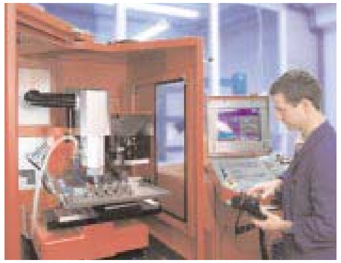
Where the highest precision is demanded



We know what you expect of us. Therefore you can rely on quality from the house of Hellma. Those who work in scientific analysis, always require precision, because the most careful work means nothing if you cannot rely on the precision of analytical instruments. Therefore precision is as important to us as it is to you. All of our cells are manufactured according to high quality standards. With the help of refined production techniques and the best qualified workers, it is possible for us to keep product quality at a continually high standard, which is valued in the laboratories of the world. Whenever demands exceed the normal standards, Hellma cells are not far away. In the following technical documents, you will discover how this happens and why Hellma is a world leader in the manufacture of cells for photometric analysis. Welcome to the world of Hellma.

Hellma® Precision in Spectro-Optics.Worldwide.

2.1.1 Registered Trademarks and Material Codes

Material

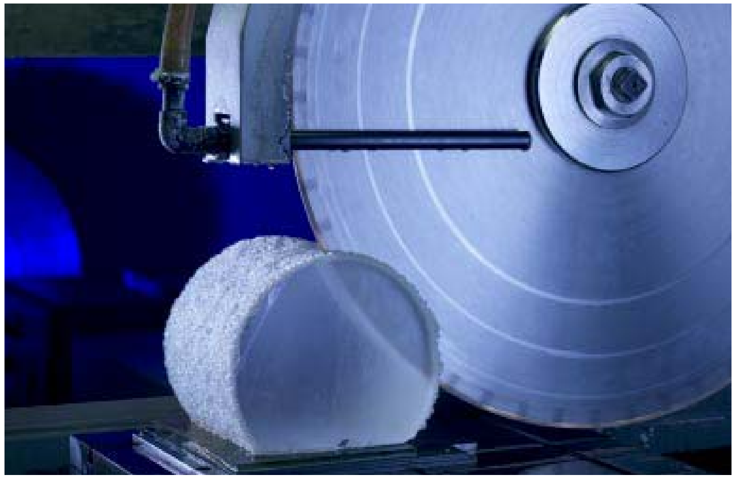
Cells illustrated in this catalogue are manufactured from various types of glass. The most important criterion for the choice of a particular type of glass is the spectral range for which the cell is intended. Coloured logos are fused onto each Hellma cell, thus indicating the spectral range over which the cell can be used.

In general we divide the glass materials that we use into two groups: Quartz and Optical Glass.
Quartz consists exclusively of silicon dioxide (SiO_2) and shows some remarkable properties:

- Quartz displays a high UV transmission, in highly purified synthetic Quartz down to well below 200 nm.
- The thermal expansion of quartz is extremely low, its coefficient of thermal expansion being 6×10^{-7} K^{-1} between 20 °C and 300 °C.
- Quartz is chemically very resistant and maintains its shape, even at high temperatures up to approximately 1000 °C.

Common criteria for all types of Optical Glass are

- that the cells made from it are used in the visible range of the spectrum,
- that the glasses we use are characterised by relatively low values of refractive index and dispersion,
- and that they display good resistance to chemicals.



Identification Logos for UV Cells

■ QS ■ is the identification logo which indicates that Quartz of the highest purity and homogeneity has been used for the window. Because it is produced from a silicon compound, it is also called synthetic Quartz. We use Quartz SUPRASIL from Heraeus Quarzglas GmbH, with which gives transmission values of more than 80 % over a spectral range of between 200 nm and 2500 nm for an empty cell.

■ QH ■ or ■ UV ■ are the trademarks which identity a Quartz that has been manufactured by melting natural crystalline quartz. We use HERASIL Quartz from Heraeus Quarzglas GmbH or equivalent material from other suppliers. An empty cell manufactured from this material gives a transmission of more than 80 % over a spectral range of between 230 nm and 2500 nm.

Identification Logos for NIR Cells

■ QX ■ stands for a synthetic Quartz that is free from OH absorption. Therefore it is suitable for applications in the near infrared range up to approximately 4000 nm. We use Quartz SUPRASIL 300 from Heraeus Quarzglas GmbH, which gives a transmission of more than 80 % over a spectral range of between 200 nm and 3500 nm for an empty cell.

Identification Logos for Cells for the Visible Spectrum

■ OS ■ indicates that SCHOTT type U K 5 is used for cells referred to in the catalogue as manufactured from “Special Optical Glass”. This crown glass is made from exceptionally pure raw materials, which gives an improved transmission in the near ultraviolet range. An empty cell will give a transmission of more than 80 % over a spectral range of between 320 nm and 2500 nm.

■ OG ■ is a trademark that distinguishes cells which are not used in spectrophotometry. Here, a glass is used, which we refer to in the catalogue as “Optical Glass”. We use B 270-Superwite from SCHOTT DESAG, a colourless highly transparent crown glass in the form of drawn panes with fire-polished surfaces. The quality of the surfaces is so high that the components can be fused using the Hellma process without further grinding and polishing. An empty cell made of B 270-Superwite will give a transmission of more than 80 % over a spectral range of between 360 nm and 2500 nm.

■ BF ■ is the trademark for cells which are manufactured entirely from borosilicate glass, the composition and properties of which are laid down by an international standard. This type of glass possesses a high chemical resistance and a low coefficient of thermal expansion of 3.3×10^{-6} K^{-1}. This makes it particularly suitable for use as laboratory glassware. For the windows of these cells we use SCHOTT Borofloat, a borosilicate glass manufactured using the float process. It combines the good chemical properties of Duran with very good optical properties (homogeneity, transmission). An empty cell made from this material has a transmission of greater than 80 % at a spectral range of between 330 nm and 2500 nm.

2.1.2 Transmission

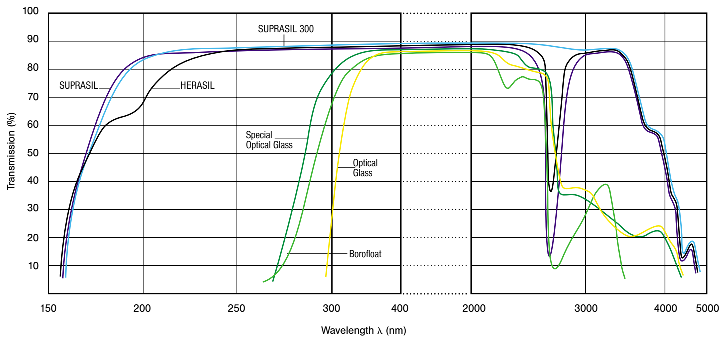
Regarding the transmission curves, please note that the measurements were carried out on empty cells. The maximum transmission values of between 80 % and almost 90% are caused in the main by reflection losses at the four glass/air boundaries. As the losses by reflection depend solely on the refractive index, the reflection losses of the empty cells can be calculated for each wavelength. For example, at a wavelength of 588 nm we obtain the following values:

Window Material	Refractive Index	Reflection Losses	Theoretical Transmission	Measured Transmission
SUPRASIL/HERASIL	1.458	13%	87%	87%±1%
Borofloat	1.473	14%	86%	85%±1%
UK 5 / B 270	1.523	16%	84%	84%±1%

The table shows that the measured transmission values within the measuring uncertainty accord with the theoretical values. From this it can be concluded that the absorption in the material at a window thickness of 1.25 mm can be disregarded.

When comparing transmission data, it is absolutely essential that identical measuring conditions prevail. Should a measurement with a clean, empty cell yield significantly higher transmission values, it is likely that this is due to a measuring error.

We can supply, on request, data sheets detailing the physical and chemical properties of the materials used.



Transmission of empty cells made of different materials

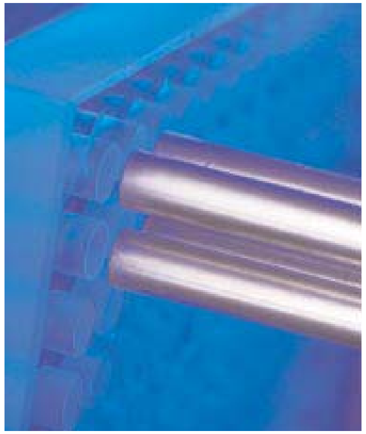
2.1.3 Production Methods

Uniquely Precise

Ever increasing demands on the cells have led to continuous development and improvement of the manufacturing processes. For our precision cells, the most important procedures are:

- Polishing
- Ultrasonic Machining
- Fusion

Polishing



Ultrasonic Machining

Fusion Technology

Polishing

The construction of the cells requires that the component parts have the optimum surface quality. We achieve this through the use of advanced machines and the experience of our highly qualified workers.

Especially for the surfaces of the cell windows, high demands apply in relation to two independent criteria. The glass surfaces must

- be free from imperfections and
- show a high degree of flatness.

Ultrasonic Machining

Many cell types, especially flow-through cells, require borings and cavities with highly complex shapes. With ultrasonic machining, which resembles the spark erosion procedure used in metal working, we possess a technology that allows us to produce high-precision borings and cavities of 0.5 mm to 60 mm in the brittle glass material. The tools required for manufacturing borings of almost any imaginable cross-sectional shape are made in our own machine-tool department.

Fusion Technology

Precision cells demand production processes which have to meet the following high standards:

- the component parts must be made with extremely tight dimensional and angle tolerances
- the polished surfaces must be exceedingly flat and free from scratches and holes
- the fusion technique used must, on the one hand guarantee a permanently stable connection of the parts, while maintaining the tolerances, and on the other it must ensure a high degree of resistance to chemicals and extremes of temperature.

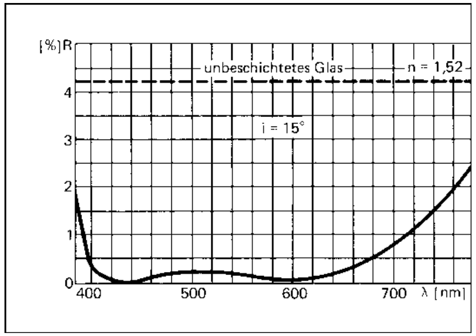
The process of direct fusion, which was developed by Hellma, and is almost always used nowadays ideally fulfils these requirements. However, it also presupposes that the surfaces to be fused together are polished and possess a flatness tolerance of less than 1 µm. Since no adhesives whatsoever are employed for fusing the glass parts, the seams display the same high resistance against chemicals and increased temperatures as the solid glass itself. Sinter glass fusing is only used in the few exceptional cases where direct fusion is impossible for technical manufacturing reasons.

Antireflection Coating

When radiation passes through the cell, part of it is reflected by the exterior surfaces. The transmission is reduced by this reflected portion by approximately 8 %. Vacuum evaporation of thin layers of a suitable material can reduce these reflections, thereby giving a higher transmission for the cell.

The standard is a multilayer antireflection coating that reduces reflection over a broad spectral range. Over a spectral range of between 440 nm and 650 nm the reduced reflectance is at most 0.4 %. This coating is highly adhesive and resistant to both abrasion and climatic influence.

On request we can also supply other kinds of AR coatings. For this purpose, please specify the spectral range and the reduced reflectance per surface. It is impossible to provide an AR coating covering the full spectral range from 200 nm to 2500 nm.

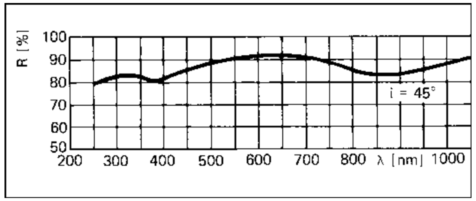


Reduced reflectance of an antireflection coated glass surface

Mirror Coating

For some purposes (e.g. fluorescence measurements) mirror coated cells are used. Both the rear window to the incident light and the left adjacent window are mirror-coated on the outside. The standard mirror coating consists of a layer of vacuum-evaporated aluminium that has a degree of reflection of more than 80 % over the spectral range between 250 nm and 2500 nm. This coating is covered with a protective layer which is extremely hard and durable. Additionally, the mirror-coated windows are protected against external scratches by a layer of black lacquer.

On request we can also supply metal coatings with different reflective properties and with the coated surfaces in other positions. Further information can be found in chapter 2.3.10.



Spectral reflectance of an aluminium layer

2.1.4 Dimensions and Tolerances

The basis for the description of all of the cells presented in this catalogue are technical drawings that give a complete specification of every product. To ensure unambiguous information for both our customers and our manufacturing department, we adhere strictly to the standards of DIN and - where available - of ISO.

The Most Important Standards

In the manufacture of cells, Hellma pays particular attention to the following standards.

- DIN 58963 Part 1 Optical cells for photometric measurements; concepts
- DIN 58963 Part 2 Optical cells for photometric measurements; requirements concerning rectangular and cylindrical spectrophotometric cells
- DIN ISO 10110 Preparation of drawings for optical elements and systems, parts 1 to 11
- DIN 58170 Part 54 Inscriptions, signs, and symbols for dimensions and tolerances for optical systems; blemishes
- DIN ISO 1101 Tolerances of shape and position

Practical Examples

We are frequently asked for general details concerning the values of flatness, parallelism and wedge error, respectively. Using a typical example, the cell model 100-QS with 10 mm light path, we will show that it is by no means easy to answer these questions.

Flatness

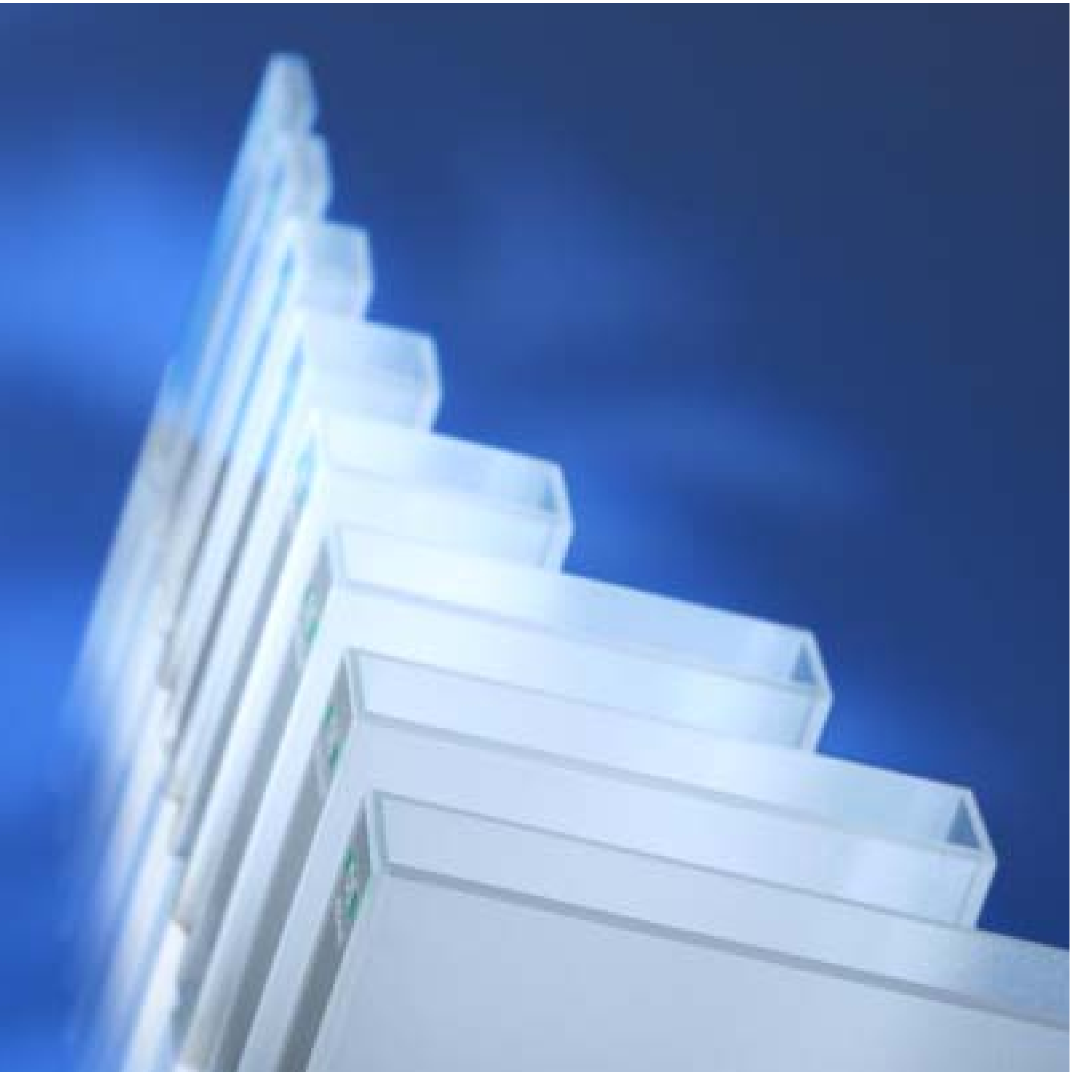
The question concerning flatness is most easily answered for loose windows. Their surfaces possess a flatness of better than 0.001 mm (1 µm). The parallelism of the two surfaces to each other is of the same order of magnitude.

On the other hand, during measurements with the filled cell, the effect of the possibly slightly distorted inner surfaces is compensated for by the similar refractive indices of liquid and glass. In this case the only meaningful value is the extent to which a plane wave is deformed upon passing through the cell. The wavefront deformation amounts to less than 4 lambda in the above example, giving about 0.002 mm (2 µm) at lambda = 546 nm.

Parallelism with Respect to Wedge Error

In this case the parallelism of the outer surfaces to each other concerns only the parallelism of the polished surfaces of the U-shaped frame, since - as already mentioned - the wedge error of the window surfaces is negligible. Using our path length tolerance and assuming the least favourable case of a horizontal wedge angle, a value of about 3 minutes of arc or expressed as deviation from parallelism of 0.01 mm results.

Since the example shows that the indicated values depend on design, shape and dimensions of the cells, values can only be given for each cell type individually. For this reason we supply, on request, a technical drawing for each cell in which all the necessary details required for use are specified.



Light Path and Tolerances

The light path is a particularly important parameter for some photometric applications. Please note the following data for tolerances, shown in relation to light path and material of the cells:

Material	Light Path	Tolerance
Quartz	0.01 mm to 0.05mm	± 0.003 mm
Quartz	0.1 mm to 0.2 mm	± 0.005 mm
Quartz	0.5 mm to 20 mm	± 0.01 mm
Quartz	40 mm to 100 mm	± 0.02 mm
Special Optical Glass	0.1 mm to 20 mm	± 0.01 mm
Special Optical Glass	40 mm to 100 mm	± 0.02 mm
Optical Glass	10 mm to 30 mm	± 0.1 mm
Optical Glass	40 mm to 100 mm	± 0.2 mm

These light path tolerances apply to absorption cells.

For fluorescence cells, both for excitation and emission the tolerance is ± 0.05 mm.

Tips

Please also note the following concerning the light path: For certain cell types you will find individually specified values for dimensions and tolerances in this catalogue.

- We recommend quartz cells for light paths below 0.5 mm because this material helps to maintain the tolerance.
- For cells with a light path below 0.1 mm, we measure, on request, the light path interferometrically to an accuracy of 0.2 µm.
- For cells with loose windows (cells 106, 124, 136, 201 and 210.003) the figures given for the light path only indicate the thickness of the frame. These figures do not necessarily match the thickness of the liquid once the cell is mounted and filled.

Hellma®
Precision in Spectro-Optics. Worldwide.

2.1.5 Spectral and Polarimetric Measurements

Spectral and Polarimetric Measurements

As a result of the improvements in glass production and through the perfection of the polishing process, all cells are produced with transmission values, which within the limits of the measuring uncertainty, agree with the theoretical transmission. (see chapter 2.1.2)

On request all cells can be spectrally calibrated and assembled into sets of equal transmission values (Measuring uncertainty ± 1%). These cells are provided with a three digit calibration code number containing coded data about the material and the transmission at a wavelength typical for the cell material.

In the case of a repeat order please be aware that, through usage, your cells will probably not have the same high transmission values as the new cells.

Polarimetric Measurement

For some applications, e.g. in polarimetry and for circular dichroism measurements, it is important to check that the cells are free of strain birefringence. The effect of possible strain birefringence is determined in the following way:

In a polarimeter the rotation of the plane of polarisation of the incident linearly polarised light ist measured. The measurement is carried out in a circular area of approximately 3 mm diameter whose centre coincides with the centre height of the empty cell. Because of the measuring geometry, only cells with an aperture diameter or aperture width of greater than 3 mm can be measured in this way.

On request, we specify the types of quartz cells whose dimensions and design permit this determination of possible strain birefringence to be carried out.

Cells that have been polarimetrically checked are marked with a “P” and are delivered together with a certificate confirming that the predetermined limit for the rotation angle of 0.01° to the left or to the right is not exceeded.

2.1.6 Handling Tips

Taking Care of Your Cells

Our precision cells are manufactured from glass and quartz and possess all the benefits of this material. We generally recommend that cells are cleaned and dried immediately after use and returned to their storage cases. Do not keep the cells in the open in a corrosive atmosphere, and do not leave the polished windows in contact with liquid over long periods of time. Both conditions could lead to formation of deposits or stains and could render the cells unusable.

To avoid scratches on the precision-polished windows, the cells should never come into contact with objects made of hard materials like glass or metal.

- Care is required when inserting the cells into a metal cell holder.
- When filling the cells with liquids using a pipette, never touch the polished windows with the pipette.
- Never use metal tweezers or pliers for carrying or holding the cells.

Use Caution When Handling Cells with Stoppers

Cells that contain liquid and are sealed with stoppers may crack as a result of increased inner pressure. The most common cause of such a pressure increase is the expansion of the liquid within the cell due to an increase in temperature.

A temperature increase can be caused by:

- heat conducted from an exterior source
- a chemical reaction within the liquid
- radiation absorption within the liquid

Tip

You can avoid the destruction of the cell by too much pressure in the following ways:

- Fill the cell just high enough so that the light beam can pass through the liquid. The liquid can expand into the remaining cell volume when its temperature increases.
- If you fill the cell to the brim, only put the stopper on loosely so that the extra liquid can escape.
- Do not try to force the stopper into place, as this will inevitably result in damage to the cell.
- Use stoppers with a pressure release capillary.

Please note that high pressure may destroy some other kinds of cells as well. This occurs if the liquid contained is subjected to extreme changes in temperature. For example, cells for anaerobic measurements may be affected.

On the one hand it is possible to cool an empty cell down to just few Kelvin without destroying it, but the same cell, even if it is not sealed will burst, if filled with water and brought to a temperture a few degrees below the freezing point. The reason for this ist the fact that water does not only expand upwards when it freezes, but in all directions equally which can cause the cell to burst.

Hellma® Precision in Spectro-Optics. Worldwide.

2.1.7 Cleaning of Cells

Quartz as well as the other optical glasses used for our cells is highly resistant to chemicals. Only hydrofluoric acid (HF) will etch the surface within a short period. Conversely, this means that with a few exceptions all alkaline and acidic solvents, including organic solvents, may be used for cleaning the cells

From this, the following general recommendation can be deduced:
If you know the nature of the contaminating substance, for cleaning, use the solvent in which the substance was dissolved. In general and also with regard to environmental aspects, we recommend cleaning with an aqueous solution of Hellmanex® II.

Cleaning Tips

Hellmanex® II is an alkaline liquid concentrate for the efficient cleaning of cells and other optical parts made of quartz and glass. It automatically and completely removes even the most stubborn contaminants such as fats, oils, waxes, dried blood, proteins, pigments, silicon oil, and traces of many other organic and inorganic substances.

Procedure

The following procedure has proved effective: The cells are placed in a bath containing a 2 % aqueous solution of Hellmanex® II. Flow-through cells are cleaned by pumping the cleaning solution through the cell in a closed cycle. The duration of the cleaning cycle depends on the degree of contamination and may last up to several hours.

Heating the cleaning solution will speed up the cleaning process. However, care must be taken especially with glass cells, and abrupt changes in temperature must be absolutely avoided .

Another possibility to boost the cleaning efficiency is to agitate the cleaning solution. Although ultrasonics improves the cleaning process noticeably, we nonetheless caution against its use. Too high an energy density and/or unfavourable frequency may destroy the cells. Particularly at risk are cells manufactured from several materials (glass, metal, plastics).

Furthermore, ultrasonic treatment may render the cells unusable by attacking the polished surfaces by cavitation. This happens relatively easily if the cell is placed directly on the bottom of the ultrasonic bath and is cleaned for too long a period.

After cleaning, the cells must be thoroughly rinsed with water, the minimum being three rinsing cycles. For rinsing it is best to use demineralised water, which has been filtered to remove solid contaminants.

Drying is best achieved by using one of the following procedures:
- Clean air drying unit
- Dust free drying oven
- Rinsing with a volatile solvent (ethanol) and subsequent evaporation.

Make sure that the cleaning solution does not remain in the cell at high temperatures thus causing it to evaporate competely. The surface of the glass could be damaged by the increased concentration and high pH-values.