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Key Elements For Good Visual Inspection

By Richard May, President, O.C. White Company

Introduction

Careful visual inspection is still the primary means of ensuring quality, and discovering defects, in electronic assembly. Indeed, most defects, such as misaligned components, solder bridging, coplanarity problems, soldering defects, and surface board damage (as well as component damage, such as 'popcorning' of plastic packages) as well as solder ball problems can be detected by visual inspection.

Certainly, there are defect types that can only be discovered by more sophisticated techniques such as X-ray imaging. But visual inspection still is the primary means of finding defects in circuit assemblies and correcting them before they reach later stages of test and make it out into the field as delivered product.

Good visual inspection requires two basic elements: a skilled and trained inspector, and the appropriate equipment to aid the inspector in his or her job. Given that we have the former, equipped with good vision, we turn to the latter, since the unaided or naked eye is insufficient in itself to closely inspect today's miniaturized parts and assemblies.

Magnification and Illumination

The human eye discerns details carried by reflected light. Therefore, it is not only necessary to magnify details, but to properly illuminate them. The reasons for this go beyond the role of discerning difficult to spot defects such as cracks in solder joints; operator comfort is a major factor in good inspection. Can a fatigued worker perform a detail-oriented task well? No, and an inspector with eye fatigue is likely to miss defects that would otherwise be detected. Therefore, it is the role of the manufacturing supervisor to ensure that his inspectors are using equipment that minimizes the possibility of eye fatigue. Appropriate levels of magnification for the job, as well as proper illumination, as well as ergonomic function of the equipment (such as adjustability and positionability) are critical.

Microscopes and Illumination

The highest level of optical inspection magnification and clarity is provided by microscopes. There are many quality microscopes available on the market, and it is not the purpose of this paper to delve into a discussion or evaluation of the many types and options available. Obviously, virtually all microscopes in use today are the stereo type, providing a very high quality image and to a certain degree, some depth perception for the operator. High-magnification CCD cameras are also used in optical inspection, whereby the image is projected onto a color monitor screen. Although there may be slightly less detail with this approach, one advantage of this equipment is that multiple individuals can view the same image simultaneously, for consensus, analysis, or instruction. It is also easy to capture digitized images for transmission over the Internet, or for training videos, etc. Either way, proper lighting is critical.

Microscope/CCD camera illumination takes several forms. One type mounts on the microscope itself, consisting of a hood enclosing a circular fluorescent bulb. The circular shape is designed to distribute illumination evenly. Fluorescent lamps have long been favored because they supply "cool" light; however, in the past, the greenish spectrum of light emitted, plus annoying flickering, shadows, and humming caused by the ballast, annoyed operators and contributed to eye fatigue. The advent of solid state technology and advances in fluorescent bulb science now make it possible for these bulbs to provide



higher intensities of cool, white light across the entire spectrum of light. Without flickering or shadows, and with silent operation. Furthermore, something that was once impossible - the ability to dim a fluorescent bulb - is now easily done through sophisticated microelectronic controls.

Another type of microscope light provides illumination generated by an external power unit, and supplied via a flexible, metal-sheathed fiberoptic cable to an attachment on the microscope. This attachment will provide light in an even, circular area through an annular ring, possibly with an iris diaphragm that can be adjusted to maintain constant Kelvin color temperature. At the generator end, the intensity of the light can be adjusted, giving the operator a high degree of control over the volume and intensity of light distributed on the inspection area.

In order to provide sufficient light to the point of illumination, light of sufficient intensity must be generated at the point of origin. In the past, there were problems with fiberoptics being burned, and intensity adjustment rheostats heating up and burning out. Today's generating units IR-filter the light to prevent damage to fiberoptics and keep the light "cool". Solid state intensity controls have replaced rheostats. Slimmer profile annular light guides facilitate connections to microscopes, and quick-connect designs make them simple to adapt to CCD cameras.

These fiberoptic systems are also supplied, in lieu of annular rings that attach to the microscope, dual point illuminators with focusable lenses. These give the operator the ability to adjust lighting in a number of different ways from an infinite variety of different angles, for complete and total flexibility of illumination into tight PCB architecture. The ability to focus the lenses adds to the operator's ability to "tailor" the illumination as well as direct the angle and source. Depending on the unit, it may be supplied with mini-annulars or an 8-spot annular (for longer working distances), an iris diaphragm, and a color filter kit.

The Role of Color

Maintaining constant Kelvin color temperature is important in some applications that use machine vision inspection. Generally, the other types of colored lighting used include yellow bulbs for inspecting photoresist, and ultraviolet (black light) for inspection of conformal coatings, plating voids and certain other flaws. The wavelength of UV used is not in the range of harmful UV associated with sunburn, etc. Overall, however, the percentage of specialty colored lighting used in inspection is quite small, and is specific to certain limited applications.

ESD Safety

The issue of ESD safety in illuminated magnification is an important one. Too often, manufacturers will go to great lengths to protect and ground everything in contact with the operator and the benchtop, only to forget a powerful potential source of ESD suspended right above the workpiece - the illuminated magnifier! The best way to protect products from potential ESD damage is to make sure that the magnifier used is designed and built of quality metal parts (hood, shade, etc.), or ESD safe plastic, a recently developed product. Certainly, operators should be as concerned that ESD is not hanging right above their work, as they are concerned about other sources.

Illuminated Magnifiers

Microscope-based inspection can be tiring for the operator. In applications where lower levels of magnification are sufficient, illuminated magnifiers are simpler and easier to use than microscopes. They provide a wide field of vision, and are less tiring to use, adjust, focus, etc. than a microscope. Often, a



whole assembly can be inspected in a single view. An illuminated magnifier is essentially a large magnifying lens mounted in a frame with built-in illumination, all attached to the end of an adjustable arm that clamps to the workbench. That's the simplest description, but the illuminated magnifier is much more than that in sum.

To begin with, there are different levels of glass, and these affect the clarity of the lens and the quality of reflected light allowed through. For example, many illuminated magnifiers use grade B green lenses, but this type of glass restricts light transmission and has been associated with long term eye fatigue. The best lenses for illuminated magnifiers are crystal clear crown white lenses that have the highest level of light transmission.

Different levels of magnification are referred to in terms of "Diopter", which is basically a unit of measurement of the refractive power of lenses equal to the reciprocal of the focal length in meters. For example, a typical 5" diameter lens may be rated a 3 diopter, with a magnification of 1.75X. Same lens in 5 diopter would have a 2.25X magnification.

Light sources for illuminated magnifiers continue to be fluorescent, and these products have also benefited from advances in fluorescent lamp technology. Usually, lamps are placed on either side, or in a "U" shape around the lens, to provide as even and shadow-free lighting as possible. Solid state microelectronics have made fluorescent dimmability possible, and have, as mentioned earlier, eliminated flickering and humming. In addition, a new "glare-free" bulb has been developed. Glare contributes to operator eye fatigue and can mask defects that would otherwise be clearly seen. A new tri-blended phosphor that differs from the familiar cool white phosphors that were designed to generate white light, but also have the drawback of creating reflective bounce-back and glare. This new phosphor blend eliminates the light that bounces back, thus reducing glare by 60%. It allows the operator eyes to better absorb and more efficiently use the light generated by the bulb. The result is enhanced comfort, better operator performance and efficiency, and a better quality product.

One cannot stress enough the breakthrough that fluorescent dimmability has been for illuminated magnified inspection. The ability to dim a fluorescent bulb from 100% down to 25% is significant because it allows highly reflective surfaces to be seen easily, whereas in the past, glare would be a significant problem.

Conclusion

A thorough knowledge of the technology available today for visual inspection, as well as the particular needs of one's inspection application, can help the manufacturer choose the most appropriate inspection equipment for the job. Minimizing operator fatigue - eye fatigue or otherwise - is essential to maintaining good inspection procedures, practices, and operator effectiveness. Optical inspection equipment is not as simple as it may seem, and ongoing technological innovations continue to improve both the quality and functionality of visual inspection equipment.

