Anti-reflection coating

OW Technical Editor **Tony Jarratt**

The supply of coated lenses has now become an everyday occurrence, with the process now being applied to more and more spectacle lenses – particularly when produced from high index material. Before discussing coatings further, it should be noted that the word 'coatings' now covers a far wider range of applications that was previously the case.

In the ophthalmic context, 'coatings' originally meant only anti-reflection coatings. However, we now have to consider: Hard coatings, anti-reflection coatings, tinted coatings (mirror coatings) and hydrophobic coatings.

Sometimes these are supplied individually, but they can be applied to the lens surface in successive layers, or even in one continuous process.

This type of 'combined coating' is now most evident when we are talking about hard and AR coating. Many coatings now combine the properties of a hard and anti-reflection coating, sometimes with the added advantage of a hydrophobic or clean coat final layer – commonly known as a 'top coat'.

AR coating and reflections

AR-coating on lenses is used for two principal reasons – to improve the optical performance and/or to improve the cosmetic appearance. These are to some extent the same thing – if we improve the optical performance of the lens, we are quite likely to improve its appearance. The prescriber /dispenser will probably consider the optical aspects of applying such a coating whilst the end user – the wearer – will see the final effect from a cosmetic point of view – a reduction in surface reflections which will enhance the cosmetic acceptability of the lenses, thus making them more attractive when being worn.

The wearer will not necessarily realise that the improved appearance also means that there will be fewer ghost reflections and an increase in transmitted light, with the resultant improvement in contrast and visual acuity. Of course, if the dispenser has done a good job, then the user will have also been made aware of these added benefits.

Formation of reflections

If we consider the lens and eye in combination, we can see that they have three external surfaces between them – front and back surfaces of the lens and the surface of the cornea. Using this model, it can be shown that four different types of reflections are formed, depending on conditions. These reflections are:

1. **Frontal reflections** – some of the light incident on the front surface is reflected back towards an observer – therefore degrading the cosmetic appearance of the lens(es). An example of this type of reflection is that produced when a spectacle wearer is in front of a television camera – the very bright studio lights are reflected from the spectacle lenses, thus obscuring the wearer's eyes behind the lenses.

2. **Backward reflections** – some of the light from behind the wearer is reflected from the back lens surface onto the eye. This causes disturbing reflections, particularly in dusk conditions or when driving at night, e.g., where ambient light levels are low and there is a bright light source such as the headlights from a car behind the driver.

3. **Internal reflections** – light is reflected between the two lens surfaces, internally. This can be caused by light from any direction. It is the cause of the multiple 'rings' seen around the edge of some high minus lenses.

4. **Corneal reflections** – caused by light being reflected from the surface of the cornea and then interacting with the lens surfaces.

The last three reflections cause ghost images and can lead to lowering of visual acuity, due to blurring and reduced contrast. They therefore diminish the optical performance of the lens. Reflection number one would appear to be only a cosmetic problem, as it results in difficulty for an observer due to the frontal reflections. However, it does reduce the amount of transmitted light, which in turn reduces the efficiency of the lens.

Surface reflections

The ability to reduce the loss of light, caused by these reflections, has become more and more important as the dispensing of high index lenses has shown a continued growth. This is because the surface reflections increase along with an increase of the index of the material.

This increase in surface reflectivity is solely a function of the material index and cannot be affected by material design or composition, as can the *V* value (or Abbé number) and material density / weight. The amount of light reflected from a lens surface is given by the formula:

$$sr = \left[\frac{n' - n}{n' + n}\right]^2$$

where

sr = surface reflectance
n' = refractive index of lens material
n = refractive index of the substance in which the lens is immersed – for spectacles this is air and $n = 1$

from this formula, it can be seen that as the material index rises, i.e. [*n'*] becomes larger, [*sr*] will also increase. This means that the amount of surface reflection will rise.

Using the above formula and some of the standard indices, which are widely available, we can calculate values for *sr* and these can be conveniently converted into percentage loss at each surface:

n	*n' –n*	*n' +n*	*sr*	= per cent loss
1.498	0.498	2.498	0.0397	3.974
1.523	0.523	2.523	0.0430	4.297
1.604	0.604	2.604	0.0538	5.380
1.660	0.660	2.660	0.0616	6.156
1.706	0.706	2.706	0.0681	6.807
1.800	0.800	2.800	0.0816	8.163
1.803	0.803	2.803	0.0821	8.207
1.900	0.900	2.900	0.0963	9.631

As we have to consider a lens there will be light lost at both surfaces, but this is not just double the figure lost at the first surface. If we take the incident light at the first surface as 100 per cent and considering the light loss for a glass of n=1.800, we have the following:

Incident light	**100.000**
Per cent loss at 1st surface (8.163 per cent of 100)	–8.163
light transmitted after first surface	91.837
Per cent loss at 2nd surface (8.163 per cent of 91.837)	–7.497
Light transmitted through lens	**84.340**

or a total loss of 15.66 per cent – assuming a 'clear' lens material and reasonably thin lens, where there is little or no light loss due to absorption by the material itself. Extra thick lenses, or those with a tint, will exhibit a lower overall light transmittance.

Table 1: Losses due to reflection for a range of materials

Material	Index	Light loss 1st surface	Light loss 2nd surface	Total per cent loss	Per cent of initial light transmitted through lens
CR39	1.498	3.97	3.82	7.79	92.21
Spectacle Crown	1.523	4.30	4.11	8.41	91.59
Polycarbonate	1.568	4.89	4.65	9.55	90.45
Mid Index Crown	1.604	5.33	5.04	10.37	89.63
High Index Plastic	1.660	6.16	5.78	11.93	88.07
Dense Flint Glass	1.706	6.81	6.34	13.15	86.85
Dense Flint Glass	1.800	8.16	7.50	15.66	84.34
Dense Flint Glass	1.803	8.21	7.53	15.74	84.26
Dense Flint Glass	1.900	9.63	8.70	18.34	81.66

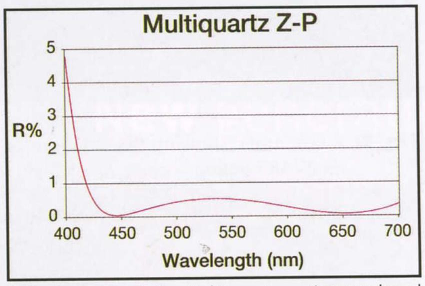
It is normally accepted that the light loss for CR39 and spectacle crown does not cause any problem for the wearer – although ghost images can cause difficulty in certain conditions. However, we can see, from the table, that the reduction in transmitted light for the higher index materials does become increasingly large.

A loss of much over 10 per cent becomes questionable and over 12 or 13 per cent, would be considered unacceptable to most users. In fact, the higher figures shown in the table – 15 to 18 per cent reductions in transmitted light, are equivalent to the sorts of levels found in cosmetic tints applied to many lenses these days.

In addition to this high light loss, the appearance of reflections for the lens surfaces is disturbing to the wearer due to the higher level of reflectance, which means that ghost images etc. are more noticeable.

For these reasons, it is advisable to provide anti-reflection coating for all materials with an index over, say, 1.66 and they are a must for 1.8 and above. It is, of course, now normal for all major manufacturers to supply their high index and very high index lenses with an AR-coating as standard.

See graph for the reflectance curve of a high quality multi-AR coating (courtesy of Satisloh). This shows the reduction of reflections to an average of about 99.5 per cent.



Reflectance graph for Multiquartz coating produced by Satisloh showing 99.5 per cent average

Why coatings work

Reflections are caused by some of the incident light being reflected by the surfaces of the lens material, theoretically when the light does not strike the lens surface at right angles. This, as we saw above, causes several types of reflection.

If we interpose a transparent layer between the light striking the lens surface and that surface, we cause two reflections – the first from the surface of the layer and the second from the surface of the lens itself. If the thickness of the layer is made ¼ of a wavelength thick, the two reflected rays will be 'out of phase', by ½ wavelength. This is because the ray, which is reflected from the lens surface, has to travel through the layer and then back again, – i.e., twice the distance.

As the two rays are out of phase by a ½ wavelength, they will be mutually de-

Fig. 1: Two images showing a lens without (L) and with high super-hydrophobic coating (R) – *courtesy of Leybold*

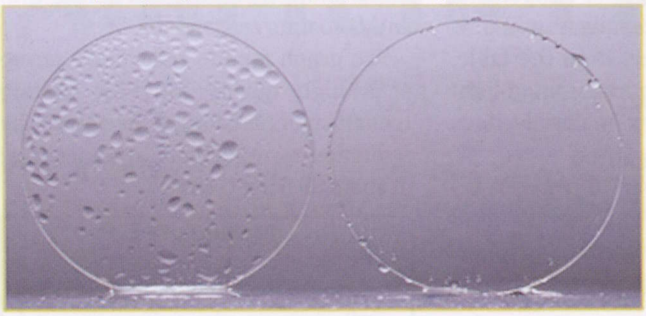
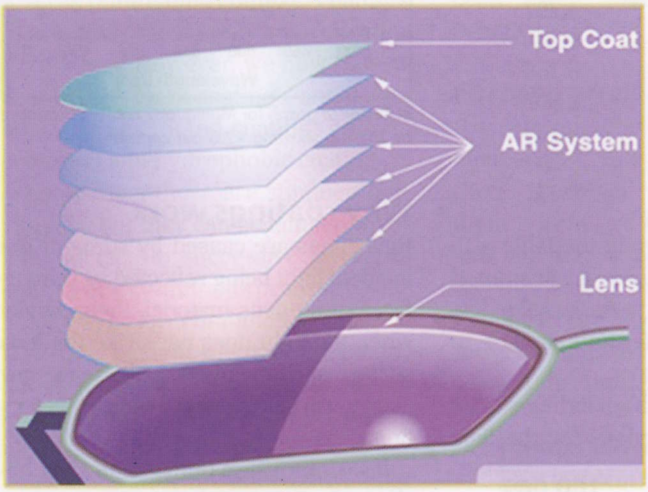


Fig. 2: A schematic showing the structure of a typical high quality multi-AR coating – *courtesy of Leybold*



structive, i.e., they will eliminate each other, thus destroying the reflection.

As this mutual destruction takes place for one wavelength, the resulting reduction in reflections will not be complete. To overcome this problem, multi-layer AR coatings were introduced. These are far more effective, eliminating reflections over a much wider range of the spectrum. Final transmissions of up to about 99.5 per cent can be achieved.

See Figures 1 and 2 for images showing the effect of a good hydrophobic top-coat (1) and a schematic (2) showing a typical structure of a multi-layer coating – both courtesy of Leybold.

Manufacture

AR coatings, initially introduced only for high index glass materials, can now be supplied to virtually all ophthalmic lens materials, both glass and plastic. Traditionally the method of applying an AR coating has been by vacuum deposition and this technique has been used since its introduction by Zeiss in the 1930's – initially for optical systems, but subsequently (in the mid 1950's) for high index glass spectacle lenses.

However, there are now several variations on the original concept and the process can now be classified into the following methods. Most depend on the deposition on the lens surface of one or more alternating low and high refractive index layers of metal oxides.

[Note: the following descriptions give a general idea of the coating processes involved – they are not intended to be definitive – but only to act as a guide. Different variations of the processes are available – according to the particular requirements of the end user and the equipment available].

1. The original evaporation process:
Under this process, the lenses are placed in a chamber, which is capable of having the air evacuated to a very low pressure, thus producing a high vacuum. The chamber and the material to be used for the coating layer(s) are then heated – in the case of the coating chemicals, to a very high temperature.

This causes the chemicals to vaporise into a gaseous state. At the same time the lens surface is charged electrically, with respect to the remainder of the chamber. As the chamber is at a high vacuum, the gas molecules can travel directly from the heating element onto the lens surface, being attracted to this by the electrically charged differential between the lens and chamber.

To achieve these results, the earlier coating machines had to achieve a very high temperature, in order to evaporate the chemicals. This temperature would have damaged the plastics lens materials. However a new method was introduced which overcame this problem.

2. 2nd variation – using an electron beam gun:
These machines use a different method of evaporation. This is achieved by means of an electron beam gun, which fires a charged beam at the chemicals, achieving evaporation at a much lower temperature. This, coupled with the use of sophisticated microprocessor control of pressure, temperature and evaporation rate, has enabled manufacturers to produce machines which can deposit single and multi-layer coatings on virtually any lens material.

3. Magnetron sputtering
A third method of deposition is that of sputtering. In this process the material to be deposited (in the form of a fixed target within the vacuum coating chamber) is eroded by energised particles (normally positive ions) striking its surface – the rate at which this takes place being controlled by magnetic fields produced by magnetrons within the chamber. The resultant material ejected from the target, being deposited on the lens surfaces. (See end note 1).

Again, this method can be carried out at a much lower temperature, making the process suitable for all types of lens substrate.

4. Plasma polymerisation
Polymerisation is basically a chemical reaction where molecules (the monomers) are joined together to form the polymer, which then consists of large repeated chains of molecules.

Plasma polymerisation is a process where the chemicals are evaporated into a gaseous state (gas-phase monomers) within the vacuum chamber and are then assisted by the plasma into forming a polymer, which is deposited onto the substrate surface. This type of process is used, for example, to deposit the 'hydrophobic' coatings as the top layer of an AR coated lens.

5. Spin coating
This is the latest method to come to the market and is based on spin hardcoat techniques, using sol-gel technology. For a full explanation of the technology

involved see the article 'Low cost, compact AR coating machines for Rx laboratories' by Dr Peter Wilkinson in the March 2010 issue of OPTICAL WORLD, pp 12 to 14.

The main benefit of the method, apart from cost considerations, is said to the better match of the AR coating to the lens substrate. Polymers such as CR39 and polycarbonate, are malleable, i.e., they are flexible when placed under stress. Their dimensions can change significantly with temperature. On the other hand normal AR coatings using 'ceramics' such as silica, are brittle and easily craze under stress. They have little ability to flex, or change dimensions, with temperature. This means that the lens substrate may alter its shape with change in temperature, whilst the coating may not, thus resulting in crazing.

The coatings applied by the sol-gel process (see Chemat review in this article) are made up of a super hydrophobic polymer matrix embedded with nano-size ceramic particles. The polymer matrix has the ability to flex, matching thermal expansion and providing a chemical bonding and hydrophobicity, whilst the ceramic particles give the refractive index required to produce an AR or mirror coating.

Other considerations

The following two pieces of information are supplied courtesy of Satisloh and are taken from their coating process guide.

Top coating options: Ease-of-care is perhaps the most important feature of AR coated lenses to the average customer. A naked AR coating is by nature rough and hydrophilic, meaning it will attract dirt and water and will be difficult to clean. Making the problem even worse is the fact that an AR coated lens will show the dirt more than a non-AR coated lens.

Fortunately, coating technology has advanced rapidly and there are a number of new chemical options available to make AR coating easier to clean than ever before. These chemicals are applied on top of AR (hence the term 'top coating') inside of a vacuum chamber.

Hydrophobic *vs* Oleophobic: When the first easy care top coatings were introduced back in the late 1980's, they were loosely referred to as hydrophobic top coatings. Hydrophobic literally means 'water-repellent' and the quality of a hydrophobic top coating has traditionally been measured by the contact angle of a drop of water on a lens. A higher contact angle (roundness of the drop of water) equates to a better hydrophobicity. Traditional hydrophobics typically have contact angles in the range of 97-104 degrees.

The newest generation of hydrophobic top coatings, referred to as super hydrophobics, have a contact angle in the range of 106-112 degrees. More important than its ability to repel water is a super hydrophobic's ability to repel oil and fingerprints, referred to as oleophobicity. The ease of removing fingerprints from the newest generation of AR lenses has resulted in a boom in AR penetration of the US ophthalmic lens market. (See entry for Cotec for measurement of contact angle).

SUPPLIERS

The following companies have kindly presented material for review. Full details of their products and processes can be found from their catalogues or websites.

Chemat

www.chemalux.com
UK – email:
peterwlk@btinternet.com

Holders of a world-wide patent on the application of multi-layer AR coating techniques using sol-gel technology, Chemat are the only company at present to offer machines for this purpose. (See previous note regarding the process, described in the article by Dr Peter Wilkinson in the March issue of OW).

Based in California with offices in Europe and China, they currently offer three sizes of the machine with capacities from 12 pairs to about 120 pairs per shift. This makes the machine (and technology) eminently suitable for the smaller laboratory that has a need to coat a small number of lenses per day, or for the large organisation that has the need to coat small numbers of specials, such as coloured mirror coatings, where the use of vacuum coating machines would be uneconomic.

Chemalux 300 from Chemat – showing its excellent small footprint

Three machines are on offer. The Chemalux 100 multi-functional spin coating system is a table-top unit and is capable of doing AR coatings, scratch resistant coatings, mirror coatings and / or easy-clean coatings in a compact space. It is designed to enable retailers and small labs to offer premium coatings in-house with an affordable investment.

Throughput is up to 12 pairs of AR coatings per day, with a coating cycle of 7 minutes per side. Dimensions of the compact unit are 23in × 21in × 21in.

The next machine in the range is the Chemalux 300. With a capacity of up to 35 pairs of AR coatings per day, this machine has a very small footprint of only 25in × 25in × 60in high, making it easy to install in even the smallest laboratory. The 300 can produce, AR, flash mirror and EZ-Clean coatings, with a processing time of about one hour (coating cycle only 5 minutes per two sides). The unit is fully automatic, with touch screen operation and has a simple and reliable electromechanical structure, making it very easy to maintain and repair.

The PLC (microcomputer) control system integrates automatic high pressure water washing with precise multi-layer spin-on coating. The machine applies the AR coating two surfaces at a time, pair by pair. Flash mirror coatings can be applied with a simple touch of the command screen.

Largest machine in the range, the Chemalux 600, is a multi-station coating system that cleans and coats eight lenses simultaneously, making it suitable for those laboratories who require a greater output capacity. It is designed to produce scratch resistant coatings, AR coatings, plus flash mirror and EZ-clean coatings.

It is controlled by a microprocessor, using a colour touch screen panel for ease of operation. The system is capable of accepting a fully automatic lens loading and unloading mechanism to make it an in-line fully automatic coating system. Throughput is up to 15 pairs per hour, with a coating cycle of 8 minutes per side. As would be expected, the machine has a large footprint – 53 in × 40 in × 72in.

Chemalux also produce three pieces of peripheral equipment of interest to the coating laboratory. The first is the Chemalux TC-2 Super hydrophobic coater. This is able to deposit the super-hydrophobic layer onto any shape of lens – uncut, edged or even still in the frame. This has the benefit of allowing the lens to be edged first, thus avoiding the problem of slippage whilst edging. It is also possible to re-apply a hydrophobic layer to a lens once the original coating has been worn out. Process cycle time is 7 minutes, with a capacity of up to 3 pairs of lenses per cycle.

The second machine is the iMirror TintCoater, specially designed for fast production of quality flash mirror coating on tinted lenses within the optician's practice. The system also does normal lens tinting. The bench-top machine offers fast heat-up time and has an overflow channel to catch spilt chemicals. Its coating curer drawer holds up to four pairs of lenses for thermal curing at temperatures up to 250°C. The coater module has a spin speed of 0 to 150 rpm and a coating cycle time of 5 to 10 minutes.

Final piece of equipment in the current range is the Chemalux GPS spectrophotometer. The instrument can be coupled with the Chemalux coating systems to 'tune' the colour of the resultant coatings. It is used to monitor and control the coating operation (AR and mirror) to ensure colour consistency during the coating cycle, adjusting operating parameters if necessary. In addition, the GPS is a useful tool for tuning the system to make a desired colour lens by lens.

The spectrophotometer is based on fibre optic technology coupled to a reflectance probe and fibre optic light source; the device measures the reflection of the coating and the resultant reflection spectra is used to determine the colour of the coating. The CCD technology used is combined with the reflection probe to produce reflection spectra simultaneously. Measurement time is 30 seconds and the device covers a range from 400 to 800nm.


The Duratest contact angle measuring system from Cotec

Cotec

www.cotec-gmbh.com

Within their large range of coating equipment and consumables, Cotec offer the Duratest which represents a new generation of contact angle measuring device. The 'universal' Duratest system is specially designed for the ophthalmic industry and offers easy handling, precise measurements and data storage, which allow the user to control the contact angle on both coated and uncoated lenses.

Special quality control for ultra-hydrophobic coatings, such as Duaralon, is possible with precise metering precision of 0.1°. The device is designed for use within the laboratory or in production control. Features of the system include:

- Fast and easy control of contact angle and surface energy
- Intuitive software providing different measuring methods
- Easy documentation of results in protocols and video image
- Optional use with laptop or PC
- High quality optics for excellent video images
- Economic pricing whilst retaining all necessary functions

The Duratest is fully automatic when measuring the contact angle, detecting the drop surface interface automatically by image processing. Additional options allow the manual setting of the measuring points and the completely manual measurement of the contact angle. The software also contains an evaluation module for measuring surface energy by comparing contact angles of two known measuring liquids.

Time dependent contact angle measuring with freely selectable cycle times and detection of roll off angle are also available.

Benefits of the system are stated to be easy handling, precise measuring, flexible use, software supported, easy data management, live video image and an economic price.

DAC Vision

www.dacvision.com

DAC Vision offer a variety of generic high-purity chemicals, hydrophobic and super-hydrophobic top coats, and an assortment of spare parts and consumables for vacuum deposition equipment. In addition DAC also engineer advanced processes to improve and develop treatments like Green of Achromatic AR with hydro or super-hydro top coat.

Lens treatment chemicals include silicon dioxide, titanium and zirconium oxides (grey and white), magnesium fluoride, silicon and chromium silicon monoxides, plus aluminium oxide and indium tin oxide.

Top coat treatment can be customised to fit chamber size and desired coating thickness. These treatments are smooth and abrasion resistant over time and provide excellent hydro and super-hydro properties. DAC list one hydrophobic 'pill' and three super hydrophobics:-

- SHP040 – coats 40 lens surfaces with an 8nm thick top coat layer
- SHP060 – coats 60 surfaces to same thickness
- SHP100 – coats 100 surfaces to same thickness
- SHP150 – coats 140 surfaces to same thickness

Three AR processes are offered – Diopside – green AR formula with top hydrophobic layer, Native – green with super-hydrophobic top layer and Delight – achromatic AR formula with top super-hydrophobic layer.

Consumables listed include, boats, liners (both in molybdenum) and filament ion guns and kits. A range of crystals (gold, silver and alloy), plus a range of spare parts are also listed in the catalogue.

DAC can also offer a range of services, including trouble shooting, maintenance, engineering, training and coating process development.

Boxer and BoxerPro from Leybold

Leybold

www.leyboldoptics.com

The company Leybold have been dealing with all aspects of vacuum technology for over 150 years. Ernst Leybold and Wilhelm Carl Heraeus laid the foundations for the present day company. Very early on these two inventors dealt with the potentials of vacuum technology and in 1967 the companies of Leybold and Heraeus merged to form the precursor of today's Leybold Optics GmbH.

Following on from the long tradition of dealing with lens coating, Leybold now offer an extensive range of coating equipment, including machines and systems for '3D coating' (items with complex geometries) and 'Web coating' (flexible substrates, including such things as packaging films).

For the ophthalmic market, their range includes the Boxer system, suitable for Rx and stock production quantities. A superior ion source technology, powerful vacuum pump, single quartz monitor, high-powered electron beam evaporator in the centre of the chamber and a highly efficient 'Meissner trap' (See endnote 2) are combined to give optimum performance.

This medium-sized coating solution guarantees easy handling, as well as simple maintenance; it offers a wide range of manufacturing processes, e.g., it is capable of producing broadband AR coatings on mineral glass or absorption coatings on sunglass lenses. The monolithic design allows for a larger coating area with reduced floor space.

The Boxer is available in three versions, each with a different capacity:

Boxer Light – 110/130pairs per eight hours
Boxer – 220/230 pairs per eight hours
Boxer Pro – 250/260 pairs per eight hours

Features and benefits include:

Cubic coating chamber with straight sides ensuring:
- Easy maintenance
- Optimised coating geometry
- Quick removal of chamber shield
- Simple click fixing of substrate carrier

Multiple hardware options including:
- Heating system for mineral substrates
- Mark II or LION ion source
- Pump upgrades (Turbo, Roots)

A second system from Leybold is the CCS Series – a design that can grow alongside the expansion of a business, allowing, as it does, for physical space and production adaptations. To achieve this, new components can be added to the machine to increase volume. Features and benefits of the system include:

- ☐ Fully automated process
- ☐ Easy and comfortable machine handling and operation
- ☐ Easy maintenance
- ☐ Compact footprint
- ☐ Ergonomic chamber shieldings
- ☐ Quick pump-down time
- ☐ Modification of process parameters to customer requirements
- ☐ Multi-layer AR coating for both organic and mineral substrates
- ☐ Remote analysis via modem and data recording

The CCS system is available in three versions – CCS Light, capacity 48-72 pairs per eight hours, CCS Light P (64 to 96 pairs) and the CCS PRO (126/182 pairs). Each of the two smaller machines can be upgraded by simply adding components to increase capacity.

The Syrus family from Leybold offers a highly efficient system for coating large batches. In classical mass production, as in Rx laboratories, the Syrus offers an exceptional cost-benefit ratio that is achieved by an intelligent modular design. In ion-assisted coating as in conventional single or multi-layer processes, this system is said to offer optimum quality at an economic cost per lens.

This system is available in two versions – Syrus III with a capacity of 450/550 pairs per eight hours and the Syrus 1350 with a capacity of 650/800 pairs.

Features and benefits include:

- Personalised processes adjusted to customers' needs
- Optimised physical space
- Easy-to-use software
- Remote analysis via modem and data recording
- Hydrophobic coatings may be applied in-chamber
- Cubic chamber providing:
- Excellent geometric coating on lenses
- Quick exposure and removal of protective chamber liners
- A click-in mechanism exchanges the substrates quickly and easily
- Easy maintenance

For those wising to add a coating system to their operation, Leybold offers the MiniLab and EasyLab. These are complete turnkey solutions priced and engineered specifically for all sizes of lab. They can be configured around either the CCS design, or for those with a larger capacity requirement, the Boxer family can be incorporated. These setups can include back-side spin hard coaters.

Satisloh

www.satisloh.com

Combining the 120 years of experience of Satis Vacuum and Loh Optical machinery, Satisloh, headquartered in Switzerland, supply complete solutions for ophthalmic and precision optical manufacturing, including vacuum coating equipment and accessories. The company has a worldwide presence in 19 countries through more than 13 subsidiaries and 10 agents.

The latest offering from the company, showcased at Mido 2010, is a new high index process – Ioncote K+ and the new cleaning and hard coating system SL-501. This system fits in with Satisloh's range of box coaters and proprietary coating processes for hard coating, AR coating and top coating. This ensures that the company can offer the market a full package of top performing coating processes.

SL-501 comprises a multistage cleaning process, followed by thermal cured dip coating with a primer stage for special lens materials such as polycarbonate. Two different lacquers can be used for index matching.

Following the success of the release of the High Index K process, Satisloh's R&D department has developed a new process – Ioncote K+ for high index and 1.5 index substrates. This is said to outperform major market benchmarks. The main characteristics of the new process are increased abrasion resistance, together with an improved top coat (Satin) life span.

The Satisloh high performance lens coating consists of:

Dip coat lacquer – DN1500 and DN1600

AR coating – Ioncote K+ – with antistatic properties and long life cleanability

Super hydrophobic coating – Satin

Over the last forty years, Satisloh have developed many AR coating stack designs. As the sophistication and controllability of vacuum chambers has improved, it has been possible to develop unique designs with specific hardness, refractive indices, optical and mechanical performance parameters. The current options include:

The 1200-DLF high volume box coater from Satisloh

Multiquartz Z-P
Performance - ML
Ioncote K-HL
Easy-coat
Multicote

The coatings are applicable to low and high index substrates and offer the following benefits:

- Superior abrasion resistance, exceeding market benchmarks
- Excellent durability of layer package in accelerated ageing tests
- Cosmetically and optically superior performance through index matching of the lacquer

The range of consumables includes a range of lacquers and primer and various substances for vacuum coating, plus Satin super hydrophobic top coat. The range of equipment currently on offer includes three coating machines – the 1200-DLF box coater and the SP-200 sputter coater, plus the MC-380.

The 1200-DLF is a high volume box coater equipped with a state-of-the-art diffusion pump and is capable of providing consistently high quality AR coatings in a very short process time. Optionally, two 1200-DLF's can work in a parallel configuration.

The system deposits anti-reflection and/or mirror coatings on organic and mineral substrates via a thermal evaporation process. It offers multiple process applications according to the material being coated and is suitable for Rx lab or stock lens production. Features of the machine are:

- Hot process for mineral lenses
- Six sector dome or a flip-over system for double side processing
- Extendable mask system
- Ion assisted deposition
- Electron beam gun with a shutter
- Multi nozzle venting system for reduced venting times
- Evaporation optimised by digital sweeper control
- Powerful pump system with one diffusion pump (two molecular pumps on request)

Benefits are:

- Consistent (uniform) AR coatings
- Highest stock lens productivity
- Fast technology with low process times
- Lowest cost per lens
- Proven Satisloh processes
- Easy job and process set-up

The 1200-DLF can handle CR39, polycarbonate, high index, acrylic, photochromic and mineral glass up to n =1.9. Capacities are from 324 lenses (51mm) to 126 (80mm) for the six-sector dome and 252 to 96 for the flip-over system.

The MC-380 is also a box coater of similar general design to the 1200-DLF, but is produced for lower throughput rates. It can handle the same lens materials and the capacities are 120 to 45 (51mm to 80mm) for the three-sector dome and 42 to 32 (48mm to 66mm) for the flip-over system (without top heaters). Production rates are fast, with 44 lenses being coated in about 50 minutes.

In the Lab-380-H version, the system is coupled with an integrated ultrasonic cleaning unit and preparation and degassing facilities. Two or more MC-Lab-380-H units can be arranged in a parallel configuration, sharing the ultrasonic system.

Features of the combined system are:

- Hot process for mineral lenses (requires heater option)
- 3-sector dome or flip over system
- Extendable mask system
- Ion assisted deposition
- Electron beam gun with shutter
- Pump system with powerful molecular turbo pump (1900 l/s)
- Touch screen operator terminal
- Fully automated cleaning, including basket transportation
- Six tanks, cleaning and rinsing under a flow box
- 'Slow lift-out' for lens drying
- Degassing oven

The third system, the SP-200 sputter coater, is designed to especially suit small batches, continuous flow coating and rush orders. It has a very fast cycle time of 15 minutes for four lenses with double-side coating. The flip-over system is fully automatic and the machine can accommodate lenses from 50 to 75mm diameter. Substrates of CR39, polycarbonate, high index, photochromic and mineral (in up to 1.9) can be handled. The machine offers ease of use and low maintenance, due to a single reactive sputtering source.

It is possible to change between differing coating types and materials, e.g, from AR coating organic materials to AR coating mineral lenses, or to mirror coating. The operator simply chooses a different process on the touch screen; no other changes are necessary.

Three configurations are available:

- Single side AR coating (one hour retail concept) – applies backside AR and hard coating
- Auto-flip AR system with UV cured hard coat (wholesale laboratory concept) – applies double sided AR and backside hard coating
- Auto-flip AR system with thermal cured hard coat (wholesale factory concept) – applied double sided AR and integrated double-sided hardcoat.

Although this review does not specifically deal with hard coating machinery, mention should be made of the Magna-spin. This is a spin coating system for front-side factory hard coated lenses. It uses UV cured lacquers, with three versions being available – suitable for CR39, high index, tintable and polycarbonate substrates.

Endnotes

(1) Meissner Trap

When pumping a chamber from atmosphere, the major residual gas component is water vapour. A Meissner trap is, essentially, a coil of tubing through which a liquid / gas cryogen flows to maintain a low surface temperature.

(2) Magnetron

A magnetron is basically a microwave generator in which electrons, generated by a heated cathode, move under the combined force of electric and magnetic fields.