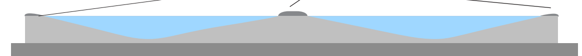
GENCOA Techinical Highlight, August 2003

# Magnetics - Your Options

*--Gone are days when a magnetron was just a magnetron.*

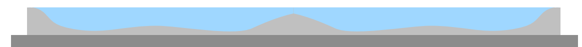
Now there is a comprehensive range of magnetic array types available that can allow you to optimize your film properties, and also reduce processing costs.
Hence, this months technical highlight explores the world of magnetic designs and can hopefully point you towards which type is optimum for your deposition process.

*Standard 2 pole Magnetics >25 % target use*

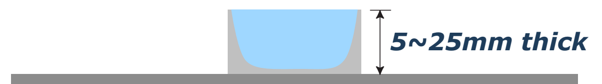



*High Yield Magnetics, >40% use*
***VERY SMALL** Re-deposition Area on Center*

*Full Face Erosion (FFE), >50% use*
***NO** Re-deposition Area on Center*



*LP/Mz/ITO Magnetrics*
***Thicker Magnetic / non-magnetic target***



## Metallizer (MZ™) type magnetics (patent pending)

This type of magnetic design is revolutionizing non-reactive deposition processes. Not only is target use very high 60-80%, but also very thick targets can be used, 1"- 1.5" common. This type of cathode offers huge savings in terms of material costs as well as machine downtime. The targets can be clamped, bonded or directly cooled, as in the same way as other cathode types.

## ITO type magnetics (patent pending)

The ITO cathode combines very strong magnetic fields over the target surface (>700 Gauss) with very high target use (50-80%). In addition features are included that reduces nodule formation on the target surface. The end result is that the operating voltage is very low (-200 V at 3w//cm2) resulting in low film resistivity.

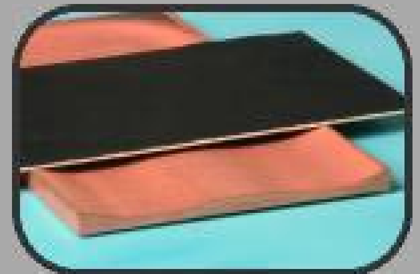
## LOOP™ (LP) type magnetics (patent pending)

As long as magnetrons have been used, sputtering of ferro-magnetic target materials has been a problem. A previous technology highlight illustrated the advantages of the LOOP type of source (Aug. 02). The LOOP source can now achieve very high target use (>50%) with any ferro-magnetic target material, combined with thick targets (6 mm thick pure Fe, 10-12mm Permalloy, 12-20mm Nickel). This normally results in target lifetime increases of 4 to 20 times. In addition, holes or slots are not required in the target material to enable efficient sputtering. One customer uses this type of cathode to sputter pure iron at 2 x 10 -4 mbar.

LOOP technical highlight: http://www.gencoa.com/eNews/aug/mail.html

## Full Face Erosion (FFE™) (patent pending)

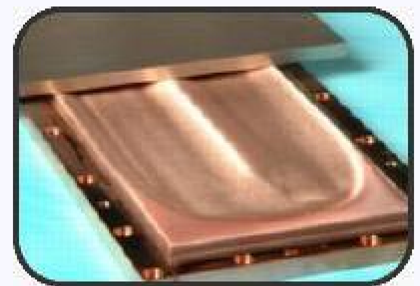
The FFE source is the king of the reactive processes. It has the ability to maintain the whole cathode surface in 'metallic' mode, hence avoiding re-deposit areas on the target surface. This is particularly important in reactive dielectric processes, since the target surface can now be maintained in the same electrical state. Circular forms of the FFE source, can combine the clean target surface with the usual methods to tune the erosion profile for uniformity enhancement for specific processes



## High Yield (HY) type magnetics

High Yield magnetics have been the employed for a long time to enhance target erosion (40-60%) compared to conventional 2 pole magnetic systems. Its also a workhorse in the reactive deposition of dielectrics, where MZ type magnetics are not recommended, and FFE type sources are too highly priced or not feasible. For the highest rates from reactive sputtering, use the **GENCOA** ***speed***flo gas control system.

***speed***flo : http://www.gencoa.com/acc/speedflo.html



## Vtech (VT) type magnetics

Vtech magnetics have the ability to vary both the degree of balance / unbalance, but also the magnetic field strength over the target surface. The variation can also be performed during the process if required. Its very useful in R&D or as an alternative to the **GENCOA** EFS system for processes that require variable plasma properties during the process time-frame.

EFS System : http://www.gencoa.com/acc/efs.html

## High uniformity (HU) & IQ type magnetics

For circular magnetron production cathodes, the ability to have high coating uniformity is all important for many applications. For system geometries where the target to substrate separation is very low (5-10cm range), although the deposition rate is optimum, the coating distribution will normally be non-uniform with standard magnetics unless a very large target is used.

The answer is to change the magnetic design such that the erosion of the target produces a highly uniform coating flux at the substrate. This HU type of cathode is design with specific process uniformity specifications in mind. For different system geometries, the magnetic profile is varied to produce the desired effect.

However, for very tight uniformity at close separations, the erosion of the target can lead to a gradual drift away from optimal layer distributions. In this case the IQ type of magnetic system can correct for this throughout the target life, and hence keep the products within specification.

## Its 'Unbalanced'

Most types of magnetic systems can be 'unbalanced'. In a crude form, this simply means strengthening the magnetic field of the outside pole to change the field shape over the target surface and promote release of electrons from the magnetic trap. There is a comprehensive explanation on our web site or CD, and the effect is commonly misunderstood.

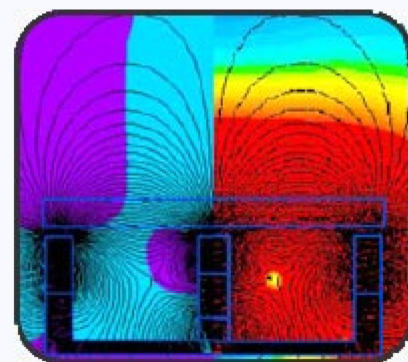
Unbalancing enhances the plasma energy imparted to the growing film. In many cases, this can be beneficial, although, conversely in some processes such as vacuum web coating, this effect can be damaging. But by knowing a specific process type we can optimize the degree of balance or unbalance on many different levels to produce the desired effect.

Unbalanced : http://www.gencoa.com/sim/bal_unbalance.html

## The Basics -2 Pole Magnetics

The traditional type of magnetic system uses just one inner and one outer pole to form the closed magnetic trap over the target surface. This type of magnetic system, whilst simple and low cost usually offers modest target usage of around 25%. Optimization of the design or shaping magnets cannot achieve much enhancement, since the magnetic field curves from one pole to the other, and hence the plasma is always highly non-uniform. The use of a magnetic shunt in the target backing plate can lead to improvements in field shape and target use, but will increase backing plate costs and reduce cooling efficiencies.

However, for low cost targets, where machine up-time is not of great importance, the simple two pole system can still be a good choice.



| Magnetic Type | | Target Use % | Application | Reactive Process |
|---|---|---|---|---|
| **SW** | - Balanced 2 Pole | 25-30 | Standard Source for general processing | ✓ |
| **PP** | - Unbalanced 2 Pole | 25-30 | Standard source for ion assited deposition | ✓✓ |
| **VT** | - Vtech Variable | 25-40 | Varies ion assist & magnetic strength | ✓✓ |
| **HY** | - High Yield | 40-60 | Enhanced target use source | ✓✓ |
| **LP** | - LOOP | 50-75 | Thick ferro-magnetic target material sputtering | ✓ |
| **MZ** | - Metallizer | 55-85 | Very thick metallic targets | ✓ |
| **FFE** | - Full Face Erosion | 50-70 | Clean target sputtering even in reactive mode | ✓✓✓ |
| **ITO** | - ITO Sputtering | 50-80 | High target use, low voltage, no nodules | ✓ |
| **AS** | - Double | See Above | Reactive dielectric deposition | ✓✓✓ |



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