A “Dual-Field” Illumination Schema for Enhanced Contrast in Automated Optical Defect and Debris Detection

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In modern clean manufacturing environments, detection of debris on and defects within microstructures by inspection presents many challenges, especially for very large samples such as wafers or displays. This creates demand for processes that can be efficient in time, space, and complexity of operation. Ion Innovations, in collaboration with Leia Inc., has developed a hardware-assisted computer vision system for automated defect detection that readily and simply acquires “dual-field” images using simultaneous dark-field and bright-field illumination without losing the information collected by either type of illumination alone and without requiring advanced post-processing. (Figure 1)

The key to this schema is the use of distinct and deliberate wavelengths for dark-field and bright-field illumination sources. Thus, information from both components of the dual-field illumination remains distinct after collection by an ordinary color camera. A monochromatic green strobing epi-illumination light source is directly focused on the sample and is combined with a monochromatic strobing red dark-field ring-light. Both flashes are triggered simultaneously, but are received with differential sensitivity by the different sensors of the camera.

This not only saves time by multiplexing image acquisition, but is more efficient from a processing perspective. Information from both light sources is inherently correlated by the perfectly identical conditions at the same time and position. No advanced image processing is required to correct for positional errors, such as those caused by sample drift or vibration; or for changes in the state of the sample itself, such as the deposition of debris or the degradation of sensitive materials.

Using these combinations of imaging modes allows objects, defects, or features not clearly visible in either separate imaging mode to become clearly visible in these dual-field images. (Figure 2) The increase in clarity and contrast allows for easy visual identification of smaller objects, features, and defects superimposed with a larger object or feature that would normally be indistinguishable. This technique is especially potent when combined with automatic identification using a relational decision tree and basic computer vision tools (Figure 3).

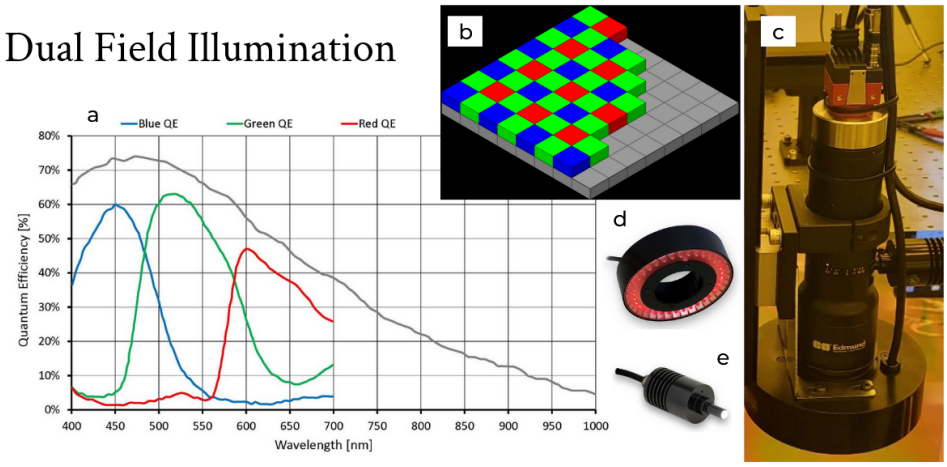

Figure 1: Dual Field Illumination allows for simultaneous dark and bright field information inherently correlated in time and space from a single exposure. By matching the wavelengths of two synchronized illumination sources (c,d[3],e[3]) with the quantum efficiency (a)[1] of a standard bayer filter (b)[2] camera, we demonstrate remarkably enhanced contrast of debris and defects as shown in Figure 2

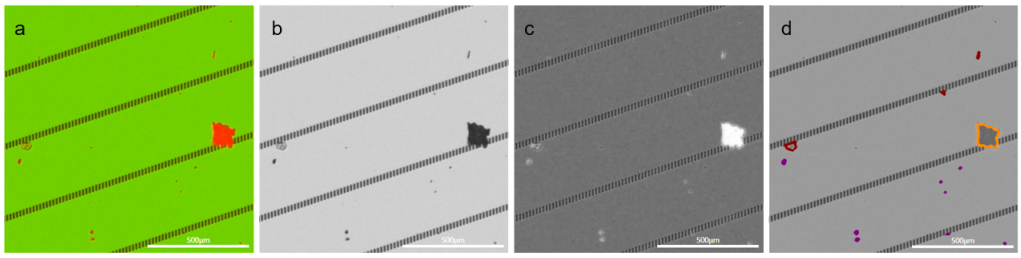

Figure 2: a) Dual Field illuminated microstructures b) extracted bright field image c) extracted dark field image d) result of classification presented in Figure 3.

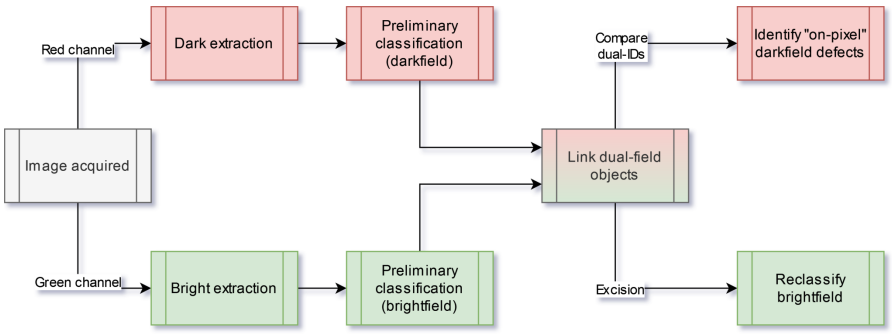

Figure 3: Example data flow for automated classification of objects detected using dual field illumination schema. The inherent spatial correlation of the two imaging modes is critical to the speed of this methodology.

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[1] https://www.alliedvision.com/
[2] https://en.wikipedia.org/wiki/Bayer_filter
[3] https://www.advancedillumination.com/