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Application Note

Speckle Pattern Fundamentals

2026

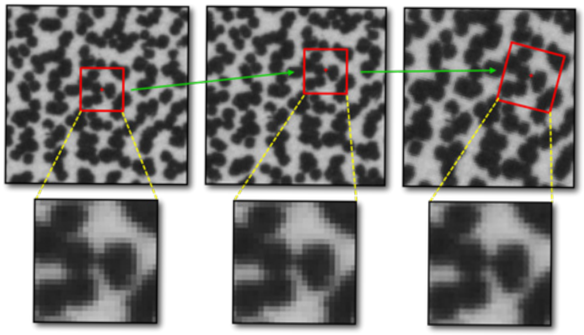
Speckle Pattern Fundamentals

Introduction

In digital image correlation, using an optimal speckle pattern is one of the most important factors in reducing measurement noise and improving overall results. Understanding the requirements of an ideal speckle pattern and how to apply one to a specimen facilitates the use of DIC. Here we discuss why a good pattern is needed, pattern requirements, common application methods, and guidance on some difficult or specific cases.

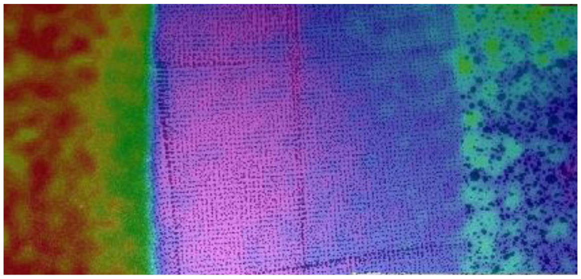
Why do I need a good pattern?

In DIC, a mesh of small subsets of the image are tracked as the specimen moves and deforms. To perform this tracking, the subsets are shifted until the pattern in the deformed image matches the reference image as closely as possible; this match is calculated by the total difference in grey levels at each point.

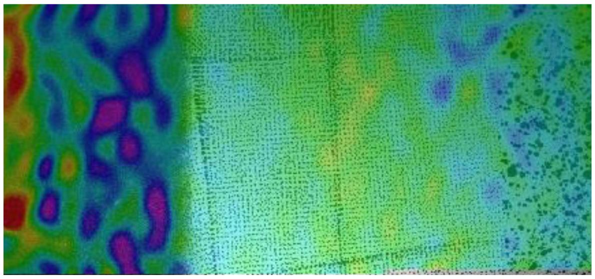


Visualization of subset tracking during movement and deformation.

A good pattern will allow the correlation to be made with high confidence and produce low noise. Below is shape and strain measurement data for a flat plate with different speckle patterns. The middle region illustrates an optimal pattern for this particular test, while the left and right regions are less adequate.



The uncertainty in shape measurement is significantly lower for good patterning.



The unstrained plate shows higher strain noise in regions with poor patterning.

Pattern Requirements

In order to provide good tracking information, the speckle pattern should consist of the following characteristics:

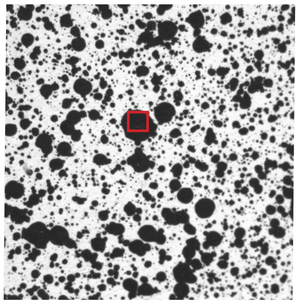
- High contrast: Either dark black dots on a bright white background or bright white dots on a dark black background.
- 50% coverage: We want about equal amounts of white and black on the surface. For example, if the speckles are 5 pixels in size, they should be approximately 5 pixels apart from one another.
- Consistent speckle sizes: speckles should be ideally 3-5 pixels in size in order to optimize spatial resolution, but the most important thing is that the speckles are consistent in size and not too small (less than 3 pixels in size is too small and can cause aliased results).
- Isotropic: The speckle pattern should not exhibit a bias in any particular orientation.
- Random: It is actually hard to achieve a pattern regular enough to cause false matching, but if you are to print repeating patterns it can occur. Even using templates/stencils with repeating dots is typically irregular enough due to the paint seeping through the stencil being irregular.

Speckle Size

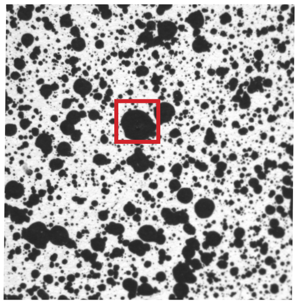
Speckles should neither be too small nor too large. In practice, there is a wide range of how large a speckle pattern may be, and still achieve excellent results. However, having an optimal pattern will give the best flexibility.

If the pattern has speckles that are too large, or if it is too sparse, we may find that certain subsets may be entirely on a region of black or region of white. This prevents good correlation, because everywhere in that region is an exact match.

We can compensate for this by increasing the subset size, but this is done at the cost of spatial resolution.

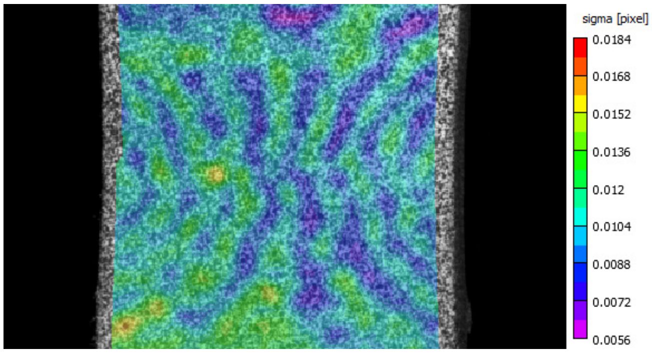


Subset contains no contrast; correlation may fail.



Larger subset needed to create contrast within subset; loss of spatial resolution.

Conversely, if the pattern is too small, the resolution of the camera may not be enough to accurately represent the specimen; in information terms, we call this aliasing. Instead of appearing to move smoothly as the specimen moves, the pattern will show jitter as it interacts with the sensor pixels; resulting images often showing a pronounced moiré pattern in the results.



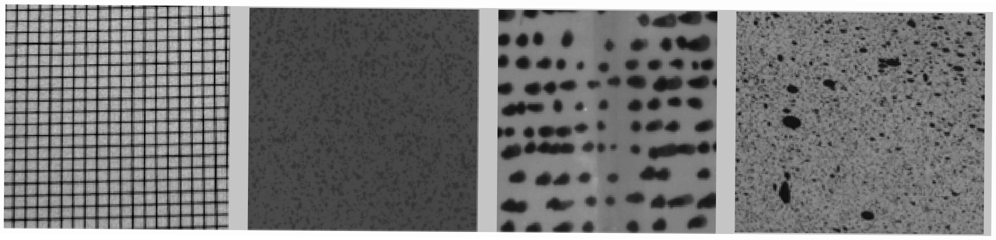
The result of overly-fine speckles causing aliasing: moiré pattern showing.

To avoid the risk of aliasing while still maximizing spatial resolution, we try to apply speckles that are 3-5 pixels in size. However, in doing so, we often end up with some of the speckles falling in the 1-2 pixel range (especially when using application methods that are harder to control). For this reason, we suggest aiming slightly larger when in doubt. Speckles should be visible as distinct features, as opposed to random black and white noise.

Note that these guidelines for sizes are in terms of pixel size; using a higher resolution camera or smaller FOV will require a pattern that looks finer than a pattern required for a lower resolution or larger FOV. For example, on a 10” FOV, a 1000x1000 pixel sensor (1MP) has 0.01” per pixel, so a good speckle size would be 0.05”. For the same FOV using a 4800x4800 pixel sensor (16MP) has 0.002” per pixel, so a good speckle would be 0.01” in size.

Poor Patterns

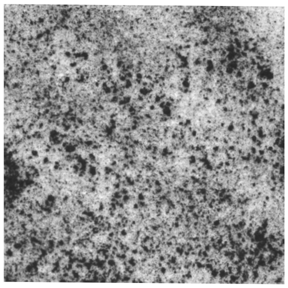
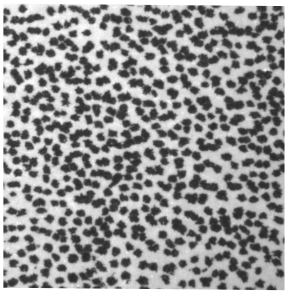
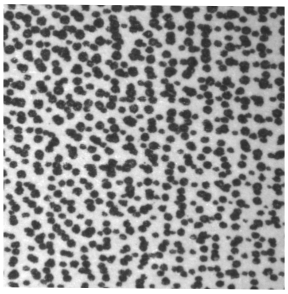
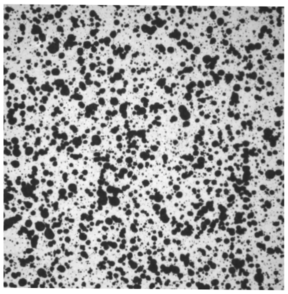
The following are some examples of patterns that fail one or more of the requirements for good patterning. These should NOT be used.



Repetitive | *Low contrast Too sparse* | *Anisotropic Too sparse* | *Inconsistent Dot SIzes*

Good Patterns

For better results, use patterns similar to the following examples.

Common Application Methods

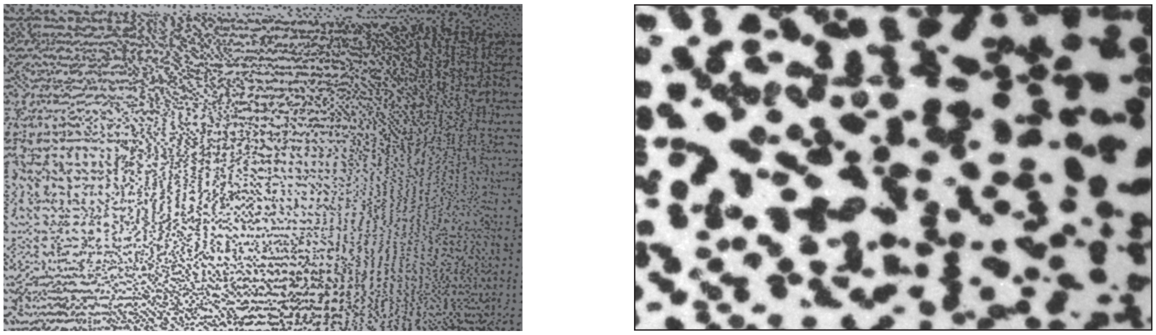
A variety of methods exist to apply a good speckle pattern to specimen. Some of the most common include:

- Correlated Solutions Speckle Kit
- Spray paint
- Sharpie patterns
- Printed patterns

Speckle Kit from Correlated Solutions

The Speckle Pattern Application Kit from Correlated Solutions contains an array of stamp rollers/rockers designed to consistently produce optimal speckle patterns. The stamp and rollers apply ink to the specimen by rolling dots onto the surface. The stamp rockers are pressed onto the specimen, or a specimen can be rolled over the unmounted stamp. The stamps have a range of dot sizes so the correct speckle can be created depending on camera resolution and FOV. It is often necessary to apply a base coat (often white paint) to the surface prior to stamping or rolling.





Speckle patterns produced using the Correlated Solutions Speckle Kit.

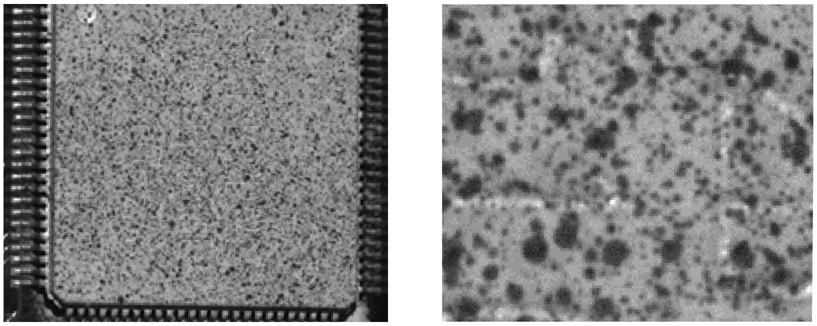
Spray Paint

Spray paint is one of the easiest and most readily available methods to apply speckle patterns. Spray paint can be used with any intermediate-size specimen. This is usually a good choice for metal, ceramic, or composite specimens from ~1" (25mm) to ~48" (1.25m).

For best results using spray paint, use matte paints; satin of gloss paint can cause specular reflections, especially under intense lighting. Some recommendations include Rust-Oleum Painter's Touch 2X Flat Black/White and Krylon Flat Black, which are commonly available at hardware stores.

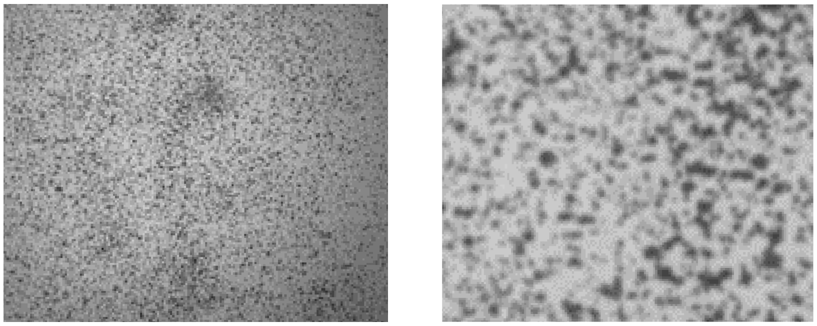
Typically, the surface of the specimen is coated white, in several very light coats. Heavy coats may lead to drips forming which change the shape of the surface. Once the base is somewhat dry, the speckles may be applied. If the base coat is still wet, the paints will blend and blur.

To apply small speckles, create a fine mist further away from the specimen. Quickly move the spray stream across the specimen. If large paint drops are landing on the specimen, consider holding the specimen above the spray stream, as to allow the larger drops to fall below.



Spray paint used on a 1" field of view.

For larger fields, larger speckles must be produced. This can be accomplished by either modifying the spray nozzle or throttling the spray. One effective technique is to place the surface horizontal and spray down onto in. If the spray nozzle is barely pushed down, large blobs will come out and fall onto the surface.



Spray paint used on a 48" panel.

Using spray paint typically produces a sufficient pattern, but the quality can vary a great deal. Due to the nature of spray paint, creating consistent speckle size is near impossible, and contrast is often reduced by fine mist effectively graying the basecoat when the speckles are applied. If a user wishes to see strains near the noise floor of DIC (typically 100-1000 microstrain), another method may need to be considered.

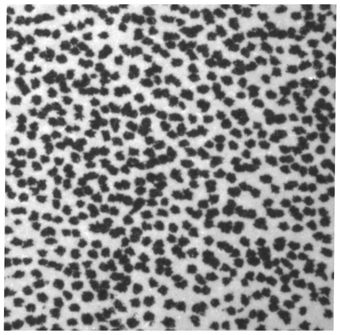
Applications where the specimen would be stiffened or chemically altered by spray paint should consider other speckling techniques if necessary.

Sharpie/permanent marker patterns

Applying speckles with a sharpie marker can often be a good technique for creating the speckle pattern. This technique affects the surface minimally and allows for measurement of very high strain. It also allows for very controlled speckle size and the ability to be applied to specimen with complex geometry and textures.

Simply dot the surface of the specimen with the marker to create dots of the desired size (several sizes are available: ultra-fine, extra-fine, fine point, marker, and bold). A white base coat with black markers provide excellent contrast.

It is also possible to use a silver colored sharpie to apply dots to a black base coat or surface. The silver appears more matte than one might think and provides good contrast against the black.



Pattern created with black marker on white base coat.

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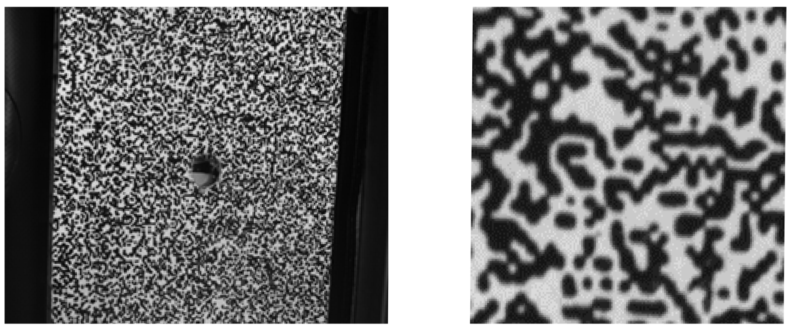
Printed patterns

For medium through large surfaces, printing speckle patterns can be effective. This technique has been used with specimens from 1” (25mm) through 12’ (4m).

Patterns can be generated using a speckle pattern generator (available for download here: http://www.correlatedsolutions.com/installs/speckle-setup.msi). The pattern can be adjusted in density, dot size, variation, and field size. Print such a pattern onto vinyl appliqué or adhesive labels, making sure it adheres to the specimen well enough to deform with the surface. Be careful of any slipping or folding that could cause measurements to not accurately represent the behavior of the actual surface.



Pattern printed on a full-sheet laser label.

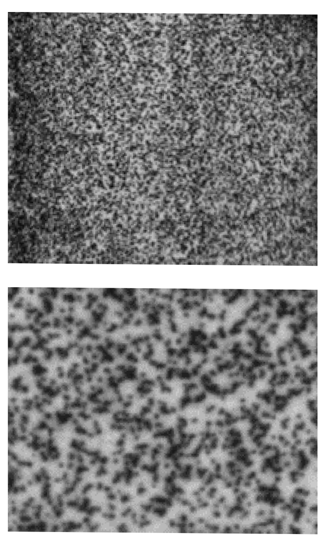
Common Application Methods

While the common methods of applying a speckle pattern are often sufficient, there are many cases where more application specific solutions are needed to create good patterns.

Small scale and microscopic

In small scale applications, it becomes difficult for common methods to produce small enough patterns.

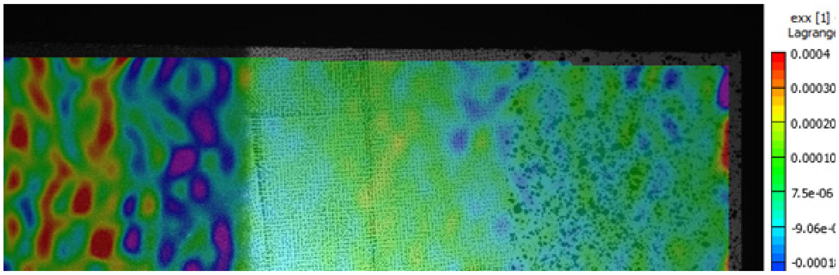
For fields down to 3mm, toner powder, carbon black, or graphite powder can be use as the speckle. The particles tend to clump together, so working with a thin amount at a time and repeatedly applying will help reduce this possibility.



This pattern was created using toner powder on a 3mm field.

There are many ways to apply the particles, but must involve blowing small amounts of them onto the surface. Some methods that yield consistent patterns of good quality include a small lens blower or atomizer. Using paint or ink with an airbrush also provides a good pattern down to around a 3mm field of view.

For patterns smaller than that, there are some other techniques such as using TEM grids as templates/stencils, photolithography, and vapor deposition. See the application note on microscope speckle application for further details.



Large scale

Very large-scale applications can include bridges, trucks, or planes that are 10's or 100's of meters in size. Using a very large stencil, like one made from a vinyl sheet using water or laser cutting, can work well. The dots will be so large that paint can simply be rolled over the stencil (using rollers that are used to paint walls).

High Temperature Tests

Standard paints and inks may crack or otherwise change when used for high temperature tests, making them not suitable. Any change in the pattern that occurs after the reference image has been taken will misrepresent actual strains. There are spray paints available at most local hardware stores that are designed for conditions up to 1200 degrees F. Enamel paints are available for use up to 2000 degrees F. Some inks are also designed for use in high temperature applications. The Industrial Sharpie Pro is rated for 500 degrees F.

Toner is generally not acceptable for high heat use due to it melting, but carbon black and graphite particles are as they can withstand high temperature.

The presence of heatwaves may complicate the use of DIC. It is important to take action to minimize this in the test setup, but using larger dots can help improve results when this occurs.

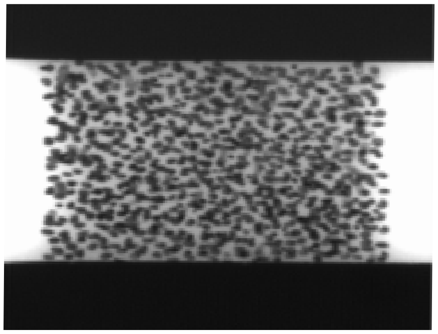
Thin/Membranous Specimens

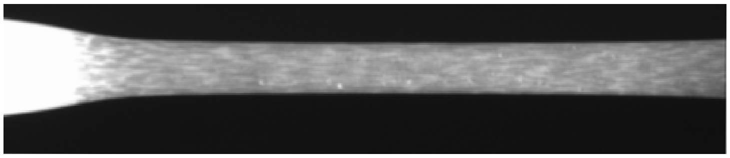
For very thin or membranous specimen, common methods for applying a speckle pattern may significantly change the properties of the specimen. For example, applying a base coat of paint may stiffen the material. It is recommended that ink is use and that if necessary, not base coat is applied.

High Strain Tests

The difficulty with high strain tests is often the original speckle pattern gets destroyed during the test. Spray paint, once dry, will become brittle and be destroyed in high strain. For high strain applications (more than 15-20%), primer spray paint might be desirable for the base coat. For example, Rust-oleum Clean Metal Primer holds 40% strain before it cures. However, after about an hour, the primer will cure and become brittle.

For strains higher than 40%, it is sometimes best to use no base coat and ink based speckles (stamps or permanent marker), so that the pattern does not crack and deteriorate. Most of the time strains this high are polymers, which tend to be light in color and non-reflective so luckily a base coat may not be required. If the specimen material is clear, you may backlight it (more on this under Backlighting).





This ½" wide HDPE specimen is patterned with no base coat and sharpie marker. Correlation was successful at strains up to 400%.

Backlighting

For transparent materials, it is possible to avoid applying a base coat and instead backlight the specimen. Apply speckles to the surface of the material as usual, then backlight the specimen using diffuse light.

When using this technique, it is important to be careful of any feature that is not on the surface of the specimen that may show up in the image. These will interfere with the ability to accurately measure surface behavior.

Biological Materials

In applications involving wet tissues or other biological-like material, standard speckling techniques may not stick to the surface well. Staining the material with an ink such as India ink can be an effective method.

Another method that has been used with success is using microbeads that bind to the specimen and provide contrast to create a speckle pattern.

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Underwater

With any specimen that is submerged in water or other fluid, the main challenge in speckling is making sure the pattern will not degrade over time. Be sure the technique used is sufficiently waterproof when doing these tests.

Inherent Patterns

Some materials such as wood or concrete display an inherent pattern. These patterns may be used for correlation if they have sufficient contrast, although they will often provide noisy results and an applied pattern is still usually optimal.

Projection of a Pattern

For shape measurements, a speckle pattern may be projected onto the surface using a computer and projector. For this method, room light should be controlled to give high contrast.

Note that because a projected pattern does not stay with a moving surface, this technique is only useful for shape measurement. Displacements will not be accurately calculated.

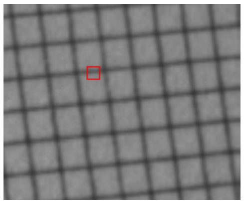
Textures

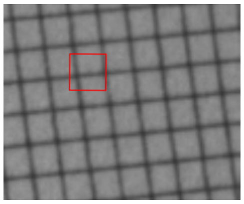
Some specimens exhibit an apparent speckle pattern due to an inherent texture; examples include sand, rough metal, and concrete. Extreme caution must be used when using these textures as a pattern; because the shading comes only from light and shadow, it may often be inconsistent between the left and right camera, or may change in unexpected ways when the specimen moves or deforms. Because of these issues, this technique should only be used when alternatives are not available.

Grids

While grid patterns are neither necessary nor optimal for DIC, they may be used, with caution. Initial guesses must be selected carefully; with a nearly-perfect grid, it's possible for DIC to find a good match that is actually off by 1 or more grid spacings. In addition, the subset size must be large enough that at least one grid intersection is always contained.

Subset too small - multiple matches along line.





Larger subset - constrains grid in both axes. Still possible for offset matching.

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Dealing with Specular Reflection

In some of these methods, the patterning technique does not provide a matte finish for the surface. Under some circumstances, this can cause specular reflections to produce oversaturated areas or glare. When present, this can produce erroneous results or cause correlation to fail.

If this becomes an issue, consider changing how the specimen is being illuminated. If using heavy lighting, consider moving the light source such that the reflections do not fall upon the camera. Using diffuse light may also be sufficient for preventing reflection. For quasi-static tests, it may be possible to use only ambient light and higher exposer times to still achieve high contrast images.

Another common solution is to use polarizing filters on light sources and camera lenses to prevent reflections and glare from appearing in images.

Support

This information should serve as a guideline, but very good results have been achieved in specimens and patterns that fall far out of these guidelines. For help with challenging specimens and techniques, or for information about analyzing difficult or poorly prepared images, please feel free to contact support@correlatedsolutions.com, or the local technical representative. We'll be happy to help evaluate options for preparation and analysis that will result in the best achievable results.