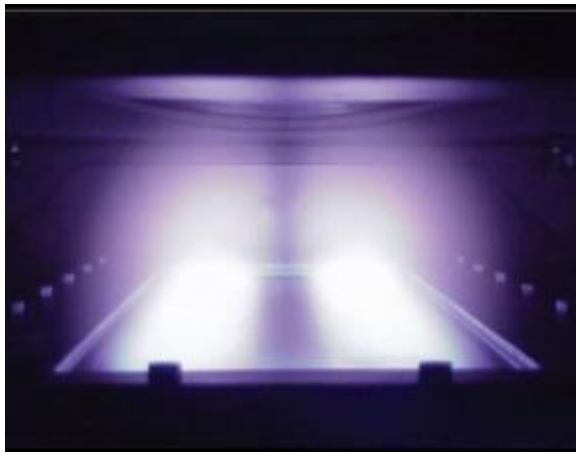
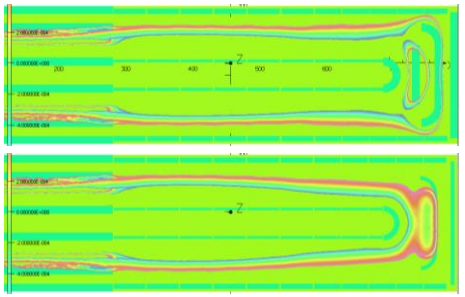
Model → **Test** → **Refine**

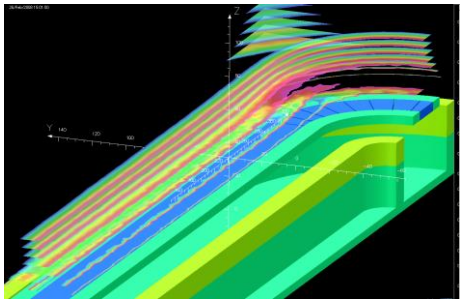


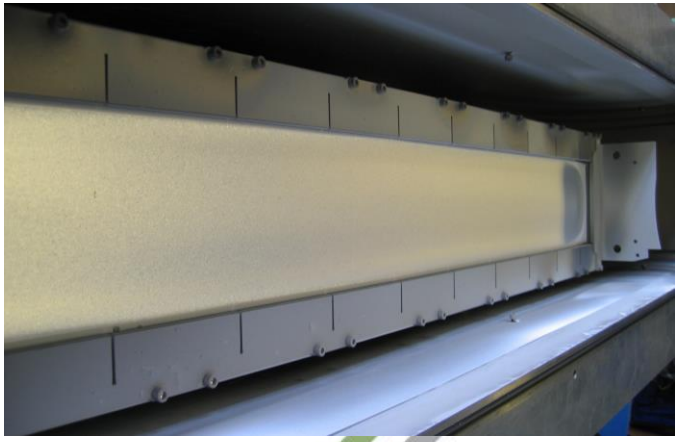
To create an optimum magnetic design and magnetron performance, 2 and 3D modelling is combined with plasma testing and analysis of the target erosion, layer uniformity and the thin film properties – its an iterative process

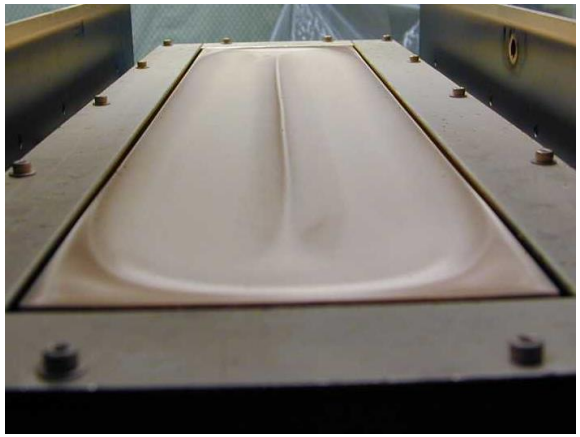


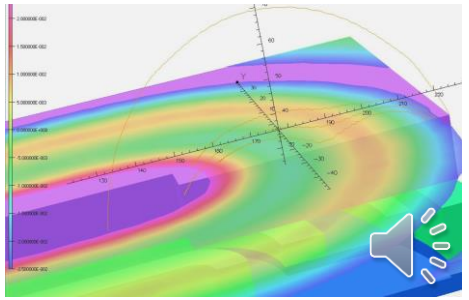










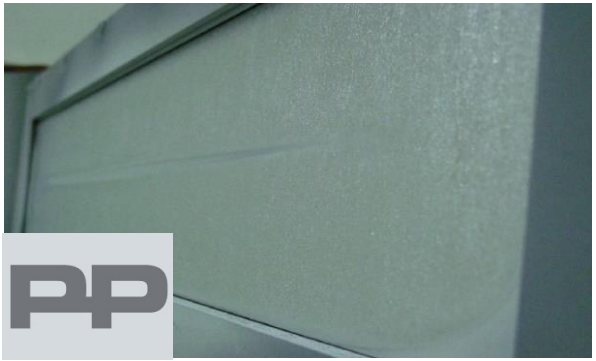


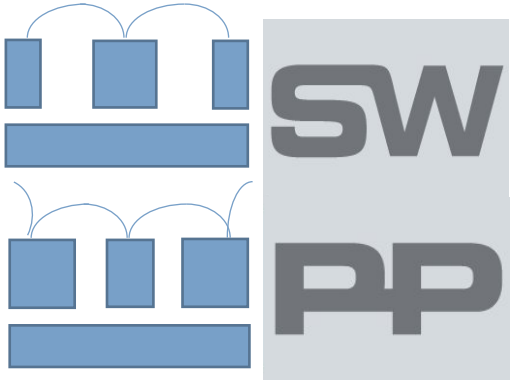
This is a summary of the magnetic options (arrays) developed by Gencoa for rectangular planar magnetrons over the last 26 years

All offer different process advantages – the 'devil' really is in the detail

Array Code	Schematic	Key Advantage	Description
SW (LS – SS – HS)		Simple with strength options	Sputter Wall, 2 pole balanced
PP (SS - HS)		Extra process energy	Plasma Plume, 2 pole unbalanced
Hy		Higher target use	High Yield, multi-pole magnetics
XH		Highest target use, clean	Extra High, moving magnetics
LOOP		Thick ferro-magnetic targets	LOOP magnetics and target design
Mz (Hy)		Long lifetimes for metal targets	Metallizer for machinable materials
VT		Variable balance and strength	Vtech independent pole movement
VT-R		Variable ion bombardment	Vtech rotation of auxillary poles
VT-Flex		Adapt strength to tune uniformity	Vtech flexibility for uniformity
VT-S		Field strength and voltage tune	Vtech simple retraction of array
HU		Ability to improve layer uniformity	High Uniformity – array fine tune

SW Sputter Wall & PP Plasma Plume 2 pole magnetics Offer excellent plasma control in different strength and balance



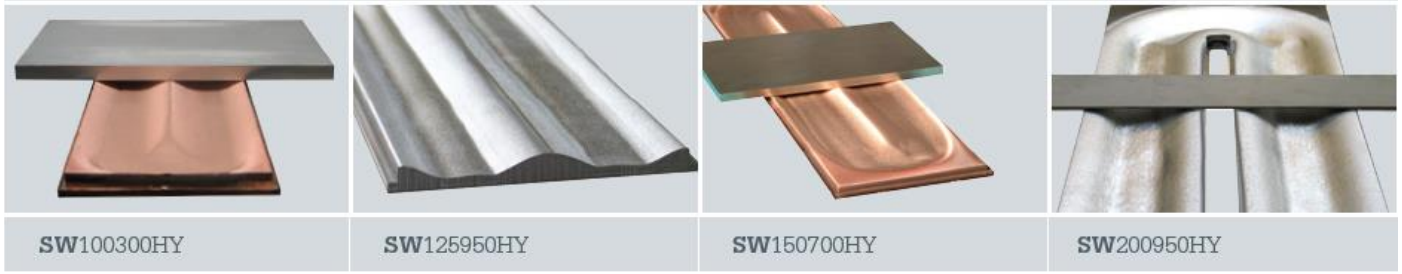


Lowest cost of magnetron, target use around 30%, clean target in non-reactive mode, strength and magnetic balance / unbalance can be tuned widely – flexible process setup

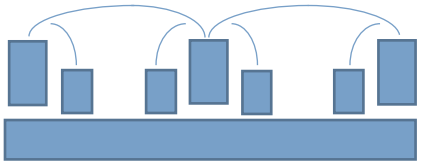
SW – Sputter Wall
Interacts with the anode to limited plasma release in order to reduce energy and heating of the substrate

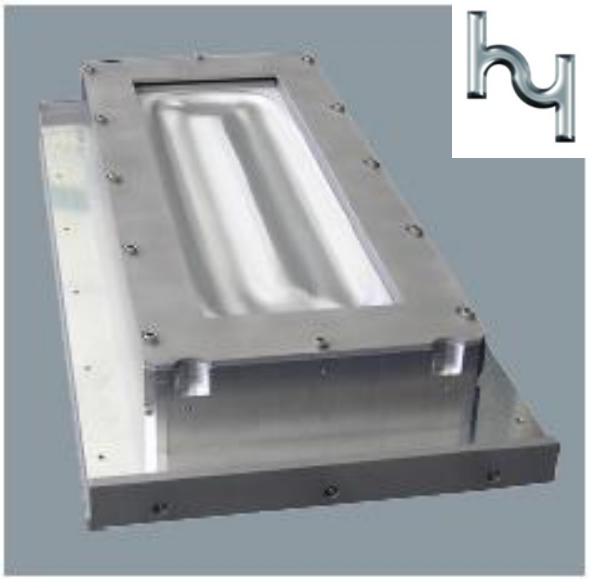
PP – Plasma Plume
Avoids interaction with the anode to increase plasma release in order to enhance energy of bombardment of the substrate

High Yield HY type multipole magnetic arrays yield for 40-50% target use

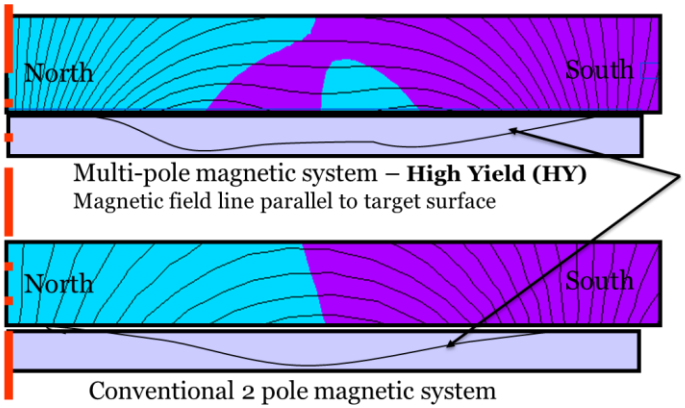


SW100300HY	SW125950HY	SW150700HY	SW200950HY





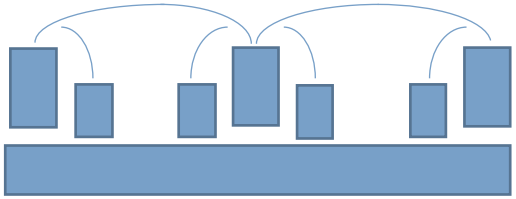
High Yield magnetics use 7 or 8 lines of magnets in order to create a flatter magnetic field over the target surface. This produces a wider and flatter erosion track. The voltage change with lifetime is less and the target remains cleaner with reactive sputtering

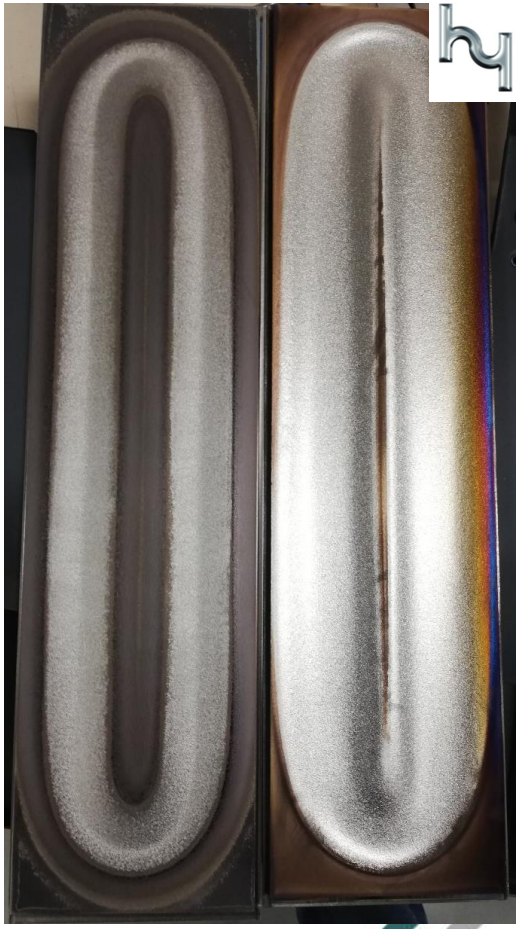


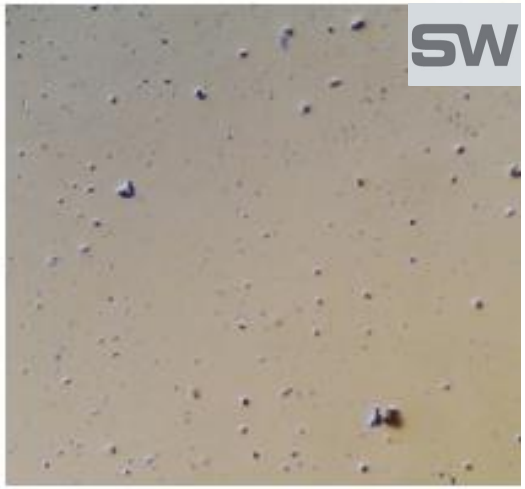
Centre of target

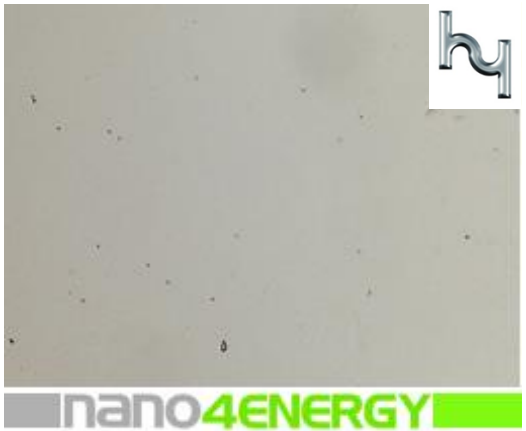
High Yield HY type multipole magnetic arrays yield for Hip³

High Yield magnetics produce much fewer defects when Hipims power is deployed









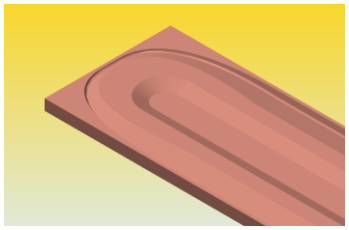
Very long deposition runs with Hipims power results in defects from arcs as the target re-deposit builds up. The HY target is 'cleaner' and hence less arcing over time. XH is another potential solution.

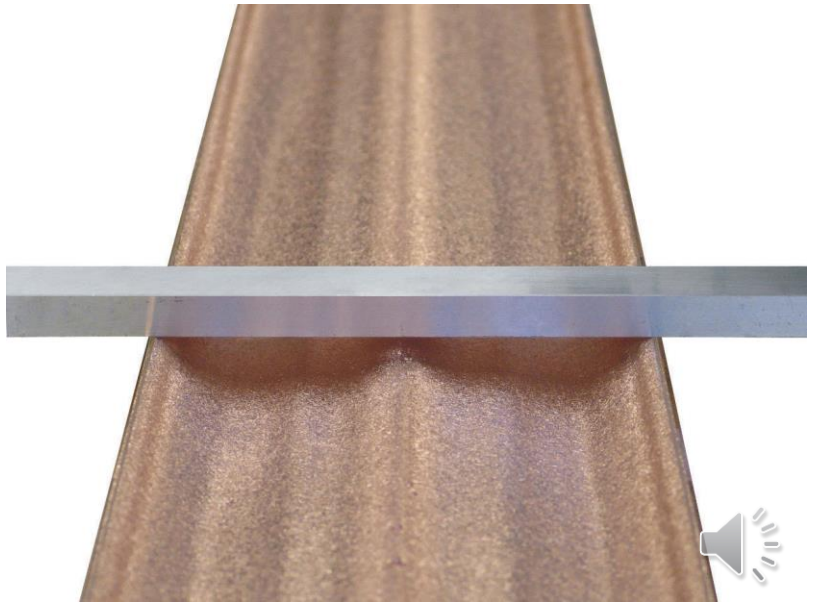
For example, Hip 12µm TiAlN in 15hrs run with no difficulty, and the same for TiN & TiSiN.

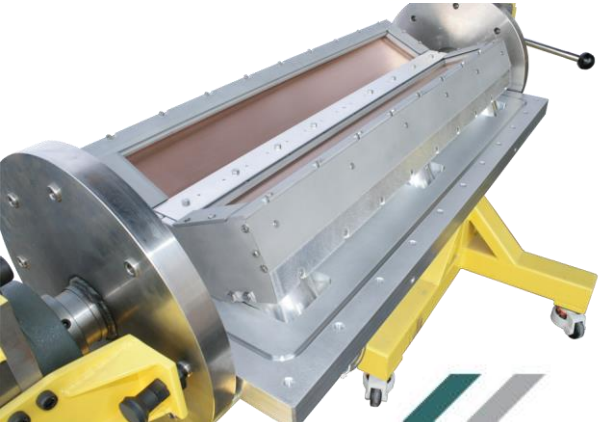
12µm TiSiN with 40GPa hardness on micro-tool for Ti machining

Metallizer for 100% increase in up-time – thicker profiled targets, hidden anode

Mz metallizer cathodes use the target top profile combined with the magnetic field shape to double the target life and produce a clean target for low defect films at high power densities

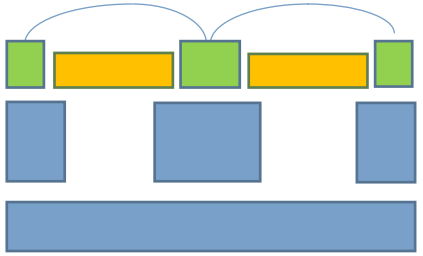


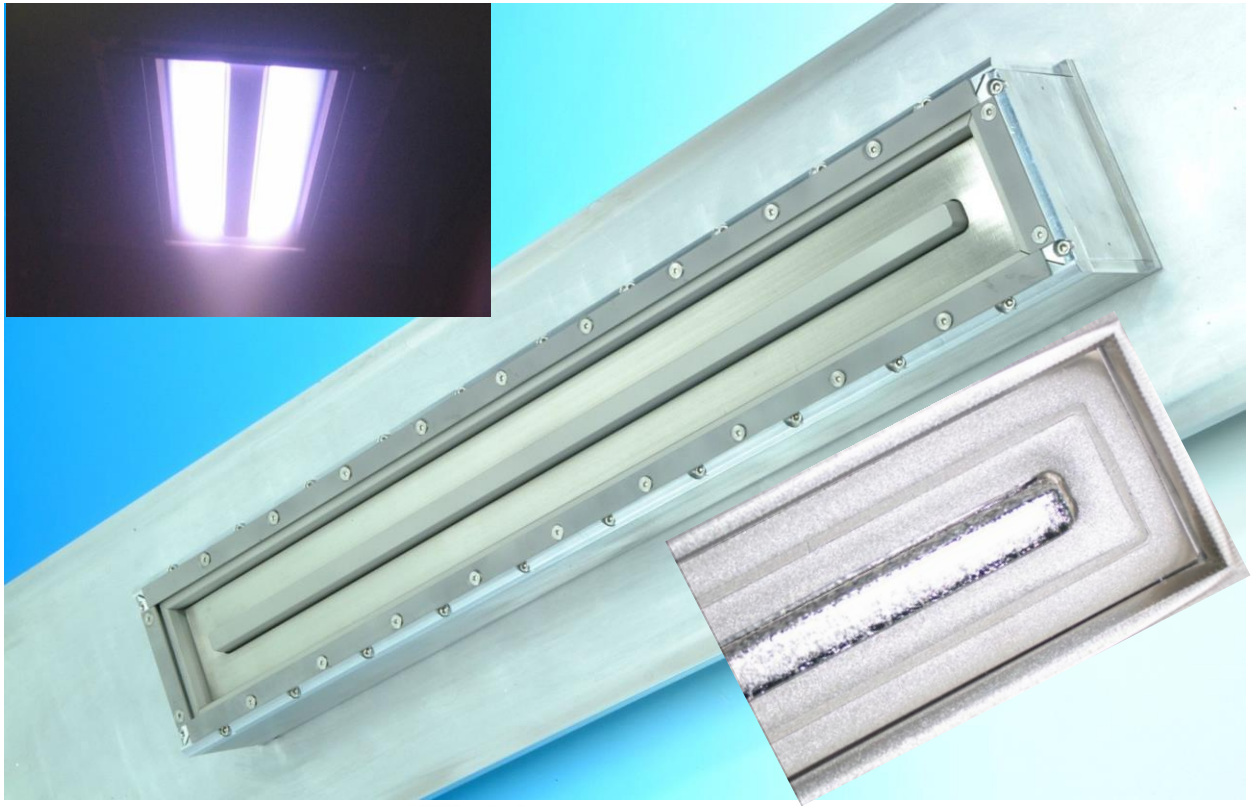




LOOP source for FerroMagnetic target materials

Loop combines a very high field strength with a specific target design to project the magnetic field over the target surface to avoid saturation within the target material

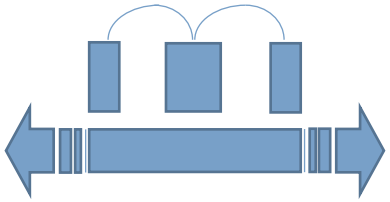




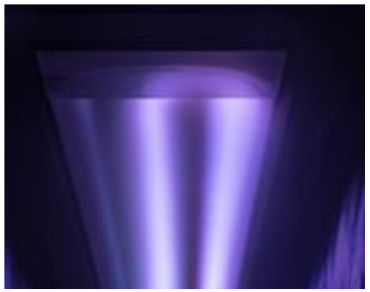
The problem of sputtering a ferromagnetic target material is a result of the magnetic field being absorbed within the target and hence limiting strength over the target. This means a thin target and low target use due to 'pinching' as the target erodes. Looping the field over the target means much thicker targets can be used upto 4mm for pure iron and 10mm for nickel as examples.

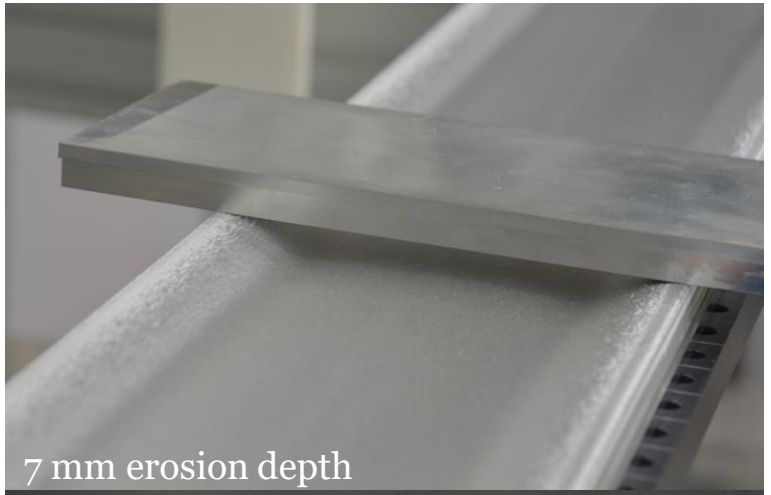
eXtraHigh Magnetron Maximises the target erosion from planar magnetron targets

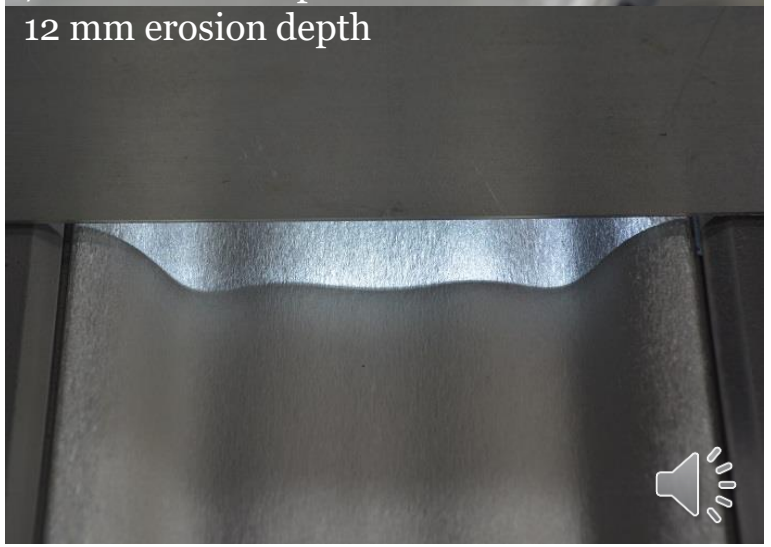
XH uses a motor to drive the magnet pack side to side to make a flat erosion profile on the target

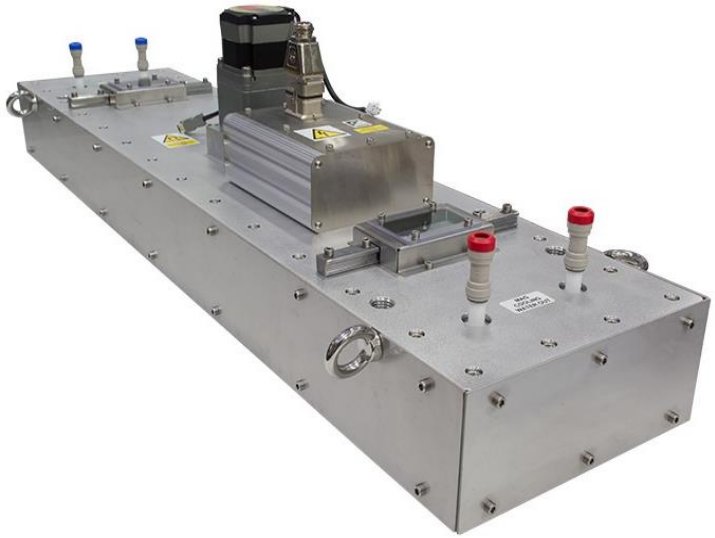


The Gencoa XH150 type magnetron uses a 150mm wide target with a thickness of up to 20mm.
The XH magnetics increases the target use up to 75% for bonded targets and 65% for thick mono-block style targets.
Also produces a clean target surface, hence fewer coating defects.



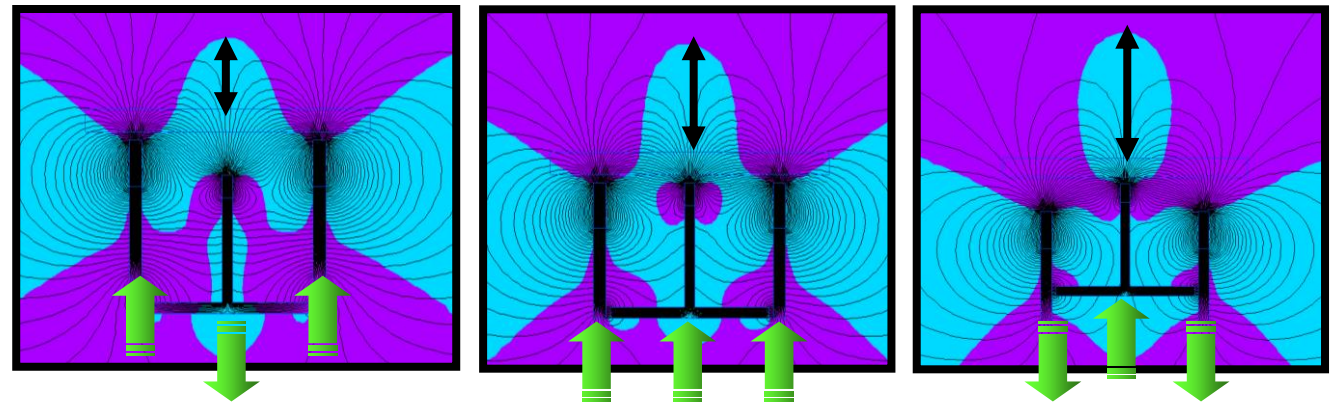


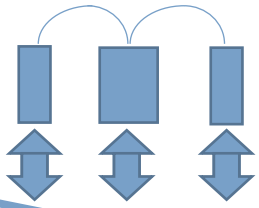




Vtech varies field strength, shape and balance/unbalance to optimize plasma properties during the coating process

vtech





VT100300 fully unbalanced position Bz=0 @ 44mm

VT100300 middle balanced position Bz=0 @ 61mm

VT100300 fully balanced position Bz=0 @ 80mm

The original VTech moves the inner and outer pole independently in order to vary the ion assistance of the process or the field strength over the target (or both combined)

Varying of the ion current is beneficial for 'batch' processes where a varying level of bombardment improves over layer performance and adhesion. It's the ultimate research and development tool as all the magnetic field parameters can be adjusted and the effect on the layer properties studied.

Gencoa Planar Magnetrons -Vtech varies field strength, shape and balance/unbalance to optimize plasma properties during the coating process

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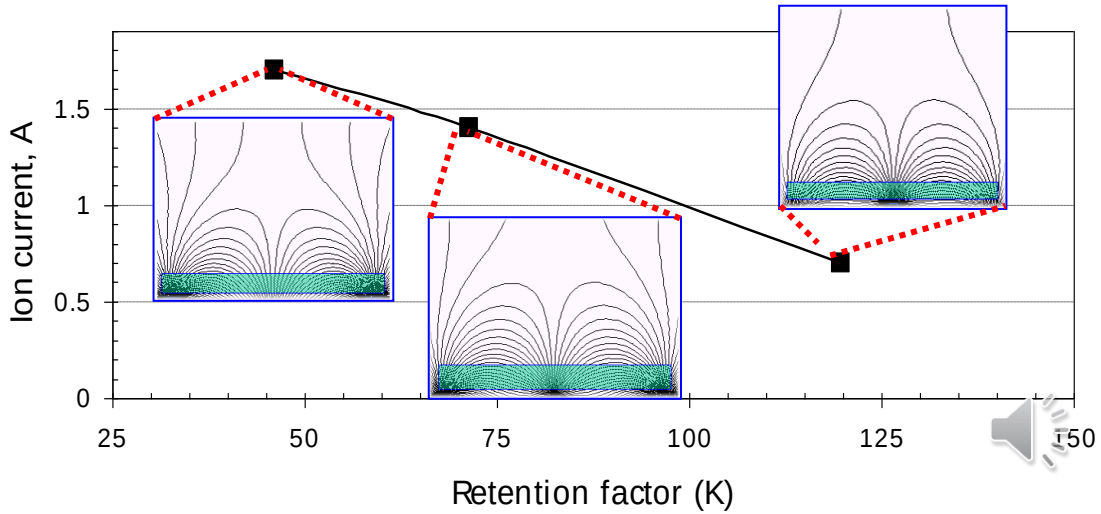

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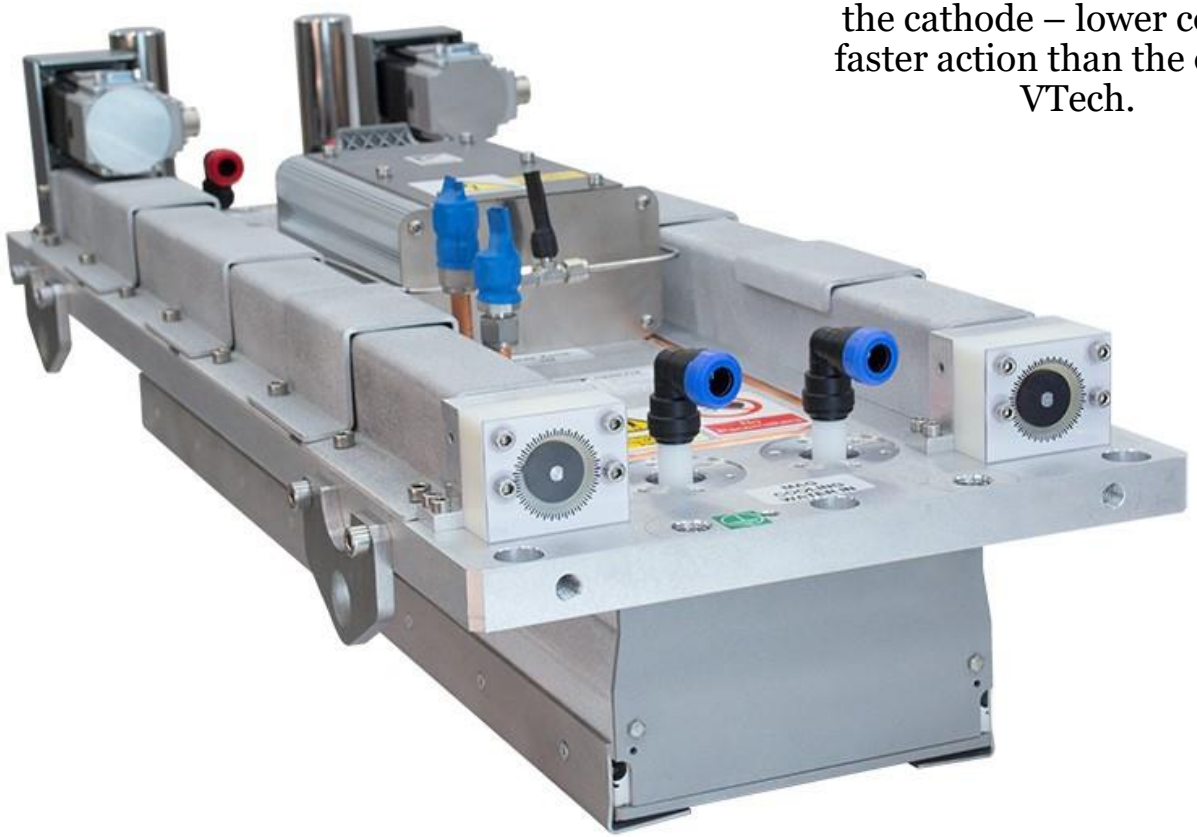
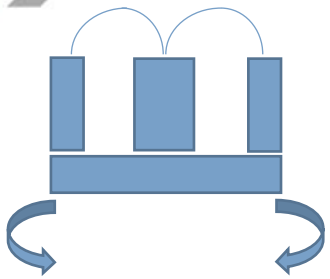
Vtech R varies field shape and balance/unbalance to optimize plasma properties during the coating process

vtech

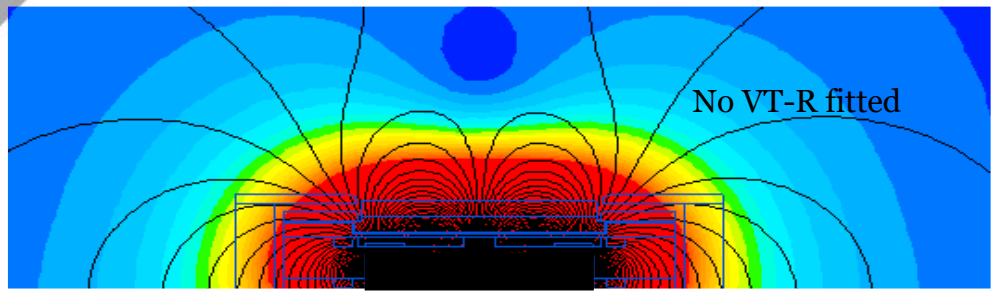


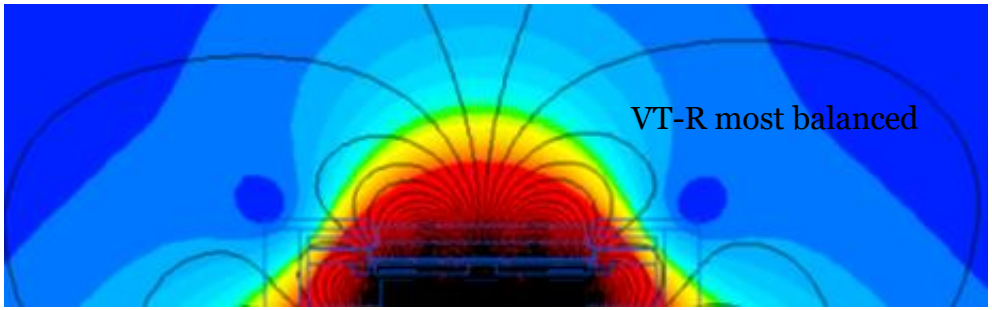
The VT-R changes the degree of balance and unbalance via rotation of two auxiliary magnetic poles on the rear of the cathode – lower cost and faster action than the original VTech.

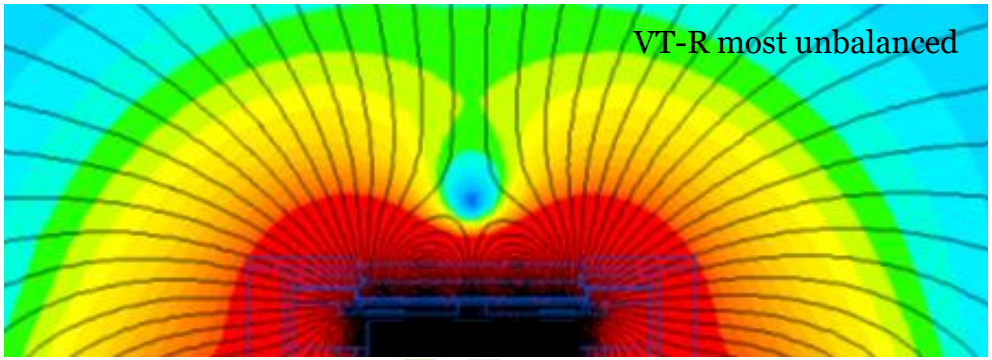


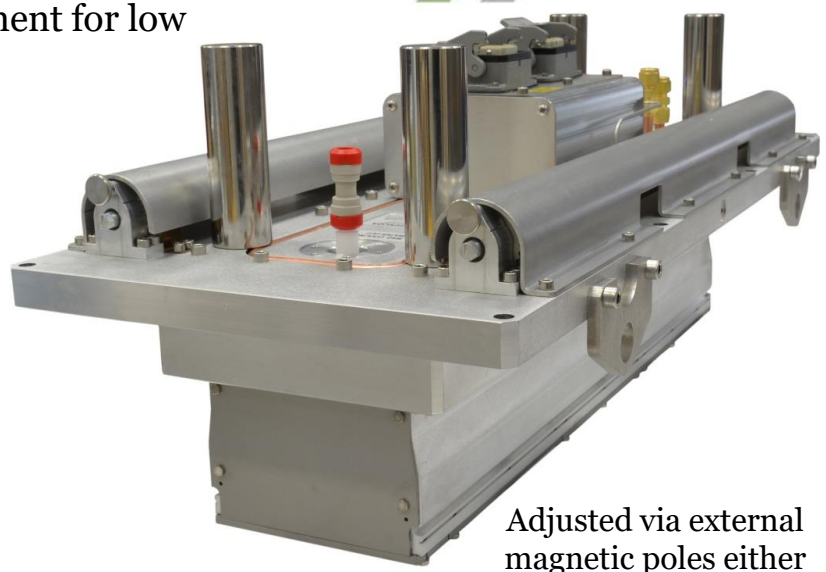
VT-R varies field shape and balance/unbalance to optimize plasma properties during the coating process

Ability to change the ion bombardment is beneficial for batch processes where high bombardment is needed for substrate pre-cleaning and hard coating, and lower bombardment for low friction layer optimisation







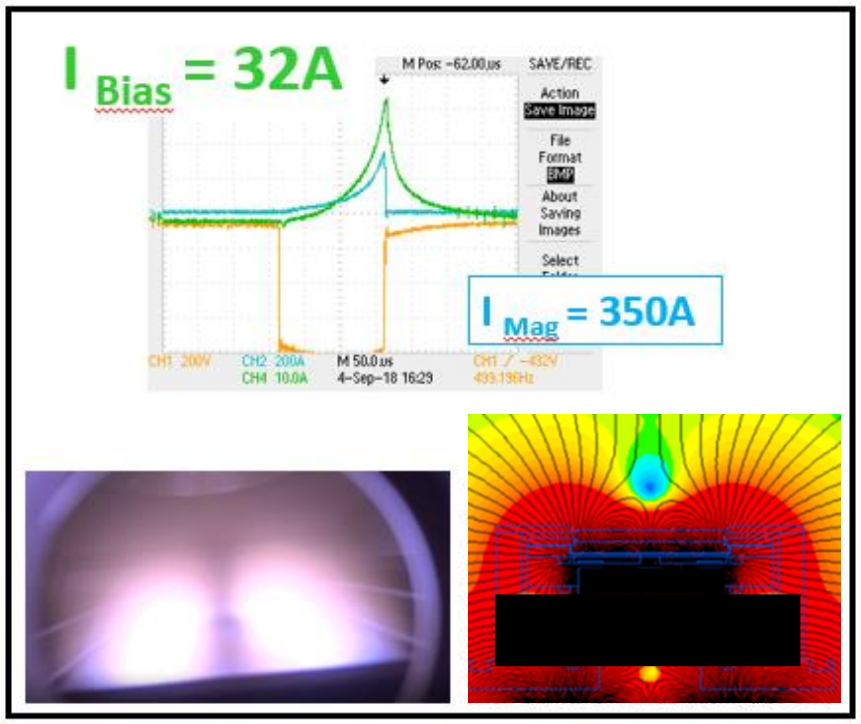


Adjusted via external magnetic poles either manually or motor adjusted.

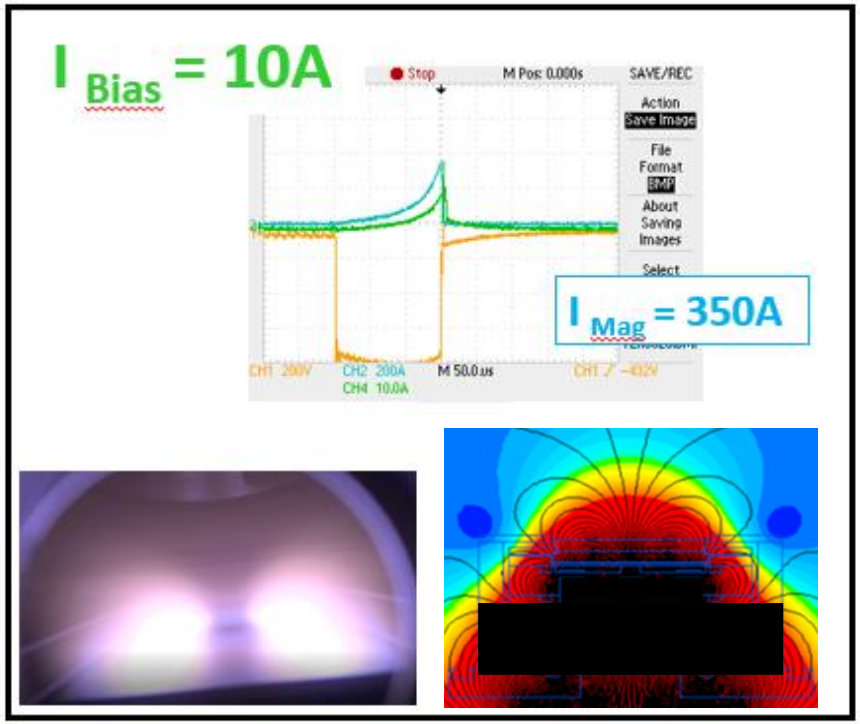
VT-R adjustment of ion current at the substrate via VT-R position
Single cathode substrate currents from 10 to 32 Amps

Tailoring coating ion assistance

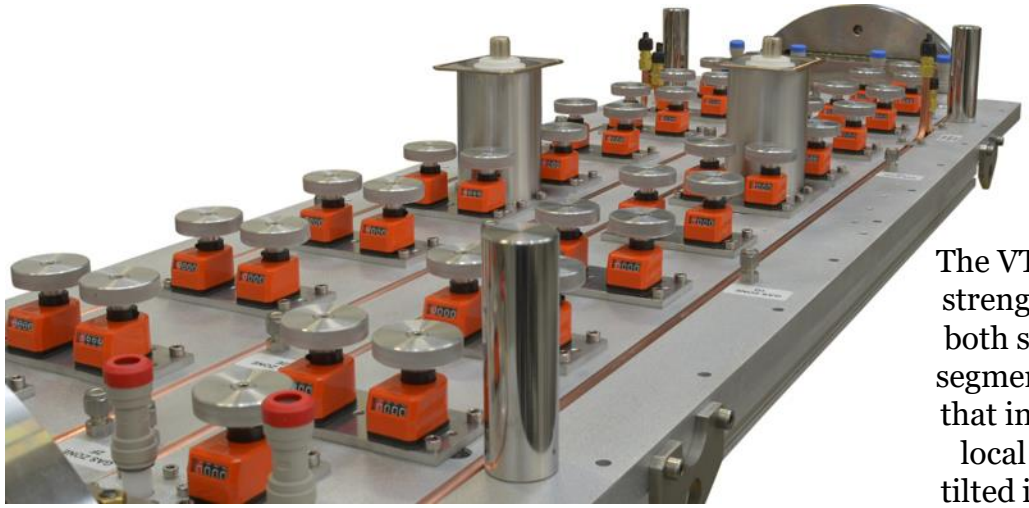
Strong UBM

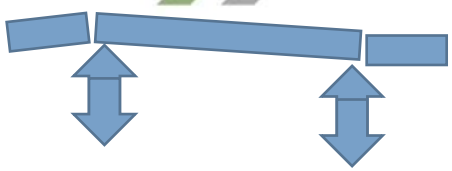


Balanced

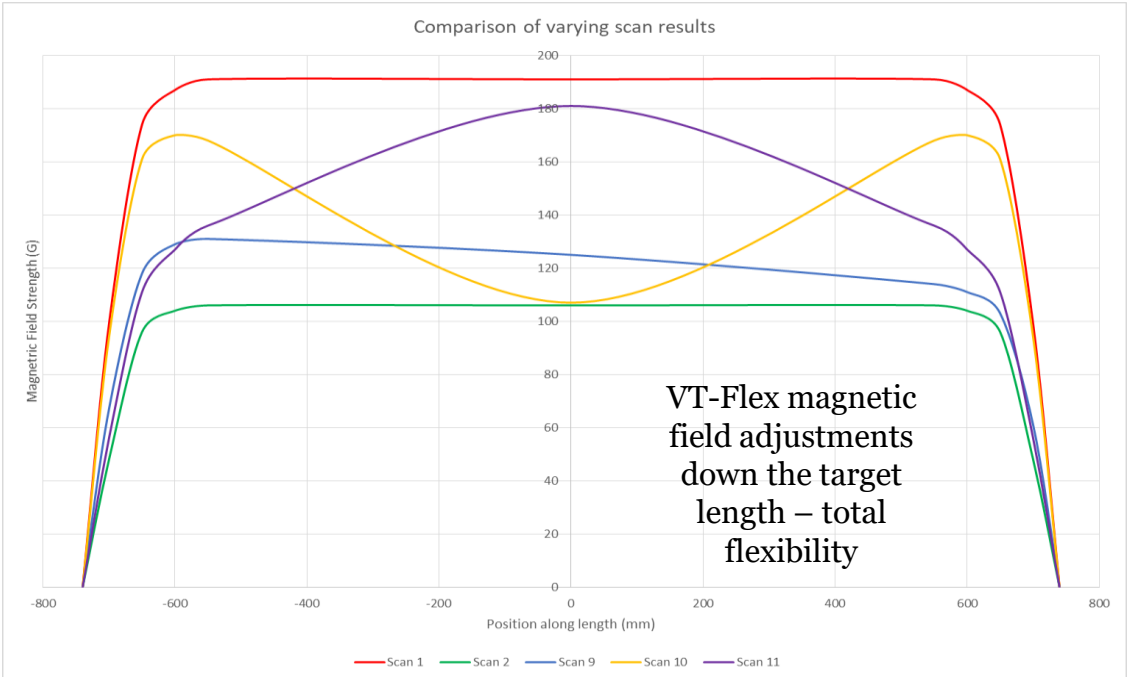


VT-Flex varies field strength locally on a magnetron target to adjust film uniformity





The VTF has the ability to tune the magnetic field strength independently on small segments down both sides of the plasma racetrack. The different segments are adjusted by a manual digital locator that increases or reduces the field strength in the local region. The segments can be retracted or tilted in either direction, which allows smooth or 'sharp' changes in field strength over the racetrack.

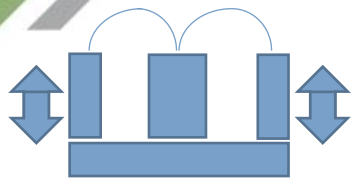


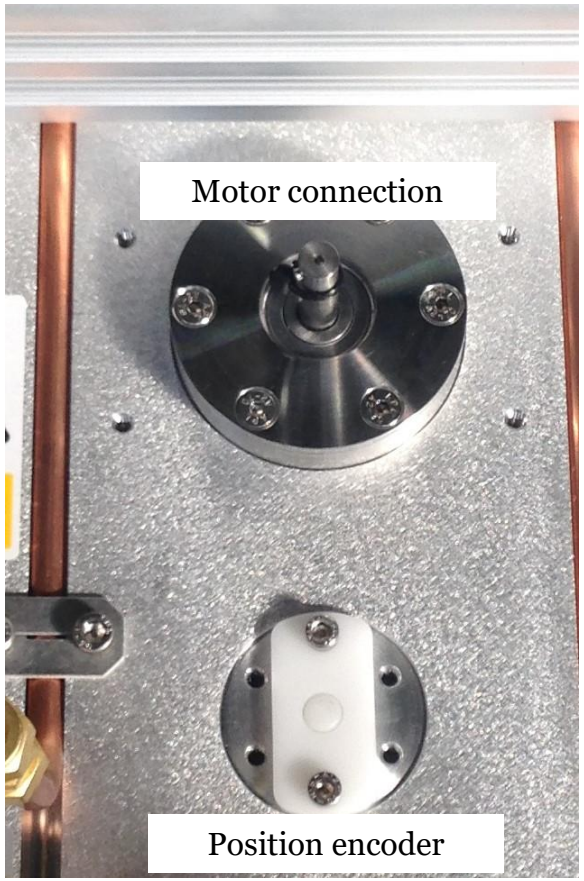
The total flexibility allows uniformities of less than 1% to be achieved with relative ease. Adjustments can also be made during the process to correct shifts in uniformity with time.

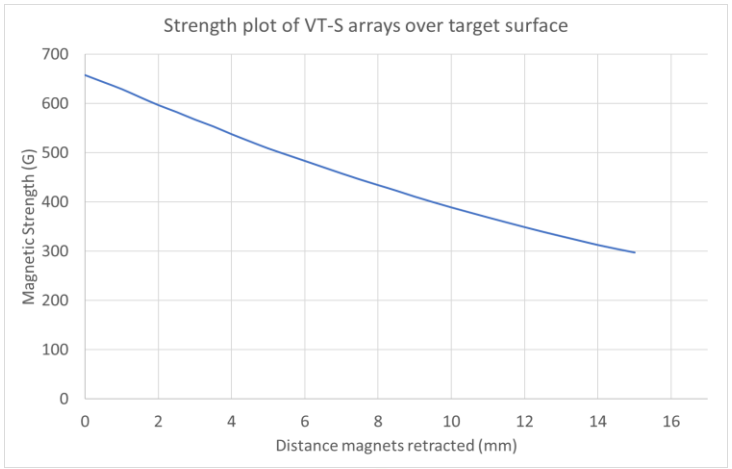
The VTF magnetrons are particularly useful where high uniformity from large area RF sputtering processes are required. The more common DC and MF type power modes can likewise be adjusted to higher uniformity demanded from certain products.

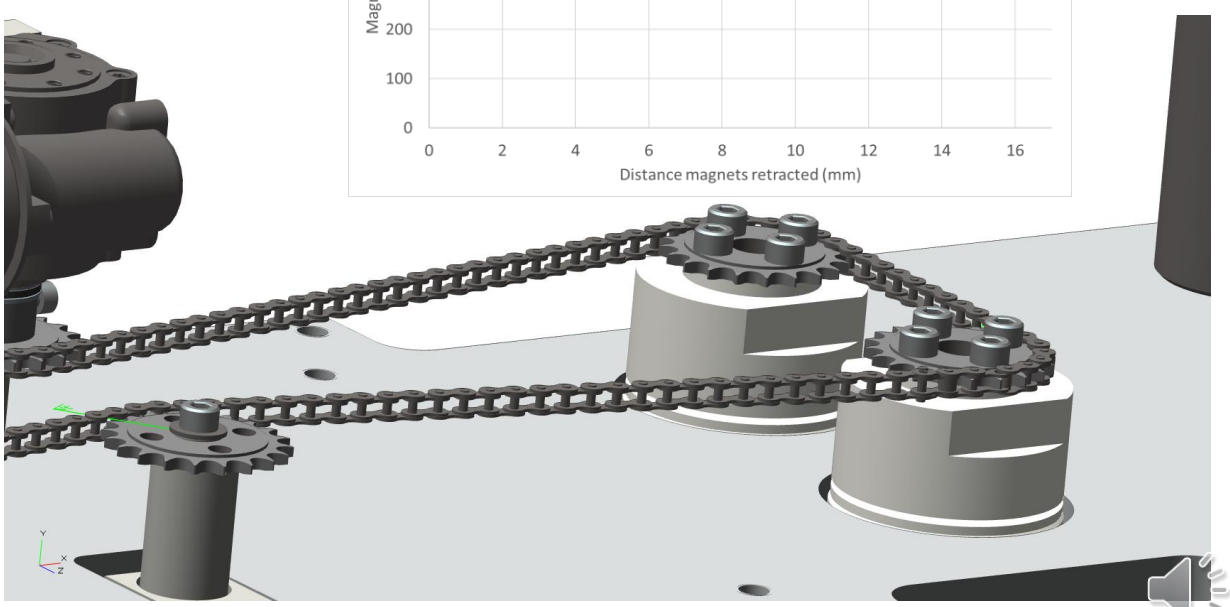
VT-S varies field strength on a magnetron target to maintain the same target voltage from start to finish, or allow a switch from PVD to CVD type processes

The VTS has the ability to adjust the magnetic field strength as the target erodes by retracting the whole magnetic array. This enables the target voltage to be set to a specific value which helps to reduce process drift and increase target use. For hybrid type PVD/CVD systems the magnets can be retracted to reduce stray fields in the chamber



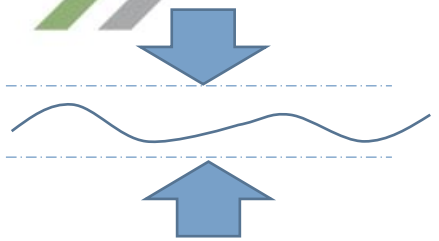


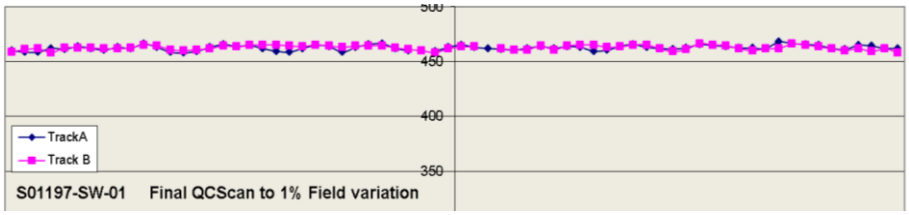




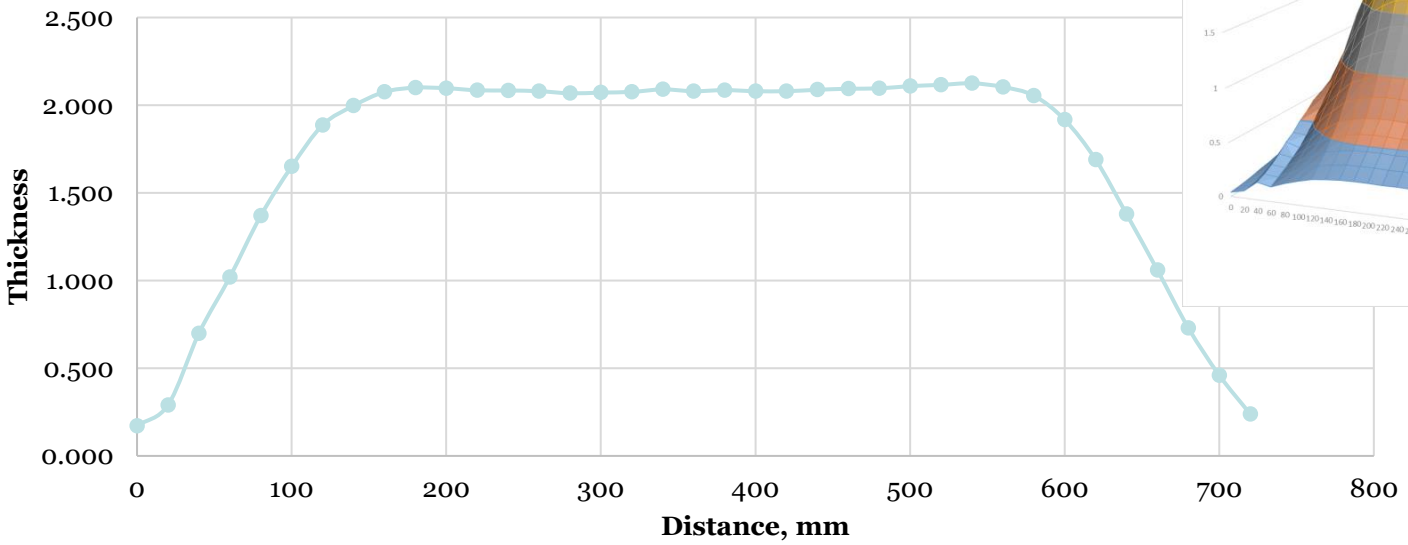
High Uniformity magnetic arrays are tuned to reduce the variation of the magnetic field to less than 2% over the linear part of the magnetron

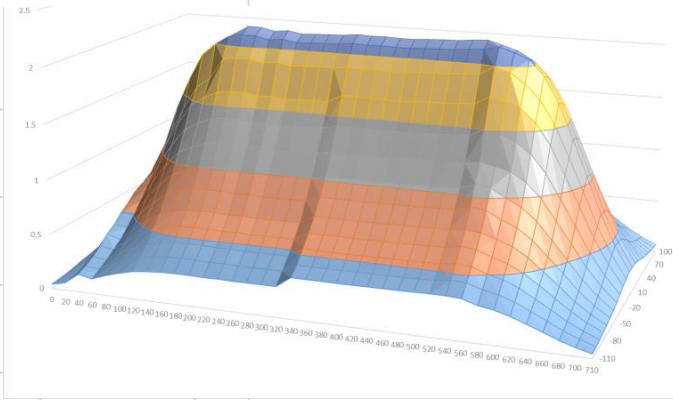
100% of Gencoa magnetic arrays are scanned after assembly into the magnetron source as a quality control check. Standard field variations are in the ±2-3% range. HU magnetic arrays reduce the field variation by scanning and selecting each magnet before array assembly to reduce the field variations from individual magnets – rejecting magnets outside a certain range.





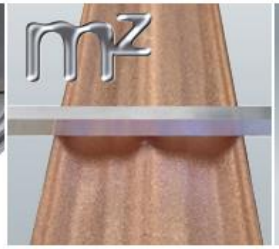
Coating Uniformity Plot: GRS75600PP magnetron for a 600mm long Cr target with 100mm target to substrate separation with DC power <±2% over 420mm

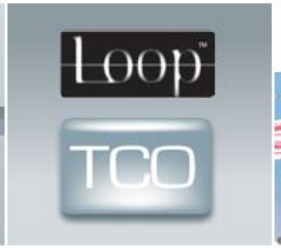




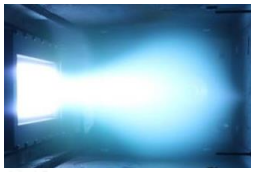
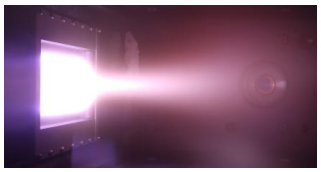
Lower magnetic field variations produce more uniform films

A wide range of optimized magnetic options available for all applications
Take you pick!





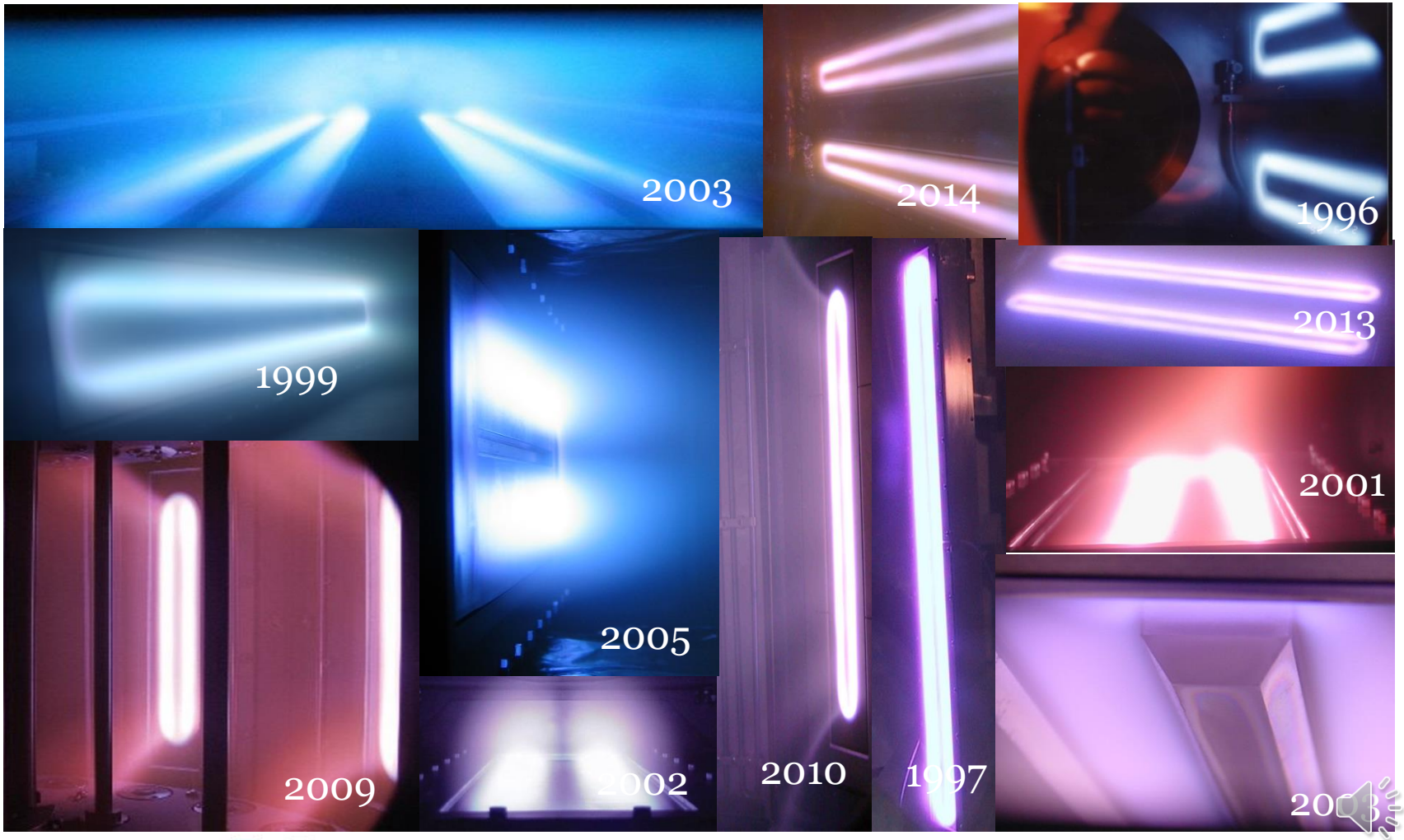
magnetics	features
SW	Standard optimised balanced 2 pole magnetics
PP	Standard optimised unbalanced 2 pole magnetics for ion assist
HY (SW or PP)	High yield multipole magnetics for >45% target use
VT	VTech constantly variable system between SW and PP
FFE	Full face erosion for clean targets and low defects
LP	LOOP design for ferro-magnetic target sputtering
HS	High strength magnetics for low pressure & low voltage sputtering
RF	Low strength magnetics for 13.52MHz sputtering


GENCOA

Gencoa planar magnetrons 26 years experience of enhanced plasma control & planar magnetron design and processes

A selection of 'historic' images from
the archive from our first 15 years of operation



Rectangular magnetrons in ‘all shapes and sizes’
- Thank you for your ‘virtual’ attention