From blank to wearer

In the second and final part in our look at the life of a lens from blank to final appliance, **Andy Hepworth** looks at coating, glazing and final checking. Module C8730, one general point for optometrists and dispensing opticians

Deblocking
At this stage we already have the required diameter and curvature of the lens so there is no further use for the aluminium block (or the metal alloy holding this block onto the lens). There are several ways in which the block can be removed, the most common methods include the following:

● Shock
Using a deblocking tool (Figure 1) both block and alloy are secured in position and struck onto a hard surface releasing the block; this is not possible for uncuts with a small diameter due to the diameter of the gap.

● Pneumatic
A semi-automatic process where the block and alloy are effectively squeezed off the lens.

● Melt
Using a water bath, the alloy and block are exposed to a temperature of 66°C which returns the alloy to its molten state thereby releasing it from the lens surface.

Following de-blocking, the front surface no longer requires protection or assistance with adhesion, so the tape is removed through a simple peeling.

Cleaning
Given the nature of processes that have taken place up to this point, in particular the use of slurry during the surface generation, the lens has to be thoroughly cleaned.

Once loaded onto panniers (Figure 2), the lenses are dipped into nine separate tanks. The first three contain washing and degreasing agents following which they are rinsed in softened water and finally dried.

Dip-dye tinting
There are many sun lens options available to practitioners today, including polarising filters which use vertically aligned iodine crystals to filter out light which reflects off a flat surface (polarised). Another example is blue light filters (for example, Airwear Melanin) which block a significant amount of blue light. To achieve these properties these filters are imbedded into the lens during the production process.

A more traditional method employed in many 'in-practice' glazing labs is to tint through dip-dying. As the name suggests this involves the lens being immersed into a heated bath containing the dyes and various additives which promote the colouring process. The length of time the lens is submerged depends on the required depth of tint (light transmission factor), lens material and thickness. Tint colour is determined by relative concentrations of the three primary colours (blue, yellow and red), so it is theoretically possible to obtain an infinite range of shades.

Graduated tints are also applied using tint baths. The lens is immersed in the tint bath upper section first and then slowly removed, so the lower section is immersed for longer and is therefore more strongly impregnated with the colour.

Figure 1 Deblocking tool

Figure 2 Panniers for dipping

Coating
Most mid- to high-index lens materials automatically include a scratch resistant coat yet many go a stage further with a reflection-free coat as standard. The process of applying these coatings differs depending on the refractive index and these differences will be highlighted as we cover each stage.

Prep-cleaning
Although the lens is cleaned to remove slurry after deblocking, in order to assist coating adhesion the lens is once again loaded onto panniers (Figure 2) and lowered into an ultrasonic bath filled with cleaning agents. Polycarbonate lenses are subjected to a greater series of chemicals compared to the thermosetting materials, as the 'handling' scratch-resistant coating added to this lens material following the production stage needs to be removed, to prepare the lens for its permanent scratch resistant coating.

Primer layer
Thermoplastic (polycarbonate) and certain thermosetting materials expand and contract more than average across a small temperature range (they have a high co-efficient of expansion). Traditionally, this caused a slight issue with regard to how much the surface could be protected using scratch-resistant coatings, as, put simply, the more ▶

hard molecules (for example, silicon) that the hard coating contained, the lower its co-efficient of expansion would be. As the lens material expanded and contracted under the influence of subtle temperature changes, the hard coat would barely alter. As a result, over a short period of time, the coating would be lifted from the lens. In the past, the only real solution was to reduce the 'hardness' of the scratch-resistant coating, thereby better matching the expansion co-efficient.

A solution arrived in the form of a primer layer which acts as a buffer between the lens itself and the scratch-resistant coating. Due to its 'stretchy' latex-like properties, coating engineers could add significantly more hard molecules to the scratch-resistant coating without it lifting.

Within Essilor manufacturing, these primer layers are systematically added to modern polycarbonate (Airwear and Eco) lenses, applied through a dipping process and cured through heating (warm air tanks).

Hard coating

To enhance the durability of the lens material, scratch-resistant coatings can be applied to the lens; it is possible to apply a hard coating through a spin coating technique. However, the performance of these has led larger modern labs to adopt the dip-coating technique.

There are several different hard coats (known as varnishes) that vary depending on the material to be coated.

In a similar manner to the primer layer, these varnishes are applied by a dipping process where the lens simultaneously receives a layer of varnish on both surfaces. They are immersed in the liquid varnish and subsequently removed at a constant rate to control the thickness of the coating. The varnish is then polymerised (cured) by heating; it is this solid hard film which provides protection from scratches.

Reflection-free coating

A reflection-free coating can now be applied to the lens. On a very basic level this involves stacking thin layers of transparent material of a specific refractive index to a precise thickness across the lens surface. This is commonly referred to as a 'multi anti-reflection' (MAR) coating. Vacuum evaporation is the technology that allows this extremely technical procedure to take place, the vacuum ensures even thickness and vastly improves adherence by ensuring the surface is free from residual contamination. Evaporation allows

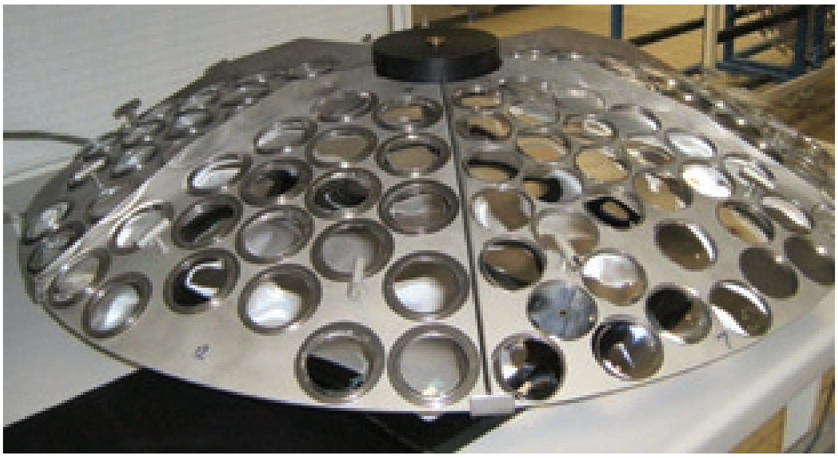

Figure 3 Lens carousel

the pure materials to be applied through condensation.

The procedure involves the lenses being loaded onto a carousel (Figure 3) which is placed into a vacuum chamber (Figure 4). Once the air has been expelled from the chamber (to create the vacuum) the carousel is rotated to ensure the deposition of the chemicals is across the entire surface.

Before these layers are applied and to ensure coating adhesion, the lens must be ultra-clean. This is achieved within the chamber through a process known as ionic bombardment.

Once the lens surface is ultra-clean, chemicals are evaporated to form the thin layers that create the reflection-free coating. Once vaporised, they rise to the top of the chamber where they meet the lens surface and condense upon it, forming a layer. Several different chemicals are used, each one to form an individual layer of the reflection-free aspect of the coating (the layers that generate the destructive interference of light).

Modern reflection-free coatings include a top layer that makes the lens more resistant to water and grease (for example, Crizal Alize). This is achieved through an additional layer being added on the top surface of the coating to 'fill in' the microscopically porous top layer. The 'new' top layer is created using a material that contains a large proportion of fluorinated molecules that repel water and grease. This combined with the improved smoothness makes the lens much easier to keep cleaner for longer.

An additional step is now available where the top coating repels water, grease and dust (for example, Crizal Alize with Scotchgard). These coatings also include an electrostatic layer within the reflection-free layers, which prevents the lens becoming negatively charged following wiping and thereby prevent dust particles from being attracted to the surface.

Figure 4 Vacuum chamber used in coating

Glazing

Although not the original 80mm blank that was formed during production, the lens is still in its uncut form and therefore needs to be cut, edged and fitted into the chosen frame. Step one involves tracing the frame so the edging equipment is able to cut the blank accurately to the required shape. While this process is happening, the lens is centred for the application of a blocking pad which ensures the accurate centration is translated into the final product. Once the blocking pad has been added, the lens is clamped into the edging machine and cut to the required shape. Once this process is complete, the lens is ready for assembly into the frame. Several frame types exist including full rim, supra and rimless, each having different assembly requirements.

Final check

All the production/manufacturing and finishing processes have now been completed so the final procedure is to make sure the lens is acceptable in relation to its optics (within British Standard as a minimum), its aspect (scratch-free), and its cosmetics (thickness is acceptable). This can be performed via manual inspection or using the latest automated equipment (for example, the Carex machine used by Essilor, see *Optician*, June 29, 2007).

Summary

It is important to distinguish between production and manufacture when considering spectacle lenses. Nearly all production takes place outside the UK with factories generating finished single-vision and semi-finished blanks.

Manufacturing processes within the UK have developed considerably over the past decade with the introduction of digital surfacing (free-form) having a big influence on the potential designs that can now be delivered.

But just because a design is generated by free-form doesn't automatically mean it will provide enhanced optical performance. It is vital to check with the manufacturer regarding the features that have been designed into the lens which can only be realised through the use of this excellent manufacturing technique.

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MULTIPLE-CHOICE QUESTIONS

1 Which of the following is NOT used to remove the block from the lens?
A Shock
B Pneumatic
C Melt
D Suction

2 What temperature is required for melt deblocking?
A 25 °C
B 66 °C
C 100 °C
D Room temperature

3 What is the purpose of a primer layer?
A Provides a flexible buffer between the expanding lens and the less flexible coating
B Acts as a hard coat
C Reduces spectacle blur
D Helps filter out short wavelength visible light

4 Which of the following has the highest expansion co-efficient?
A Glass
B Polycarbonate
C CR39
D Polarised filters

5 How many separate tanks are typically used in the cleaning process?
A 4
B 6
C 9
D 20

6 Which of the following is used in hydrophobic surface coatings?
A Bromine
B Iodine
C Fluorine
D Astatine

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