

Prism®

Electronic Speckle Pattern Interferometry

Residual stress measurement based on hole-drilling and ESPI



stresstech group

Prism® Unique Features

Prism is a new way to measure residual stress in a wide variety of materials. It combines the tried-and-true hole-drilling method with digital imaging and ESPI (electronic speckle pattern interferometry). No special sample preparation – such as the application of a strain gage – is required. The instrument delivers the complete planar stress state.

The typical application for Prism is stress depth profile measurements by incremental drilling. Basically any material that can be drilled can be measured. A particular advantage of the instrument is its speed, which is most effective when several similar samples or a series of locations on one part are to be analyzed. Measurement is simple and can be performed in a fully automatic mode.



Prism Residual Stress Measurement

Prism dramatically improves the ability to make quick, accurate residual stress measurements. The technology utilizes a stress-relaxation technique, where a small hole is drilled into the part, thereby removing residual stress and causing a rebalancing of the remaining stresses. This leads to a slight surface distortion, which is measured optically using electronic speckle pattern interferometry (ESPI).

A standard Prism system comprises computer, laser light source, illumination and video heads and a high-speed drill. The system software fully integrates the hardware to provide all functions for data

acquisition and analysis. Measurements can be performed one depth increment at a time, as a complete depth profile fully automatically or anything in-between. The instrument is easy to set up and easy to operate. Measurement is highly accurate and fast.

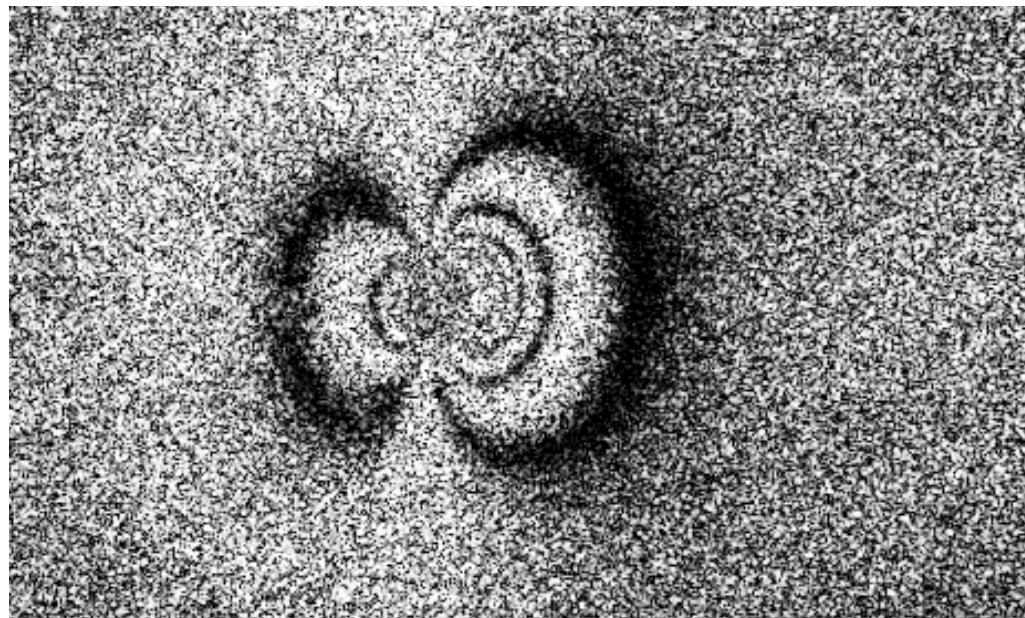
Key Benefits

- **Little preparation:** clean measurement surface with low-reflectivity
- **Fast:** typical measurement and analysis in less than 5 minutes, extensive depth profile within ½ hour
- **Easy:** computer controlled, automated drilling

- **High-resolution:** monitor stress changes much less than 7 MPa (1 ksi)
- **Customizable:** complete planar stresses, single-depth and depth profile measurements
- **Accurate:** full-field analysis, alignment not required
- **Non-contact:** only requires direct visual path to part; no strain gages to be applied
- **Materials:** includes materials difficult for XRD like titanium and plastics; limited mainly by the ability to drill holes

Hole-drilling

Hole-drilling is a residual stress measurement technique where stressed material is removed by drilling a small blind hole into the component of interest. After drilling the remaining material in the vicinity of the hole spontaneously finds a new stress equilibrium. This re-arrangement of stresses leads to a slight distortion of the surface near the hole. Though the displacements are small, they are measurable and allow the calculation of the stresses that were present in the component prior to drilling. The hole-drilling method is considered a semi-destructive method, because the hole drilled may have a negligibly small effect on part performance.



Example of a speckle pattern near a drilled hole. The fringe pattern is a quantitative indication of the stress relieved.

Measurement Procedure

The typical measurement procedure starts with determining the surface, i.e. the location from where hole depth is measured. Prism detects the surface by an electrical contact method, where the drill moves towards the part until it starts cutting it and electrical contact between drill bit and part occurs. Alternatively, visual surface detection may be used. The user then sets a list of drilling depths and starts data acquisition. The individual drilling step is always performed automatically. Laser images of the surface are taken after each drilling step. One additional image is taken for defining hole position and image scale.

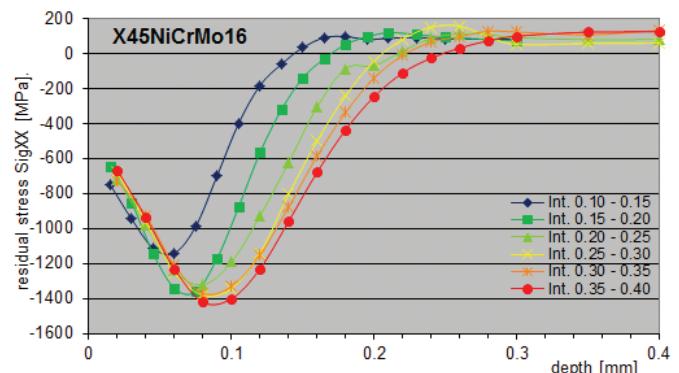
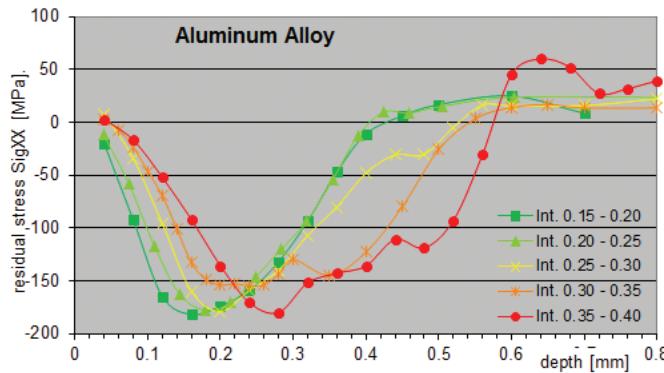
PrismS Software

The new software PrismS makes measurement and data management simple and convenient. Each data file combines multiple measurements and multiple stress calculations can be saved for each measurement. White-light images can be added to document the process. Measurement execution is intuitive. The user can run individual drilling increments manually to monitor the process or switch to fully automatic measurement at any time. The drilling process can be customized via several parameters to address the challenges different materials pose for drilling.

Stress Results

The stress calculation follows the Integral Method and uses incremental referencing. Stress depth profiles are calculated for the sample coordinate system – horizontal, vertical and shear stresses – and for the principal stress directions. Regularization and other calculation variables such as data correction are integrated as options.

The software automatically generates multiple graphs for easy comparison of different calculations and measurements. Data export is very easy.



Measurement examples from two material shot peened with different intensities, shot peened aluminum (left) and shot peened tool steel (right).

Technical Specifications

Safety

- Prism is a Class 3R laser instrument. The laser head actually produces about 25 mW power but is completely encased. The intended operation and maintenance do not provide access to laser power of 5 mW or more.
- Product complies with 21 CFR Subchapter J except for deviations pursuant to Laser Notice 50, dated June 24, 2007, and IEC60825-1, 2007.



- Prism uses electronic shutters for this instrument. They are closed unless opened using a software command.

Prism system hardware

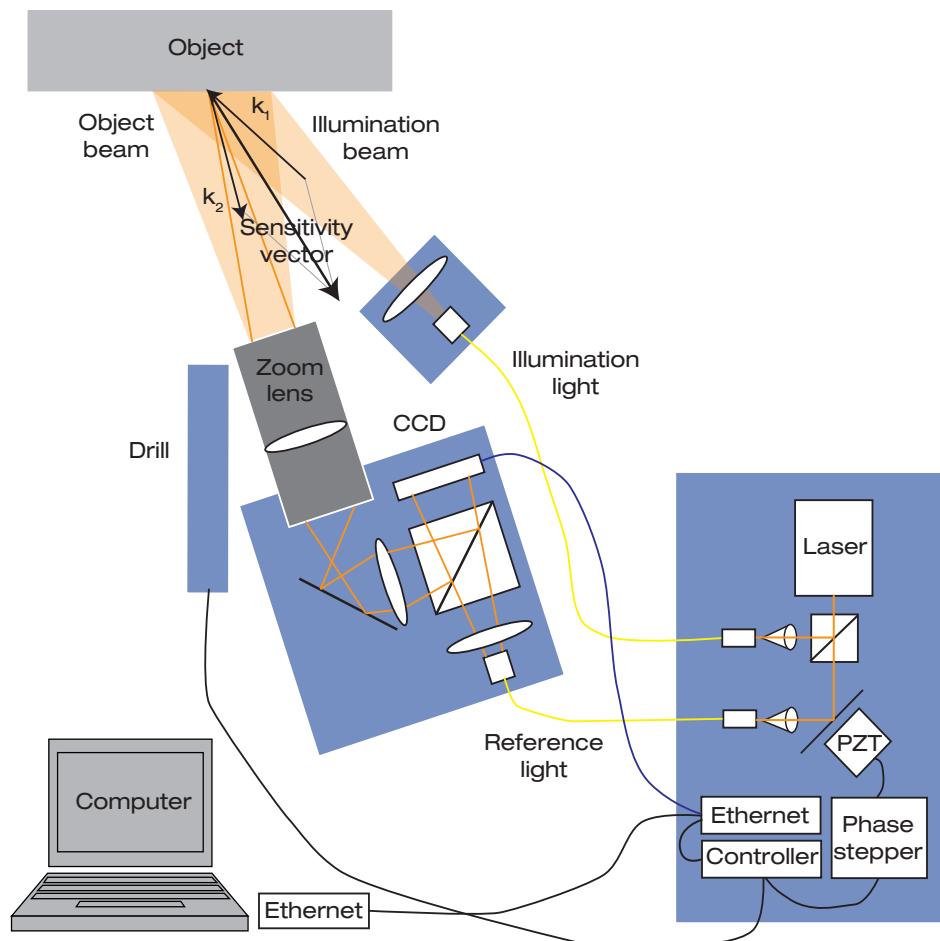
- Light source unit
- Illumination head
- Video head with optical zoom barrel
- Fiber optics
- Breadboard or optical table
- High-speed electric drill
- Linear stage, actuator and linear motion controller
- Pneumatic air controller
- Chip air system
- Personal Computer

PrismS Software

- The software fully integrates the hardware to provide computer controlled hole-drilling and imaging.
- Stress calculations can be performed for single- and multiple-depth holes. Tikhonov regularization is integrated for stress profiles.
- Windows based software (Windows 7 or 8, etc.)

Requirements

- Regular electrical power, 220 V / 110 V
- Vibration control via optical table or breadboard
- Pressurized air for cooling the high-speed electric drill and for chip removal



Contact Stresstech Group offices to discuss your particular application.



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