Application Note

# Processes for automation: the quality control of phosphate coatings

## An insight into the development of an automation tool using the Phenom Programming Interface

Phosphate coatings are applied to metallic objects to prevent corrosion or to improve lubricity. The performance of phosphate coatings strongly depends on the morphology of the coating crystals and on the degree of coverage. The coverage can be measured using a scanning electron microscope (SEM) equipped with a BSE detector, where the phosphate crystals and the uncoated surface appear in different shades of gray. As the quality control process may require the analysis of hundreds of images over large areas of the coated objects, an automation script increases the efficiency and accuracy of this analysis significantly.

Phosphate coatings are frequently used in the automotive industry as they are used to protect steel against corrosion, as a lubricant layer or as a base for subsequent coatings. Typically, manganese, iron and zinc are used in these coatings. **Zinc phosphate coatings** are widely used in the automotive industries, for those components that require high corrosion resistance. Zinc phosphate coatings are applied by either immersion or spray. **Manganese phosphate coating**, which is typically applied by immersion, is used to prevent corrosion and to increase the lubricity. Depending on the material of the component, **iron coatings**, applied by either immersion or spraying, may be required as a base for subsequent coatings.

In the quality control process, the expected performance of the coatings is evaluated by analyzing its morphological properties. While a microcrystalline structure is beneficial for the corrosion resistance, a coarse grain structure impregnated with oil is ideal for improving the wear resistance. Equally important is the measurement of the percentage of coverage on the coated object.

One of the main challenges that companies are currently facing is integrating the quality check into the production line. An analysis that delivers quick feedback is key to an efficient way of working. While a SEM is a powerful tool in checking the quality of coatings, most SEMs require dedicated users and a significant investment. With the Phenom microscope, we offer a fast, affordable and easy-to-use instrument for these analyses. Combined with the programming interface (PPI), the Phenom microscope can be equipped with an automation tool, increasing the efficiency and reliability of the production process.

### BSD imaging of phosphate coatings

Imaging with a backscattered electron detector (BSD) provides information on the material composition of the sample surface. Lighter atoms, like carbon, appear darker than heavier elements, such as iron. The same happens when imaging the phosphate crystals on a steel part: the phosphor, being lighter than iron, appears darker, as shown in Figure 1.

In order to measure the percentage of coverage based on the BSD image, a threshold on the gray scale level must be set. Pixels with intensities above the threshold (thus brighter pixels) will be considered as *steel surface,* whereas the pixels with intensities below the threshold (thus darker pixels) will be considered as *coating*.

Fig. 1: Backscattered electron image of a steel surface covered with zinc phosphate coating. Imaging with the BSE detector at low acceleration voltages enhances the material contrast of the sample.

## PPI: Why automation is essential

The analysis of the coating coverage is a key step in the quality check. To gain valuable results, this process requires the acquisition of many images at a relatively low magnification (e.g. 2000x) over a large area. When hundreds of images are acquired, measuring the coverage manually with the help of tools like ImageJ is not only very tedious, but also a potential source of errors. One way to overcome these problems is by automating the process with dedicated software, where the acquisition of the images and the calculation of the coverage based on a threshold are implemented. PPI is the right choice for developing automated processes, in an easy-to-use and worry-free platform.

We have developed a PPI script for measuring the coverage of phosphate coating samples. Figures 2 and 3 show the user interface for the acquisition of the set of images, and for the subsequent analysis. In the acquisition UI, the imaging settings, such as the magnification, the size of the total area to be scanned and the number of images, can be adjusted. A live SEM imaging window shows the BSD image of the sample, which is then used to set the threshold. Once the set of images is acquired, the calculation of the coverage can be launched in the analysis window, shown in Figure 3. Once the analysis is complete, the average coverage value is given, as well as a histogram showing the distribution. The results of the analysis can be then saved in a report.

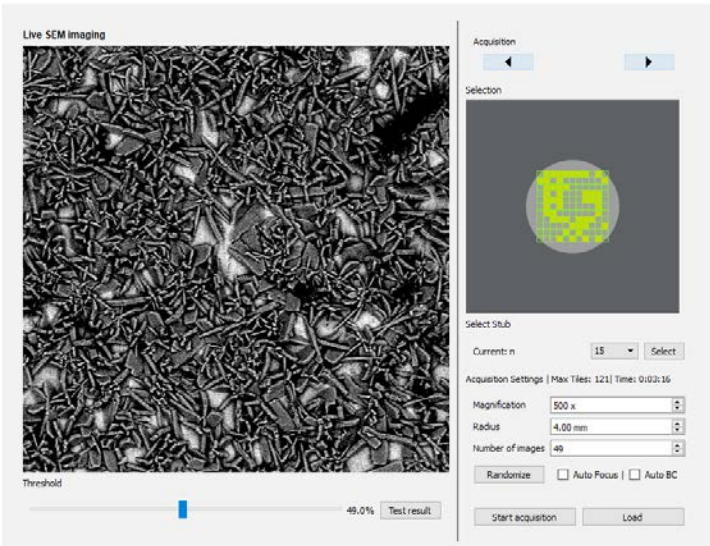


Fig. 2: User interface of the PPI script for checking the quality of coated samples – acquisition window.

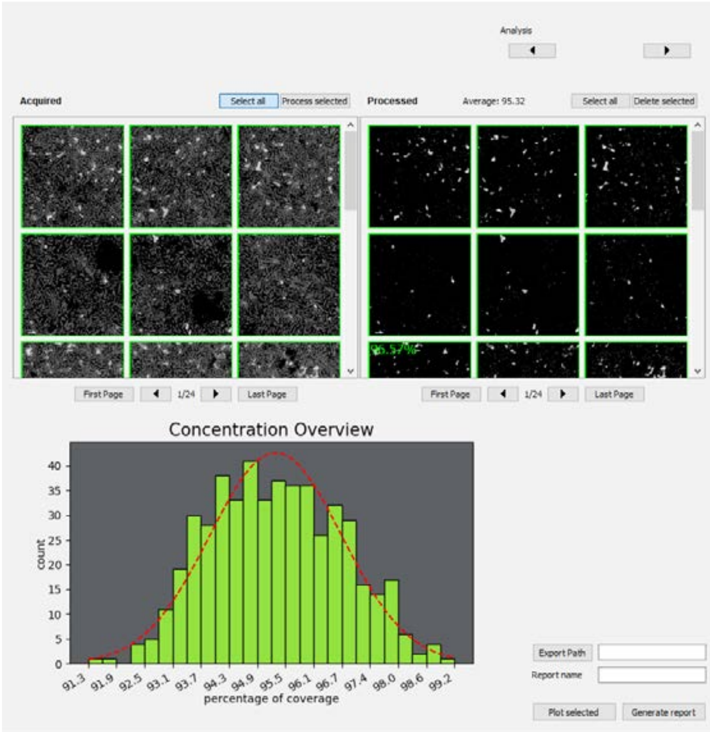


Fig. 3: User interface of the PPI script checking the quality of coated samples – analysis window.

## Benefits of the Phenom SEM

During quality control, the coverage percentage of coated samples is routinely checked. The analysis is typically performed in a measurement laboratory, which is located far from the production line. Accessing the measurement laboratories can be challenging and costly, and the results may take a long time to be available. This results in undesired delays in the production lines.

Combining PPI with the Phenom microscope is a low cost, easy-to-use and fast way to check the percentage of coverage, as well as the crystal morphology. The system can be situated close to the production line, avoiding long waiting times before results are provided. Furthermore, the PPI script on the coating coverage analysis allows non-dedicated operators to perform the analyses reliably and without any additional infrastructure.

## References


Louda, P., *"Applications of thin coatings in automotive industry."*, Journal of achievements in Materials and Manufacturing Engineering 24.1 (2007): 51-56.




©2018. Specifications and prices are subject to change without notice. All rights reserved. Reproduction, copying, usage, modifying, hiring, renting, public performance, transmission and/or broadcasting in whole or in part is prohibited without the written consent of Phenom-World BV. Find your Phenom-World contact information at www.phenom-world.com

PHENOMWORLD part of Thermo Fisher Scientific