Why blocking needs a UV free plastic blocking technology

PROS AND CONS OF DIFFERENT TECHNOLOGICAL PRINCIPLES

For many years, the discussion about which technology could eventually replace alloy has been ongoing — and has produced many different alternatives. All these alternatives have two things in common: First, no alloy replacement technology can exactly replace alloy, with all its technical and economic benefits. And secondly, no alloy replacement technology has actually replaced alloy on a large scale. Some are somewhat beginning to enter the market, but the enthusiasm so far has been limited. To understand why, this article takes a look at different technologies approached today and derives their different profiles and the pros and cons of their technological principles, regardless of machine or manufacturer. So, any lab owner, production responsible or marketing strategist can decide for himself which technology fits their individual strategic, ecologic and commercial footprint best.

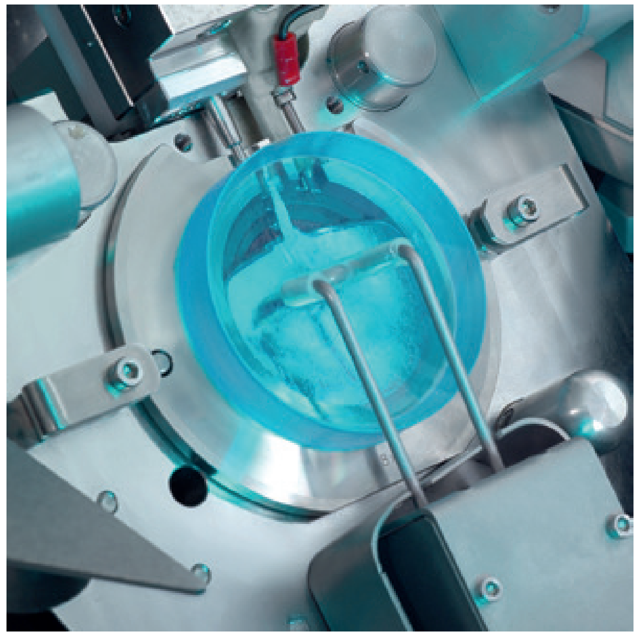


Fig. 1: Blocking station of an alloy blocker during the process.

Fig. 2: CCB modulo – Automated alloy-free blocking, intelligently combined.

The challenge to replace alloy as blocking technology is almost as old as the technology itself. From its early beginnings, it was always challenged by previous approaches as well as ideas developed in parallel. The quest for alloy replacement is so old in fact that even the arguments against it have changed! From cost to health to environment, its challenges have swapped. And still, alloy remains the dominant technology.

Apparently, those who have decided in its favor have decided well – and now have little appetite to switch. All alternative solutions so far seem to have a down side to them, preventing their imminent breakthrough. And to understand these down sides and how current and future technology might address them is vital to any decision maker wondering if their next generation blocking should be alloy or one of its alternatives, and if so: which one?

WHY ALLOY FREE BLOCKING IS SO HARD TO TACKLE

To appreciate the challenges of replacing alloy as the blocking technology, we must first recall the target functions of blocking.

- >> Force and deformation-free mounting
- >> Transfer of cutting forces
- >> Damping vibrations
- >> Supporting the lens against elastic deformation
- >> Quick blocking
- >> Quick and force-free deblocking

At first glance it is not obvious how contradictory many of these functions are. Most certainly, the lens must be mounted into the machine to take on strong cutting forces applied to it during milling or PKD turning operations. However, at the same time, this mounting must itself be force-free to minimize deformation of the lens during the process. In an environment where deformations in the range of fractions of microns actually have an impact on the optical quality of a lens, this provides a serious technological challenge.

Secondly, the block must support the lens against elastic deformation applied during lathe turning, when the diamond thrusts into the material at up to 40g of acceleration, up to one hundred times a second. Yet it must not resonate or react to the beating in any mechanical way.

Thirdly, the block must be somewhat chemically inert, as the lens is subject to aggressive coolants and different chemicals during generating, polishing and cleaning operations.

Lastly, as strong and firm as the support needs to be during surfacing operations, as easy and force-free it needs to be undone. The fragile final product needs to be gently released for further processing.

Adding to this, blocking problems almost always come in disguise! Rarely do we see blocked lenses actually falling down or flying off the chuck! But this worst-case scenario is only one of many problems that occur due to a bad blocking process. Much more common are problems where bad blocking produces features that are easily mistaken for problems of other process steps.

Weak support, particularly towards the rim of the lens, may create waviness and haze, easily to be mistaken as polishing problems.

Weak support towards the center can cause power problems and center defects, often mistaken for generator issues. Only assuming the broader technology perspective (which lenses create which problems when) can correctly identify blocking problems for what they truly are. But technology experts capable of doing so are rare, particularly in new or smaller labs. wSo, at times we may hear comments like: "blocking works fine, but we have big polishing issues now...!"

THE BENEFITS (AND DOWN SIDES) OF ALLOY

Alloy provides the chance to steer clear of many such issues, as it has potentially all of the aforementioned qualities. It mounts the lens without much force. Shrinkage of alloy is very well understood and can be factored into the equation. Its metal nature and the use of adequate block rings supports the lens very well, including the largest common diameters. And melting it away easily and quickly removes it force-free from even the thinnest knife-edged lenses. Residue free reusability ensures a great cost-per lens ratio, and closed loop automation within the blocking/de-blocking cycle removes all health and handling concerns in the lab.

All of this makes it the currently most established, the most mastered, the most cost-efficient blocking technology and sets the quality standard of blocking today, as modern industrialized labs are reluctant to accept significant additional constraints, nor additional costs. And the most pressing argument for its replacement, a regulatory ban, has not materialized, and there is no clear indication that it will any time soon. Neither the EU nor the US have a ban currently on the agenda. So does it even make sense to replace alloy?

It certainly does. Because despite closed loop automation solutions available today, alloy remains a consumable. Milligram per milligram of alloy propagates into the environment, but tens of millions of lenses manufactured every year are adding to tons of mercury, indium and cadmium that are sold, used and eventually lost to the biosphere every year.

The down side of consuming even small quantities is even more significant in regions where disposal costs of contaminated waste are high.

Secondly, customers seem to no longer just pay attention to price, quality and return time. Consumers more and more attach value to the social and environmental footprint of the products and services they use.

Thirdly, the question of alloy could be used as a non-tariff barrier to trade in certain regional markets that are subject to intense lobbying by special interest groups. So, as certain strategies may require alternative blocking solutions, it makes sense to look for alternatives and understand their pros and cons.

VACUUM

Among the oldest technological alternatives, particularly in precision optics, is the absence of any blocking material – directly mounting the lens and holding it with a vacuum. While the technology has proven quite capable with mineral glass lenses in precision optics applications, the situation is very different with organic blanks. While grinded mineral glass provides for extremely high surface accuracy, the situation is very different for modern organic blanks.

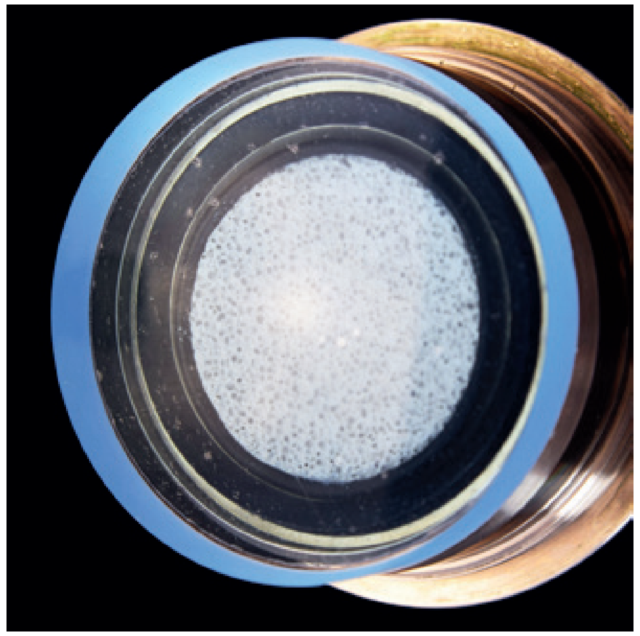


Fig. 3: Vacuum chuck with blank, inlay and seal.

The polymerization process and subsequent internal material tension always leads to slight surface deviations of the front curve. The lens does not fully lie against the chuck, but only touches the negative in arbitrary areas. When now sucked into the chuck, the blank deforms in unpredictable ways, creating an unstable surface during generating.

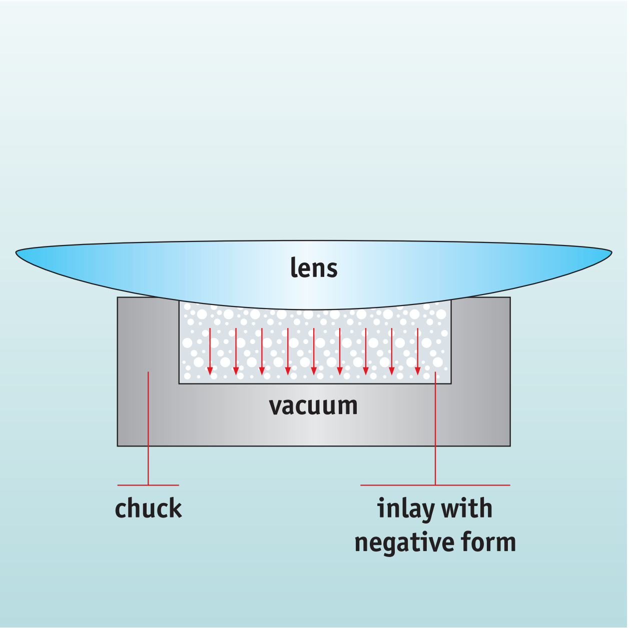


Fig. 4: Working principle of vacuum blocking.

In addition, any gap or chip between the frontside of the blank and the curve of the mounting chuck will immediately cause deformation and power problems amid high cutting forces in modern day generators. Thus, a stable process would require unprecedented accuracy of the blanks and extreme cleanliness of both the front side surface and the chuck. Any operation that might currently cut into alloy (e.g. complex cripping) is impossible, as it would destroy the vacuum.

Different front curves, progressives, and bifocals would either require different inlays, different mounting chucks, or a flexible support like rubber or a gel cushion, making the needed firm support impossible. Labs using vacuum chucking would have to accept severe constraints as to what blanks to use, what front curves to manufacture, and what quality to achieve.

The seal and the support inlet would have to be extremely clean at all times, as any dirt or deviation in the system would immediately destabilize the process. Hard to imagine why anyone would be willing to accept these fundamental technology down sides in an industrial environment.

WAX

Another traditional blocking material is wax. In comparison with alloy, wax allows for comparably high flexibility with regard to front curve, prism and blank size. However, higher shrinkage poses a problem, and the support of the lens during generating and polishing is weaker. The main issue with wax however is the chemical contamination of the lens that affects the process steps after surfacing. Wax blocked lenses have long proven to be extremely problematic in coating. Despite these quality impacts, low costs per lens give wax some market share in low-cost / lower quality productions with no expectations to coating quality. In large scale mass manufacturing labs, wax has found limited acceptance.

HOW UV CURED GLUE BLOCKING WORKS

The history of UV cured polymers reaches back nearly half a century, when advancements in polyurethane chemistry in the 70's gave way to the developments of complex acrylates that form the main compound of most UV cured glues. The first entrances to the ophthalmic industry were made during the early 90's when the idea to use UV glues for blocking emerged for the first time.

By the 2000's, the technology was well understood, however it also became clear that using UV cured polymers pose fundamental technological problems. To understand these drawbacks and how they limit their usefulness for the ophthalmic industry, we have to understand how they actually work.

UV glue usually consists of acrylate oligomers as the main component and photo initiators to start the polymerization process. The photo initiators are weakly bound unstable molecules with a binding energy of precisely the energy of light photons of a certain wavelength.

The photo initiators determine what form of radiation will start the chemical reaction, visible light and UV are common, but also other forms of radiation are possible.

When their main bond gets dissolved by radiation, the breaking point forms a radical which chemically activates the surrounding oligomers. This then begins connecting to other neighboring molecules, activating them in the process. This process is a chemical chain-reaction called polymerization.

The radicalized oligomer molecules form non-polar covalent atom-to-atom bonds with very high strengths. As a result, molecules form larger and larger strings or networks, growing a solids phase into the liquid phase of the adhesive.

The process is self-sustaining and generates a considerable amount of heat, as the newly built covalent bonds are stronger than the weaker ones before. In other words, chemicals are activated or 'cooked', creating a permanently hardened material. The result is a thermoset, a solid plastic compound that is

>> thermally resistant
>> insolvable
>> mechanically resistant

The process is an irreversible chemical reaction. But as blocking needs to be reversible, the very principle of UV cured glue causes a fundamental problem.

THE PROBLEM OF UV BLOCKING

The problem with UV glue as blocking material is that the curing process is an irreversible chemical reaction, which contradicts one of the main demands of a successful blocking process.

It is certainly possible to glue a lens tightly to a block piece, but gluing it tightly in a reversible way is fundamentally impossible, as the curing process itself is irreversible.

The way this is addressed in modern day UV blocking systems is by adjusting the curing process itself either by adjusting the adhesive or the curing time or both. Shorter curing times mean incomplete polymerization, decreasing the adhesion of the glue, making it easier to remove. However, by the same principle, this sacrifices hardness and thus support of the lens, potentially creating power problems, waviness, center dots and cosmetic defects (see Fig. 5).

The reason why these effects appear is that during generating, particularly during the fast-tool operation of lathe turning, modern generators like the Schneider HSC XTS or Satisloh's VFT- orbit 2 perform the turning operation with extremely high acceleration, resulting in high force of inertia.

While the machines of today are made of polymer concrete for maximum stiffness and vibration dampening, an incompletely cured polymer film directly behind the lens becomes the weak link, allowing the lens to vibrate or budge amid the dashing diamond, causing undesirable surface errors.

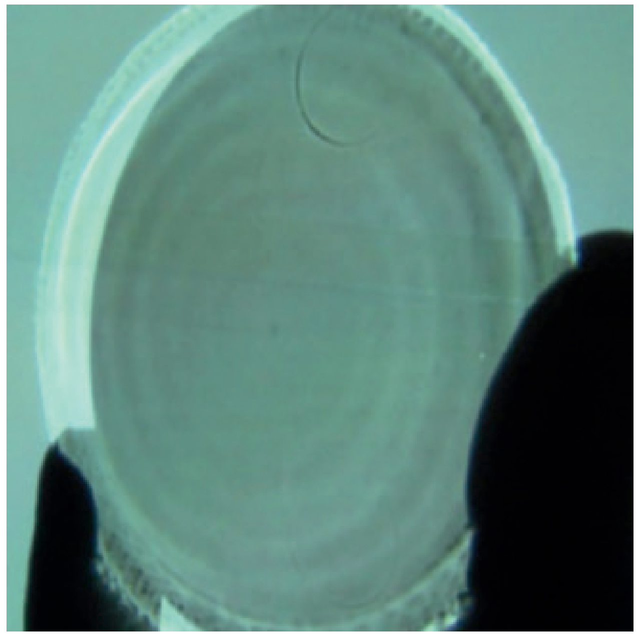


Fig. 5: Typical defects of a UV-blocked lens, caused by weak adhesion during generating.

A stronger cohesion to better support the lens can be achieved by fully completing the curing process, forming a strong and durable layer of thermoset between lens and block piece.

However, strong adhesion, while desirable during generating, can cause problems during deblocking, as it requires strong force either mechanically or through water jet, damaging and potentially destroying particularly thin lenses or lenses with fragile edges (see Fig. 6). While these lenses require maximum support during previous processes, this exact support is what damages them in the later ones.

The problem is that UV curing is an irreversible chemical reaction. Hardness, or more precisely, adhesion and cohesion of the thermoset once introduced into the polymer during curing, will stay in regardless of further process needs. For most applications of UV cured adhesives, this is very desirable, as the adhesive process is meant to last for the lifetime of the product (for instance during spin coating). For ophthalmic surfacing, however, it is a problem. Thermosets are not made (and are not meant) to be reversible.

That is the fundamental difference to blocking: here the connection is not meant to last, as it is only a very brief necessity during surfacing. As blocking needs to be reversible, thermosets in principle cannot fulfill modern day industry needs. Wherefore, from the author's point of view, blocking needs a UV-free technology.

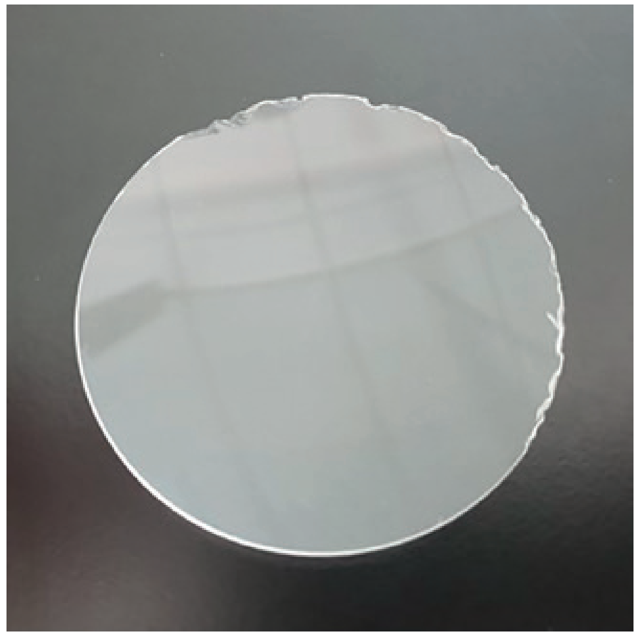


Fig. 6: Typical defects of a UV-blocked lens caused by strong adhesion during de-blocking

HOW EFT SOLVES THE PARADOX OF UV BLOCKING

As the process of blocking requires substantially different levels of firm support during the process chain, with strong support needed first and weak adhesion needed subsequently, a substance generating firmness out of an irreversible chemical reaction appears inapplicable.

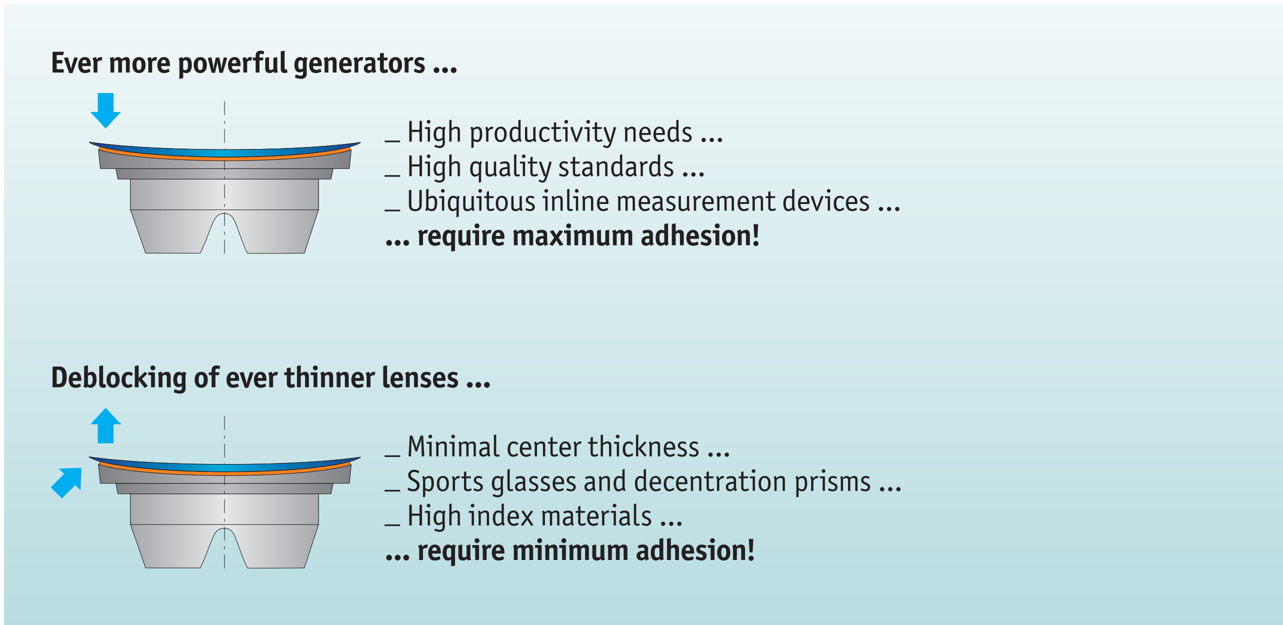
To fulfill the fundamental need of reversibility of the blocking process, the fundamental principle of hardening is required to be reversible too. The aforementioned technologies alloy, vacuum and wax all fulfill this.

Alloy and wax both harden as a result of a phase change from liquid phase to solid phase and back again, while vacuum chucks work through a reversible pressure difference between the chuck and the outside. As discussed, these technologies all have significant down sides, requiring yet another technological approach.

Eco Fuse Technology (EFT), a thermoplastic compound specifically designed for ophthalmic lens blocking, offers a new solution. Thermoplastic polymers do not form network covalent solids like thermosets, but molecular solids bound by weaker intermolecular bonding EFT consists of a number of chemically stable polymers that form semi crystalline solids.

The solid state provides excellent support, both static and dynamic, transferring cutting forces straight into the machine bed. The high Young's Modulus required to transfer the forces with as little deformation as possible is based on the specific semi crystalline structure of the solid compound.

However, unlike thermosets, their solidity is not caused entirely by non-polar covalent bonds, but by a carefully designed combination of irreversible intramolecular covalent bonds on the one hand and reversible intermolecular bonding on the other hand: hydrogen bonds between certain polar groups within the molecules and van der Waals forces between the molecules as a whole. Hydrogen bonds and particularly van der Waals forces are highly distance-dependent, yet 10-100 times weaker than the covalent bonds within the molecules.



When heated, the movement of the molecules increases. As the molecules begin to twist and turn, the distance between them increases. The bonds weaken and the thermoset quickly loses its mechanical integrity, becoming notably softer and ductile at about 110°F / 43°C. At 140°F /60°C the substance is semi-fluid. In this state it can be easily applied during blocking and will fill in even the most complex gaps between block piece and blank.

However, the phase change is not a chemical reaction! The molecules stay unchanged. The process is therefore entirely reversible.

When the substance cools down, the decreasing molecular movement also decreases the distance between the molecules. Hydrogen bonds form again, forcing the compound into its semi crystalline state, only minutes after the beginning of the cooling phase.

FROM LIQUID TO SOLID – AND BACK AGAIN!

The reversible qualities of EFT blocking: Three different states exactly resemble the process requirements during the different process steps of surfacing.

The semi liquid phase during
BLOCKING

At only 140°F /60°C, the compound is semi-liquid and will easily fill in any gap between even complex front curves (progressives, bifocals, etc.) and the block piece without any cavities or holes (as opposed to the cavities frequently seen in alloy). The blocking process requires no block ring, allowing for unparalleled versatility with respect to lens diameters. Prisms up to 6° can be blocked with standard EFT block pieces, special block pieces allow for prisms even larger.

The solid phase during
GENERATING

At 30°C and below, the compound is solid. The carefully designed semicrystalline structure allows for a very high elastic modulus and provides unparalleled support for the lens, minimizing waviness, center dots, power deviations and cosmetic defects. The absence of block rings allows for full lens support, superior even to alloy.

The intermediate phase during
DEBLOCKING

Between the two temperatures, the thermoplastic doesn't change phase but rather enters a transition phase of decreasing viscosity with rising temperature. This allows for the most gentle deblocking, protecting even the thinnest lenses from fissures and cracks. In addition, even conventional deblocking with deblocking rings is easily possible.

Fig. 7: EFT in its solid state.

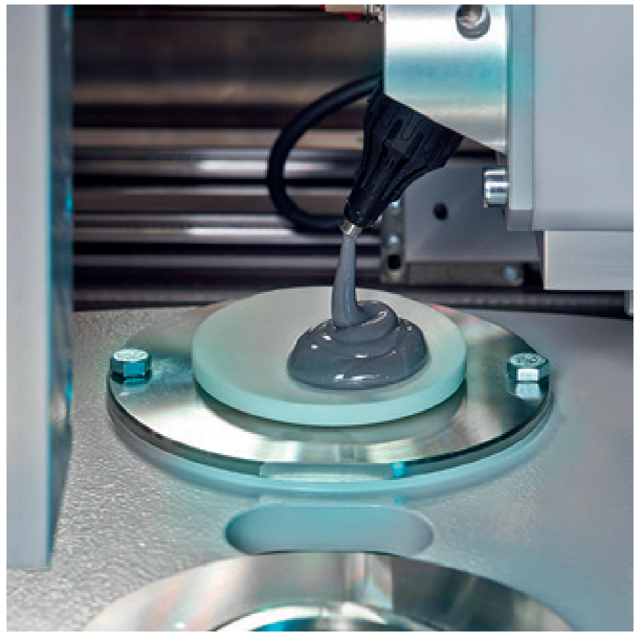


Fig. 8: EFT in its semi-fluid state during blocking, at about 140°F / 60°C.

CCB MODULO AND DTS MODULO

The alloy-free thin film blocker, CCB Modulo, and deblocker, DTS Modulo, contribute to an environmentally-friendly production based on the new Eco-Fuse blocking Technology (EFT).

SUMMARY AND OUTLOOK

Blocking technology is one of the most quality defining technologies in the lab today. Many process steps, but particularly generating and deblocking, have very specific requirements towards it. Modern generators with their productivity and quality aims require firm and rock-solid support for the lens across its entire surface, to be able to deliver productivity and quality, thereby requiring strongest possible adhesion.

Strong adhesion however poses a challenge to deblocking, particularly with ever thinner lenses and fragile edges. Mechanical stress applied to the lens can cause visible and invisible cracks and fissures, jeopardizing coating quality or destroying the product. During deblocking, adhesion is therefore required to be as weak as possible, gently holding the lens for it to be effortlessly removed.

As the blocking process needs to be reversible, the technological principle of blocking needs to be reversible too. Otherwise lab owners and production managers find themselves in the dilemma that only one process will work well: generating or deblocking. Never both.

EFT utilizes a technological principle that is entirely reversible, and therefore allows for a technology where the adhesion of the blocking material can be adjusted to the needs of the specific process through heat. EFT allows for a blocking technology where all process steps achieve maximum performance. In addition to being more cost-effective than UV glue, EFT solves the paradox of UV glue through a superior technological principle.

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