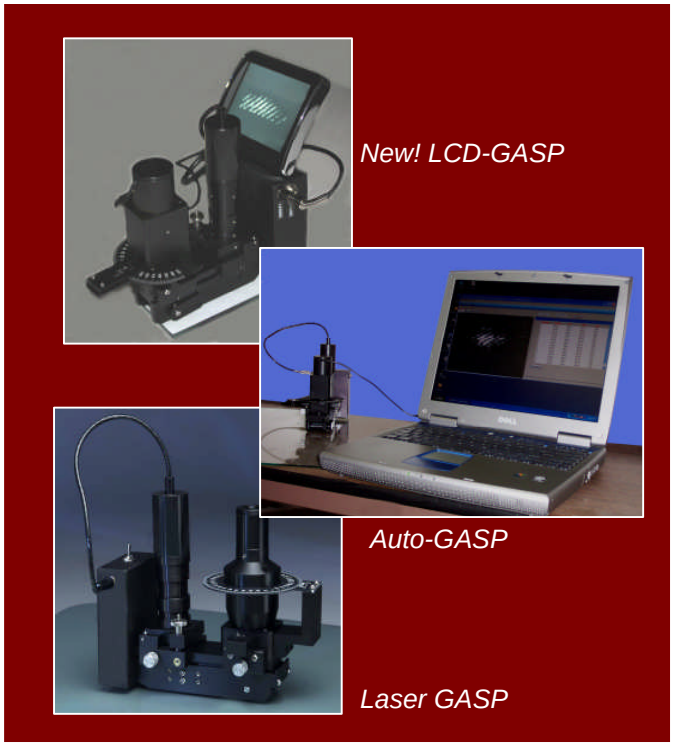
GASP® INSTRUMENTS

FOR MEASURING SURFACE STRESS IN TEMPERED, HEAT-STRENGTHENED, AND ANNEALED GLASS



The GASP Grazing Angle Surface Polarimeter is used for obtaining quantitative, non-destructive measurements of residual surface stress (pre-stress) on the “tin side” of flat, soda-lime float glass. Suitable for in-plant or field testing, it provides fabricators and end users with an accurate and simple method to:

- Measure surface compression levels in heat-treated architectural, structural, solar, and automotive glass to ensure required mechanical strength and fragmentation characteristics
- Reduce or eliminate the need for destructive testing for many types of glass products
- Improve process control and productivity through optimization of furnace parameters
- Assure proper annealing
- Comply with worldwide industry standards and test methods, including ASTM, GANA, and CE requirements*

Models for borosilicate float glass available on special order.

GASP Models

The GASP polarimeter is available in two basic models: :

GASP - the standard model for flat surfaces. It can also be used for slightly curved surfaces (radius of curvature >500 mm).

GASP-CS - recommended for curved surfaces with a radius of curvature >200 mm.

Either of these models is offered with a choice of light sources. A low-power diode laser is standard and a high-intensity fiberoptic light for darker glass is also available. Video GASP options replace the standard eyepiece with either a separate or built-in LCD video monitor.

In conjunction with licensed software and a PC, an ac-operated **Auto-GASP** option enables automatic calculation of measurements by replacing the GASP visual eyepiece with a video camera (not for annealed glass).

* The GASP may be used for verification of surface compression in production samples of safety glazing, but not for certification.

GASP instrument packages include:

- **GASP-STATION™** recharger/base station OR AGP power station/cradle for ac models
- Rechargeable batteries for battery-operated models
- Standard (1X) measuring wedge for heat-treated glass, high-sensitivity (2X) measuring wedge for annealed glass, or extended range (0.5X) measuring wedge for very highly tempered glass.
- GASP index matching fluid (4 oz)
- Portable UV light (tin side detector)
- **CAL-PLATE™** for instrument verification
- Operator manual with calibration chart and certification documents
- Instrument-quality carrying case

Strainoptics®

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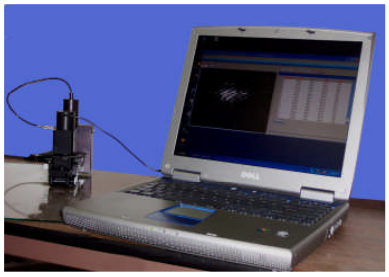

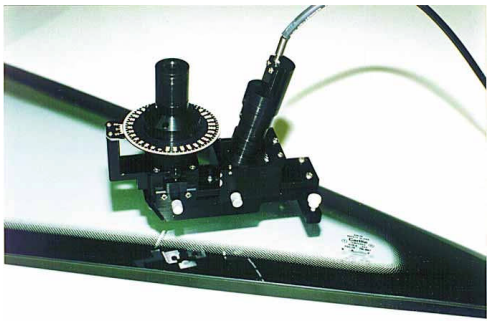

Applications for GASP Measurements:

- Heat-Treated Glass
- Safety Glass
- Annealed Glass
- Solar Glass
- Automotive Glass

Specifications (Soda-Lime Float Glass Model)

Light Source:	Diode Laser	Fiberoptic (White Light)
GASP or GASP-CS with 1X Standard Wedge		
Measuring Range:	0 to 180 MPa (0 to 25,000 psi)	0 to 90 MPa (0 to13,000 psi)
Resolution (+/-):		
Tempered Glass:	3.4 MPa (500 psi)	3.4 MPa (500 psi)
Heat-Strengthened:	1.7 MPa (250 psi)	1.7 MPa (250 psi)
Annealed:	0.75 MPa (100 psi)	0.75 MPa (100 psi))
GASP or GASP-CS with 2X High-Sensitivity Wedge		
Measuring Range:	0 to 84 MPa (0-12,000 psi)	0 to 35 MPa (0 to 5,000 psi)
Resolution (+/-):		
Annealed:	0.50 MPa (75 psi)	

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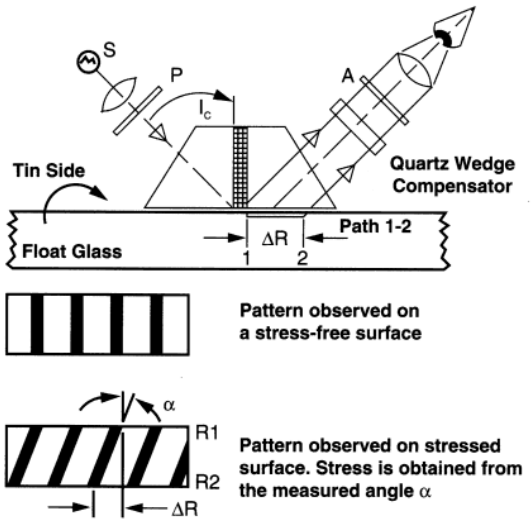
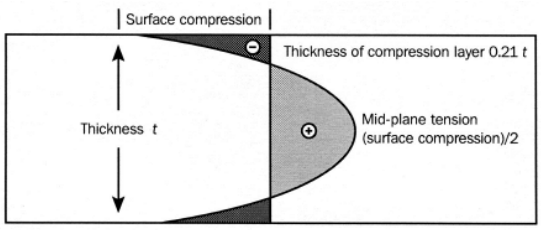
How the GASP® Polarimeter Works



The GASP surface polarimeter is based on photoelastic test methods, using light rays traveling along the glass surface. The operation schematic is shown below. In use, the operator places a drop of index matching fluid on the tin side of soda-lime float glass) to ensure optical contact. The instrument is placed with its prism surfaces on the fluid, such that light travels through the entrance prism at a critical angle i_c, enters the top surface of the glass and propagates parallel to the surface for a distance before emerging at a critical angle into the exit prism and up toward the eyepiece.

The surface stress introduces a photoelastic retardation R that increases linearly along the path 1-2. A quartz wedge (Babinet) compensator, containing a tight set of straight fringes, is placed on the path of the exit beam. The change in retardation, ΔR, from 1 to 2, produces a tilt of the fringes at an angle α, which is viewed through the GASP eyepiece. A dual reticle also appears in the eyepiece, which is rotated by the operator to match the fringe angle. The angle of the reticle lines is easily read by the operator and converted to a stress reading (psi, MPa). A calibration chart provides the surface stress measurement for each angle reading. The higher the angle, the higher the surface stress. Left-leaning lines indicate compression; right-leaning lines indicate tension (The opposite is true for the Video- and Auto-GASP due to image inversion by the camera optics).

Applications



Tempered (Toughened) Glass. The strength of tempered glass is created by a heating and quenching process which creates a surface layer of compressive stresses, offsetting any tension caused by wind pressure, thermal shock, impact or other applied forces. ASTM C1048, EN12150-1 and other specifications require a minimum level of surface compression for glass to be classified as "Fully Tempered". While higher surface compression assures glass strength, the tempering process also creates tensile stress in the glass mid-plane (see figure) which should also be controlled. If the tensile stress is too high, the glass may spontaneously rupture if it contains certain inclusions or defects. For this reason, an upper stress limit should be established to avoid potentially serious problems.

Safety Glass. "Safety" glass is strong, and it breaks into small, relatively harmless fragments. The surface stress in safety glass is typically above 15,000 psi (100 MPa). Break pattern testing is destructive and imprecise, and can result in substantial production loss if the results are not satisfactory. As with fully tempered glass, spontaneous breakage is known to develop in safety glass, with even larger financial losses. To optimize furnace settings, ensure conformance to specifications and avoid under- or over-stressing, safety glass should be frequently tested with the GASP.

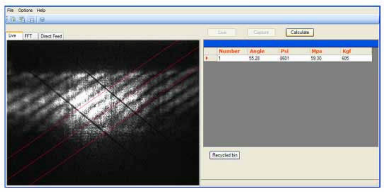
Heat-Strengthened Glass. Heat-strengthened glass is stronger than annealed glass, but does not break into small fragments like safety glass. This characteristic is desirable when "fallout resistance" is required, such as for exterior glass in high story buildings. Surface stress in heat-strengthened glass must fall within narrow limits, specified by ASTM C1048, EN1863-1 and related standards. Fragmentation testing is not practical because the break pattern is very unpredictable, making the GASP surface polarimeter the most reliable way to test heat-strengthened glass for conformance to industry specifications.

Annealed and Low-Stress Glass. Non-destructive measurements of surface stress in annealed and low-stress glasses can be measured using a GASP instrument equipped with a high sensitivity wedge. In bent glass and in laminated automotive windscreens, the surface stresses are higher than in annealed glass and should be tightly controlled to remain within limits and detect areas of undesirable surface tension caused by bending.

Solar Glass. Manufacturers supplying the solar glass industry use the GASP surface polarimeter to ensure that both cover glasses and substrate glasses conform to their customer's specifications. Solar panel fabricators use it for incoming QC for the same reason. Non-uniform stresses in glass used for solar applications can cause a range of problems, ranging from degraded efficiency, poor impact resistance and mechanical strength, to lamination and assembly issues that can cause expensive field failures.

Note: This instrument is not suitable for the following types of glass: chemically-strengthened, patterned (rolled), low transmittance (<25% LTA), low tin, or coated on the tin side. For these applications, Strainoptics may be able to offer an alternative means of stress measurement. Please inquire.

Auto-GASP™ • Video-GASP™ • LCD-GASP™



Auto-GASP Screen

Video-GASP System

The new Auto-GASP makes it possible to calculate surface stress in heat-strengthened or tempered glass automatically without the need for referral to a calibration chart, and then to save the stress data to a computer. The standard GASP eyepiece is replaced by a CCD camera and the image obtained by the operator is analyzed by specialized software, minimizing the chance for operator error. The Video-GASP system includes a GASP instrument also equipped with a CCD camera, but there is no automatic analysis. The image normally seen through the eyepiece is displayed on a 13" monochromatic monitor for ease in viewing and less operator fatigue when frequent measurements are required. The new LCD Video-GASP features a built-in 3.5" video display for added convenience and portability. Conversion kits are available for field retrofit of standard GASP instruments to the Auto-GASP or Video-GASP. Conversion from the standard or Video GASP to the LCD Video GASP can be done at the factory.

LCD Video-GASP System

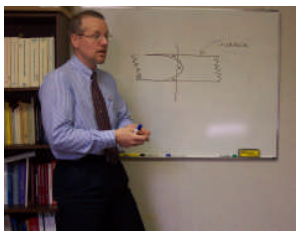
Vertical Fixture

Calibration and Certification

Each GASP instrument is factory calibrated and comes with a certificate of traceable calibration according to ASTM Procedure C1377. Strainoptics offers annual or periodic recalibration services as required. A certified CAL-PLATE is supplied with each complete GASP system to enable customers to self-certify their instrument where possible.

Cal-Plate with Calibration Certificate

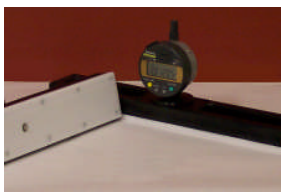
Testing and Training Services



Surface stress, edge stress, and other laboratory residual stress testing services are available from Strainoptics using equipment and test methods in accordance with ASTM and NIST standards. Strainoptics also provides training programs free to customers at our facility in North Wales, PA, or on a fee basis at a customer's location.

Other Strainoptics Products

In addition to the GASP surface polarimeter, Strainoptics manufactures a complete range of manually operated and PC-based instrumentation for glass manufacturers and fabricators. These include on-line stress scanners for float glass production, visual and automatic edge stress meters, laboratory polarimeters and polarizing microscopes for analyzing stress distribution, specialized instruments for measuring stress and light transmission in automotive glass, roller wave gauges for measuring reflective distortion in architectural tempered glass, simple strain viewers (polariscopes) for visual inspection using photoelastic evaluation, and UV tin side detectors. Custom inquiries are always welcome. For more information, please visit our website or call.



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