opera
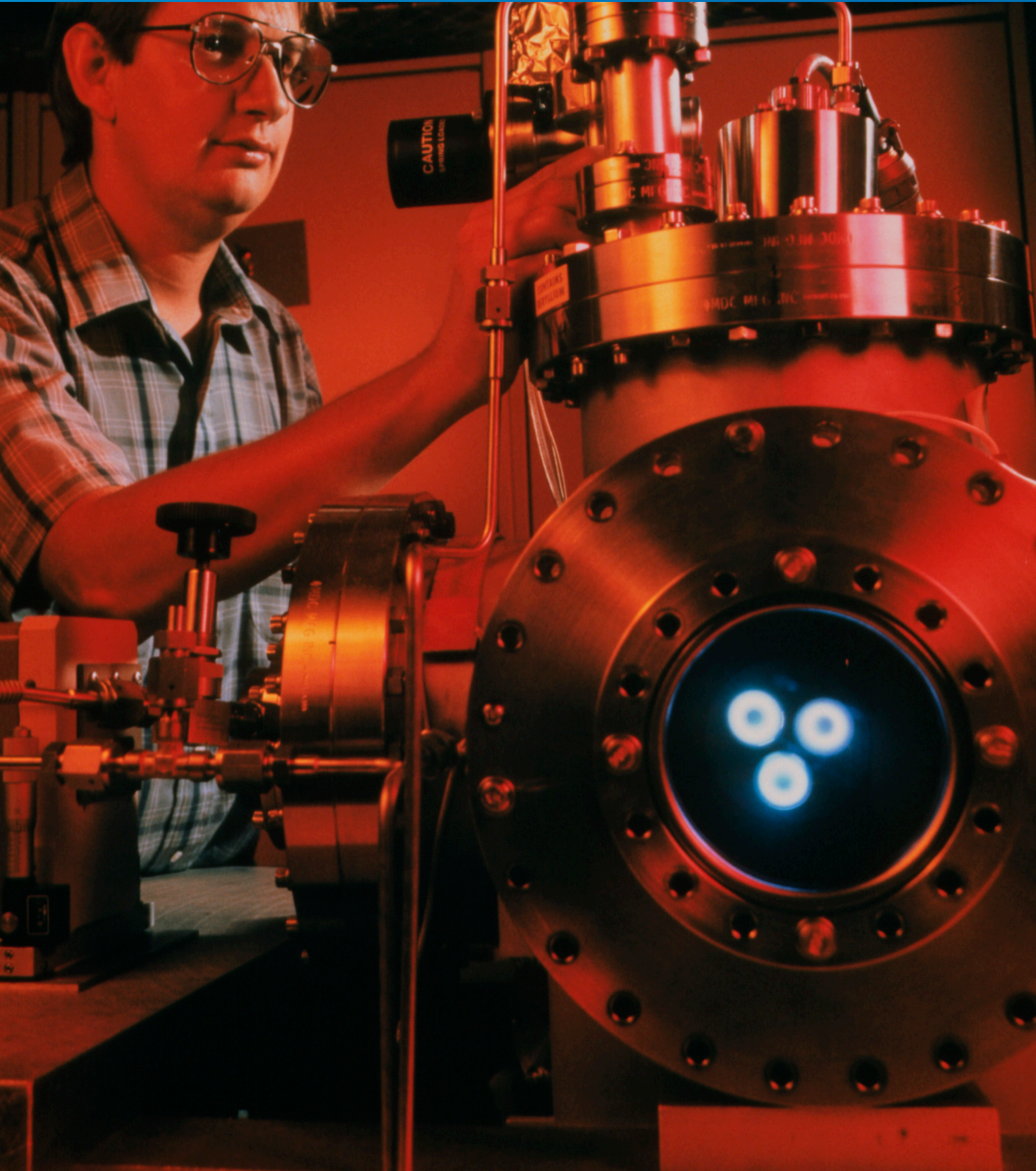simulation software

COBHAM

Magnetron Sputter Coater Design Software

The most important thing we build is trust

opera
simulation software

Magnetron Sputter Coater Design Software

Accelerate and optimize your design with the Opera simulation software

Opera combines accurate finite element analysis with detailed models for plasma, sputtering, and film deposition to provide the first practical tools for magnetron design and optimization.

For the first time, designers of magnetrons and sputter coaters have access to an effective design simulation tool. In many areas of engineering and product design such tools have proven ability for enhancing performance, reducing costs and development timescales and aiding innovation to provide a competitive edge.

Opera can be used to predict target erosion and to optimize utilization. It can accurately characterize the design of magnet systems, including multi-target coaters, and it can predict deposited film profiles and the deposition dynamics.
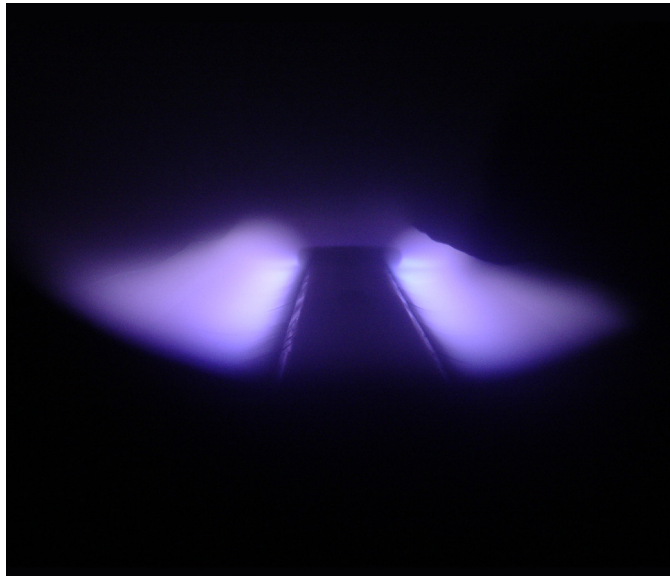

Magnetron plasma
Image courtesy of Colorado Concept Coatings LLC
Loveland, Colorado, USA
www.coloconcept.com

Sputter coating is widely used for the fabrication of thin films in a highly diverse range of applications - from decorative and low emissivity coatings on glass, through to deposition on circuits and engineering coating on products used in some of today's most demanding applications.

Of the many different types of sputter process, magnetron sputtering, (where the sputtered atoms are ejected from a target by ions produced in a magnetically confined plasma), has a number of advantages that have made it a popular choice. Among these are its high sputtering efficiency and increased sputter rates at low pressure - owing to the increased working gas ionization caused by the extended electron path length - and the flexibility to vary the properties of the plasma to control the characteristics of the deposited film.
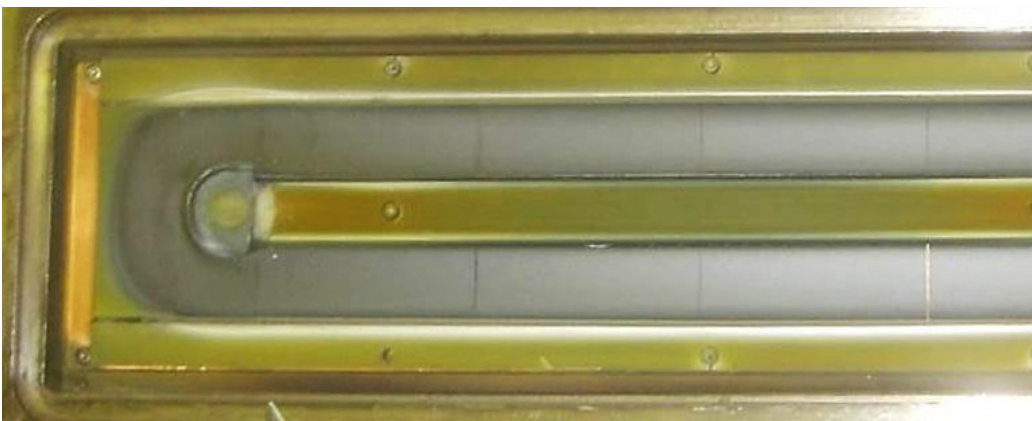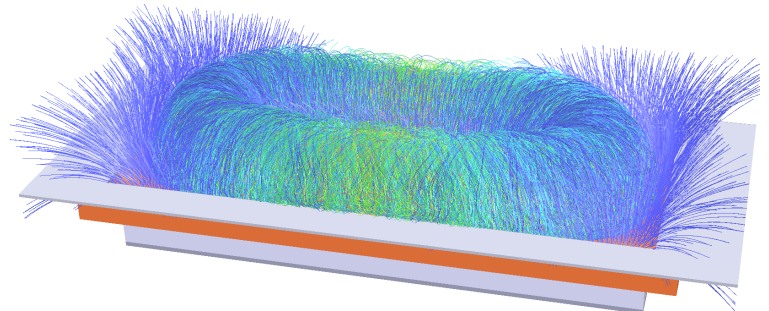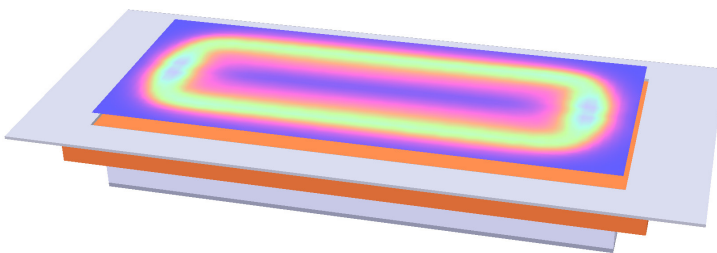

Magnetron cathode
Image courtesy of Colorado Concept Coatings LLC
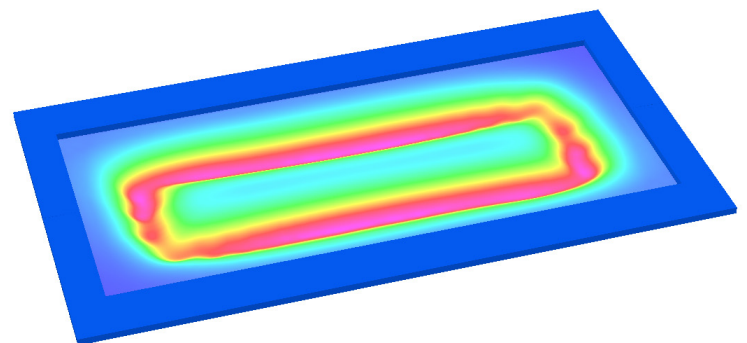Loveland, Colorado, USA
www.coloconcept.com
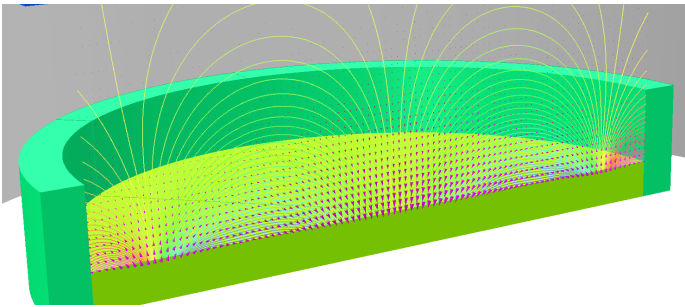
Magnetic flux density above circular magnetron

Electron cloud over target

Ion current density above target

Target erosion groove

While the purpose and scale of the process vary greatly between applications, there are some aspects of common importance, including optimizing the deposition profile and quality of film, maximizing utilization of sputter targets and minimizing process time. Achieving these can lead to improved quality end products and reduced cost, but success may require the use of innovative designs and operating regimes. Exploring the range of possible design options experimentally would be costly and time consuming - if practicle at all. But now, for the first time, this task can be performed effectively and efficiently by simulation.

Accurate virtual design and analysis software allows engineers to investigate a wide range of designs and operating regimes in a fraction of the time, and at a fraction of the cost, of an experimental programme, and enables the optimization of full life-cycle-costs from the outset. In many industries where virtual design is routinely used, the development process, end products and life-cycle costs have all improved dramatically.

Opera is the first high-fidelity simulation tool that uses the accuracy of Finite Element Analysis to model magnetron sputtering in the detail required to design practical systems. It uses advanced numerical methods to model the detailed physical interactions, such as ionization in the working gas, and the sputtering of atoms from the surface of the target.

The simulations are fast and accurate, and have been demonstrated to predict target utilization to a fraction of a percent.

opera
simulation software

Magnetron Sputter Coater Design Software

Accelerate and optimize your design with the Opera simulation software

DC and DC biased magnetron analysis and optimization

Opera provides an unrivalled capability to aid the design of magnetrons, and allows the engineer rapidly to evaluate and optimize such vital characteristics as:

- deposited film profile
- erosion groove profile
- target utilization

Although magnetron sputtering is well established as the process of choice for many coating applications, the physical processes involved are complex, involving the interaction of both charged and uncharged particles in volumes and on surfaces, in the presence of electric and magnetic fields. Many variables determine the performance of a sputter coater and the quality of the deposited films, but up to now, the engineer has had few efficient, modern design tools to assist in design and optimization.

Benefits of Opera

With Opera, you can include all significant physical processes in a simulation, and vary them at will in the virtual environment. Explore the design space more thoroughly while reducing the number of expensive physical prototypes in the design cycle - improve products at lower cost and with shorter time to market.

In addition to manual exploration of the design space, Opera includes a powerful optimizer that allows multi-variable, multi-objective optimization. Opera supports parameterized variables, and any combination of these may be used as variables in an optimization. The user has the complete freedom to define objectives - any quantity or combination of quantities that can be calculated in the Post-Processor can be used, from simple field values to more complex derived quantities, such as deposited film profile and target utilization.

Operation

The magnetron operates by confining the electrons close to the target, where they form spiral trajectories in the magnetic field and ionize the working gas. This extended interaction between the electrons and the gas gives the magnetron its key advantages of high ionization efficiency and sputter rates. The positive gas ions are then accelerated towards the target by the applied electric field, where they can eject atoms of the target material. If un-ionized, these atoms travel ballistically until they deposit on the substrate or the device walls; if ionized, they may be returned to the target by the electric field.

Opera allows the user to select the properties of the species present in the working gas, and to define the interactions to be used within the gas, and with the target and substrate surfaces. With these, Opera can include all significant physical processes.
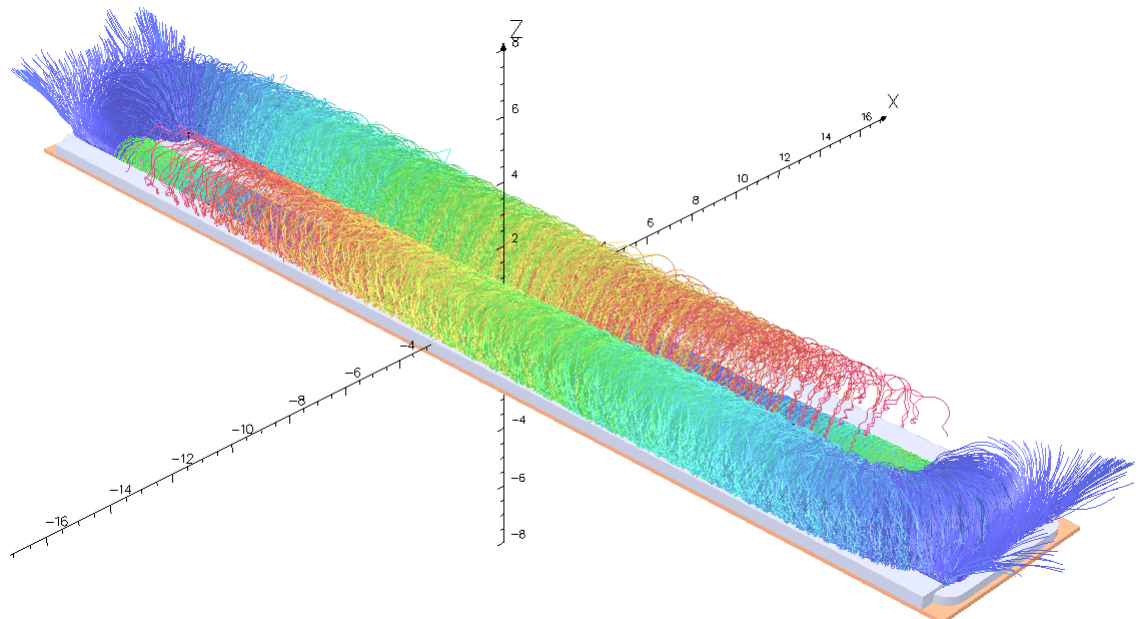
Electron tracks above rectangular magnetron
Image courtesy of Thin Film Consulting
Longmont, Colorado, USA
Email: thnflmcn@rmi.net

Magnetron Sputter Coater Design Software

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Accelerate and optimize your design with the Opera simulation software

Design flexibility

With the Opera software the user has complete freedom to specify the device. All types of magnetron can be designed, be they circular, rectangular, balanced or unbalanced varieties.

Opera's efficiency also allows the analysis of multi-target coaters, where the additional complication of stray fields may be investigated and their effects mitigated through subsequent iterations of simulated designs.

Assured accuracy

Opera is an established product that has been extensively validated for many applications, including those involving the interaction of charged particles with electric and magnetic fields. Its simulation of, for example, magnetic fields is recognized in the industry as one of the most accurate. The capability to accurately model magnetron sputter coaters and to predict, among other things, the target utilization has been validated against production devices.

Cobham Technical Services - Vector Fields Software has over 25 years' experience in the development of advanced software for charged particle devices. The scope of the Opera software suite has been driven by industry requirements to ensure its relevance to the market-place. The software is fast and accurate, and provides a cost-effective engineering solution to real-world design problems. Our customers include some of the largest and most advanced designers and manufacturers from many industries, as well as prestigious research laboratories and academic institutions.
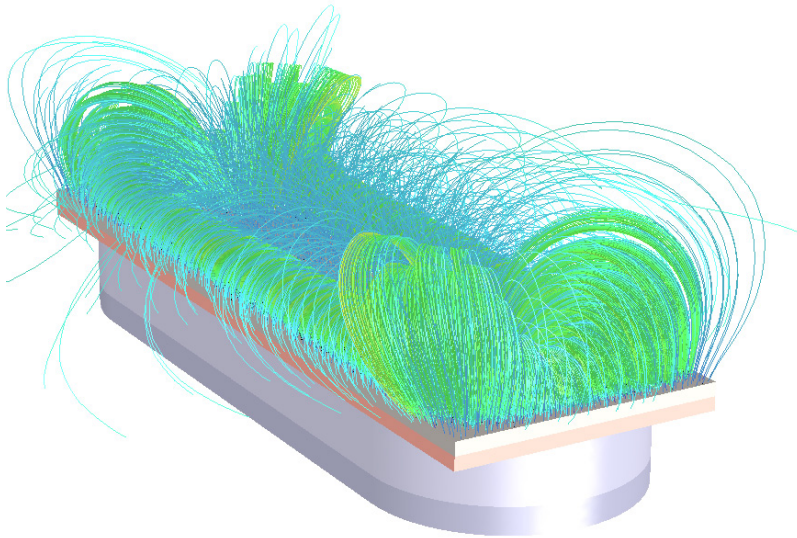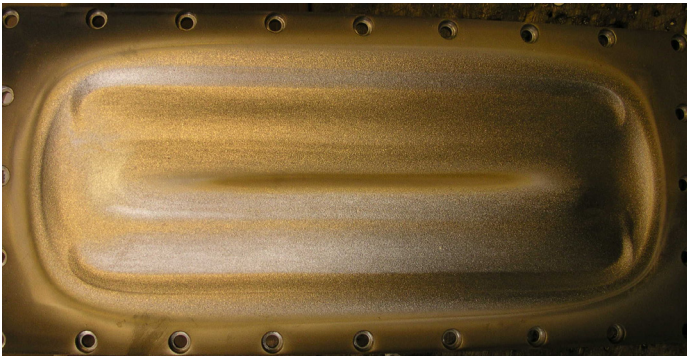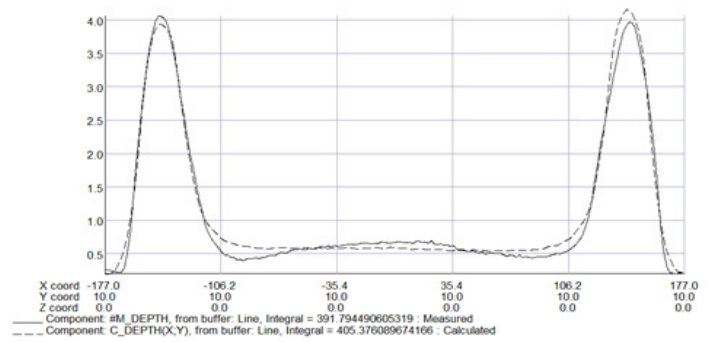

Rectangular magnetron
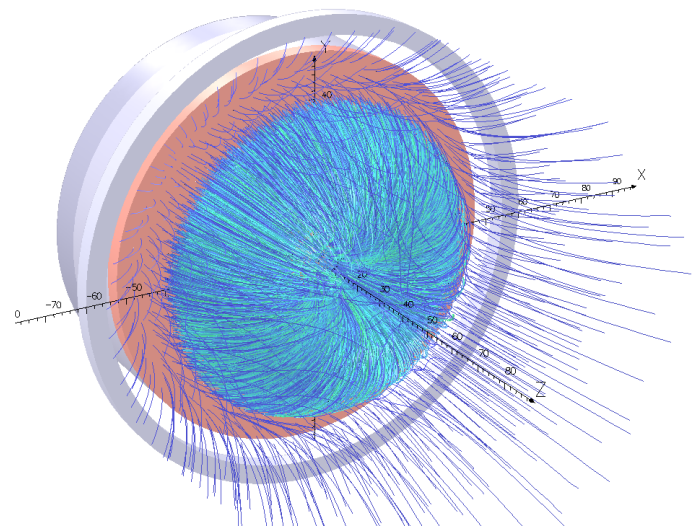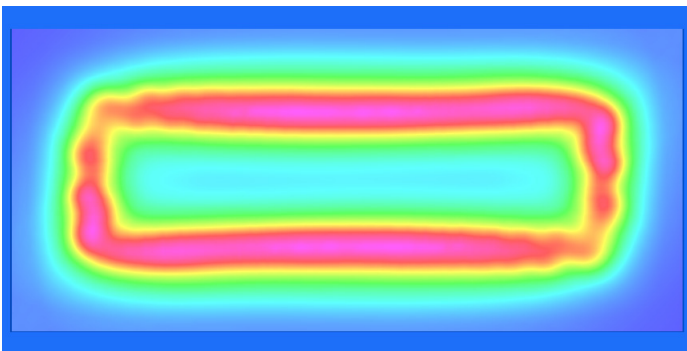

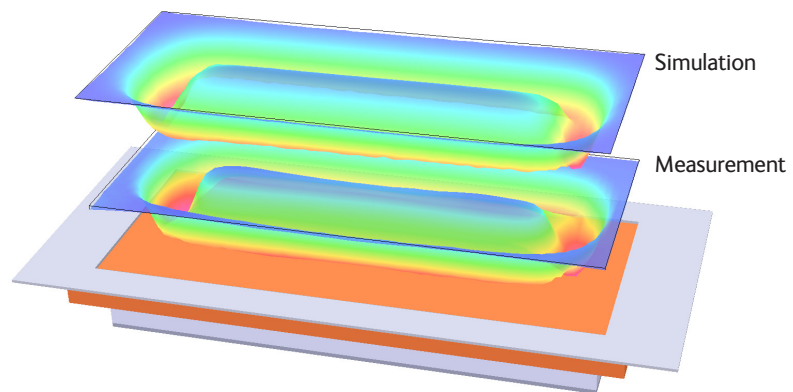Circular magnetron

Target erosion groove

Experimental magnetron eroded target
Image courtesy of Miba Coating Group, Teer Coatings Ltd Droitwich, UK
www.miba.com/Coatings-Sites-Teer_Coatings,130,en.html,
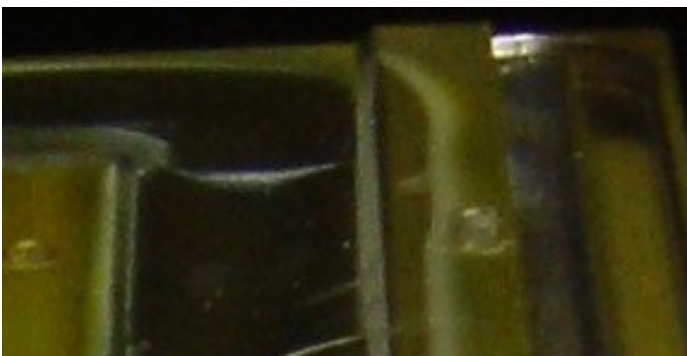www.teercoatings.co.uk

Comparison of erosion depth for experimental magnetron

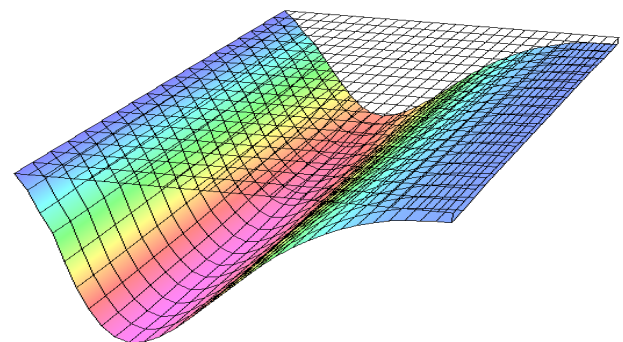Simulated target erosion showing corner asymmetry

Comparison of erosion profile for experimental magnetron

Magnetron target erosion groove
Image courtesy of Colorado Concept Coatings LLC
Loveland, Colorado, USA
www.coloconcept.com

Simulated erosion profile showing groove asymmetry

Designed for productivity

The Opera suite has been designed to assist users to become proficient and productive in the minimum time. It includes an easy to use 3D geometric modeller in which devices may be built, or imported from CAD, and prepared for simulation. The associated Post-Processor includes tools for immediate calculation and display of required outputs, such as the flux and trajectories of the various particle species in the simulation. Any additional derived quantities may be calculated as required.

Opera also includes a very powerful, plain language, scripting facility, which may be used to further enhance productivity. Scripts can be used to perform any of the operations of the Modeller and Post-Processor, or to issue operating system commands. With these, the user can produce customized tools to perform specific functions, or indeed, to automate the entire model creation, simulation and post-processing operation.

In Brief

Opera is a software suite for electromagnetic design that can model virtually any electromagnetic device. It includes a special solver for modelling the interaction of plasmas in electromagnetic fields, which can be used to simulate magnetron sputtering.

Opera enables rapid assessment of design variants with assured accuracy – simulations have been demonstrated to be comparable with measurements.

Opera's simulation features of particular relevance to magnetron designers include:

- Full 3D system evaluation and design using advanced finite element simulation
- Magnetic fields calculations during the simulation, including stray fields from adjacent magnetrons in a multi-magnetron coater environment
- Self-consistent charged particle modelling, including space charge and relativistic effects
- Rapid assessment of design variants
- Multi-variable, multi-objective optimization

With Opera, the designer can predict and optimize:

- Erosion groove profiles
- Target utilization
- Substrate coating profiles
- Coating dynamics - for characteristics and quality
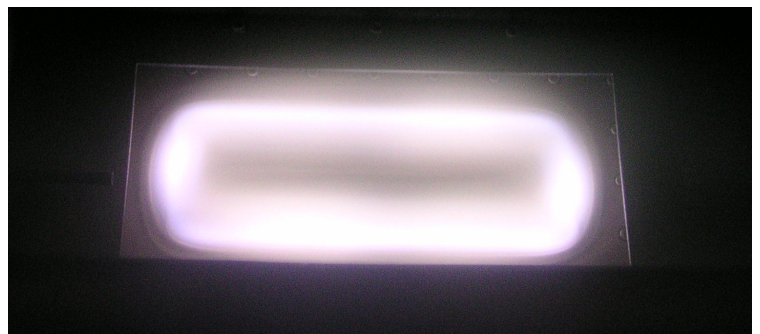
Left: magnetron coating system; Right: plasma in experimental magnetron
Image courtesy of Miba Coating Group, Teer Coatings Ltd Droitwich, UK
www.miba.com/Coatings-Sites-Teer_Coatings,130,en.html,
www.teercoatings.co.uk

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Analysis Tools

- Magneto and electrostatic analysis
- Multi-species particle emission
- Particle tracking
- Thermal analysis
- Coupled physics
- 3d solid modelling
- CAD import
- Parameterization and scripting
- Multi-objective optimization

Design Capabilities

- DC magnetron design and optimization
- Magnet array design
- Single and multi-target coaters
- Balanced and unbalanced configurations
- Target erosion profile and utilization
- Deposition rate
- Deposition profile
- Temperature rise/thermal loading

Customer Support

We provide support to Opera users from our offices in the UK and the USA, and through a worldwide network of local distributors.

Our support engineers have an extensive knowledge of plasma devices and are available to assist both existing and prospective customers with their design requirements. In addition, regular training courses are held, which provide "hands-on" training in the use of Opera for designing these types of systems. Whatever your application and wherever you are located, you can be sure of our attention and support.

The use of accurate finite element simulation is now a vital part of the development process; companies who use these techniques are able to differentiate themselves with optimal design performance, short development timescales and cost-effective manufacture. Cobham has over 25 years' experience working with foremost system manufacturers to produce some of the most accurate and functionally advanced software for simulation of electromagnetics and plasma devices.

For more information about Opera, including numerical simulation of plasma devices, please refer to the relevant technical data sheets and application notes, which can be obtained from our website, operaFEA.com. This contains a range of information, including technical publications, videos and webinars of general interest to engineers involved in electromagnetics and plasma device design.

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