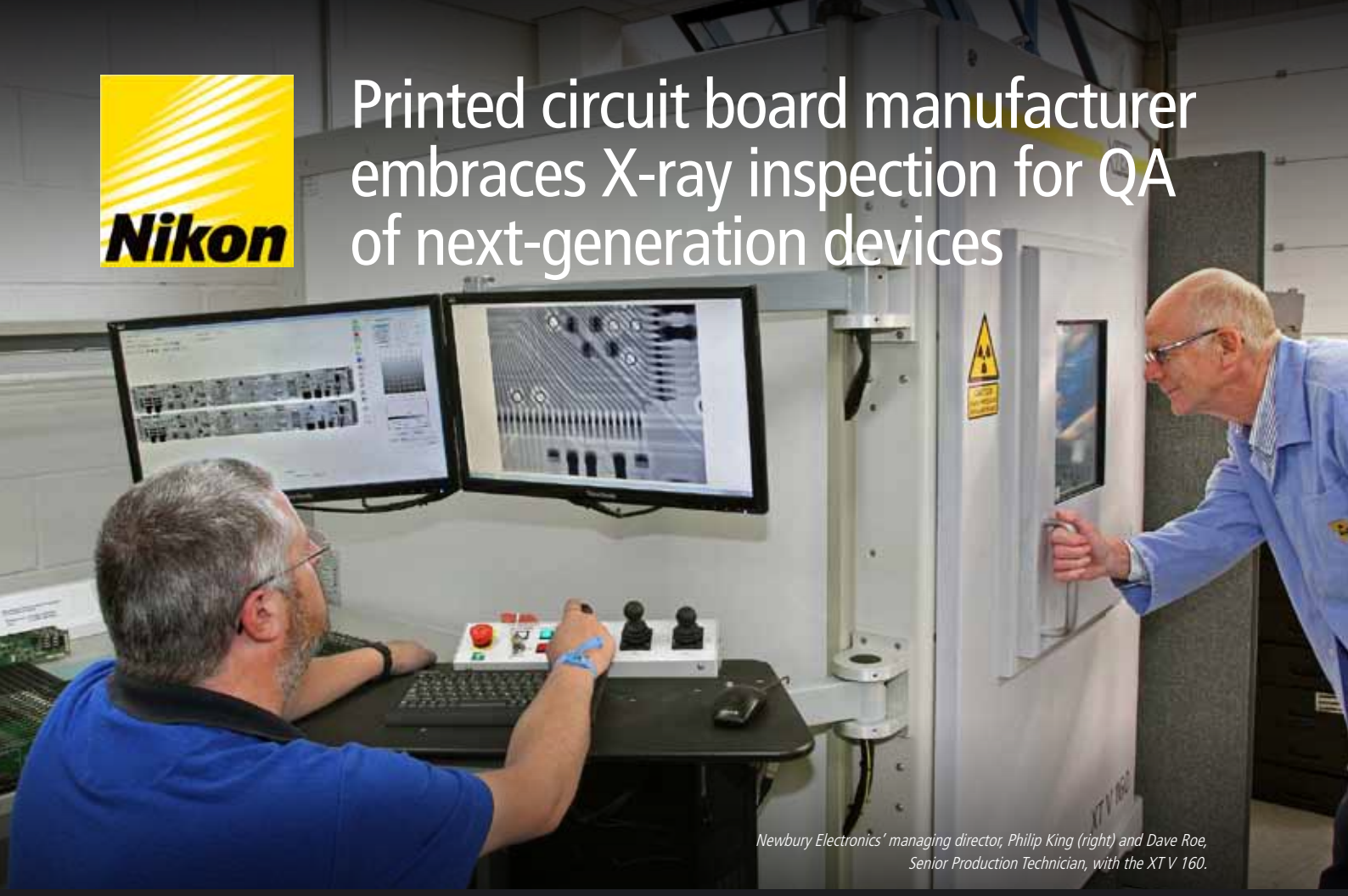
Printed circuit board manufacturer embraces X-ray inspection for QA of next-generation devices



Newbury Electronics' managing director, Philip King (right) and Dave Roe, Senior Production Technician, with the XT V 160.

Nikon Metrology X-ray machine cuts the price of placing BGA devices by 70 per cent

Subcontract manufacturers of printed circuit board assemblies (PCBAs) for applications such as electric motorbike control, ground movement detection and touch-sensitive sound generation, generally use a number of different tools for quality control. These include flying probe testers, camera-based automated optical inspection, and X-ray equipment. Very few manufacturers in the UK, however, can boast such sophisticated X-ray inspection capability as Newbury Electronics, following the company's purchase of a Nikon Metrology XT V 160.

Ball grid arrays (BGAs) and quad-flat no-lead (QFN) interconnections are two features of PCBAs that require close inspection. A challenge when inspecting modern BGAs in particular is that they have become very complex, with tighter pitches and smaller ball diameters. It means they are mounted so close to the body of the PCB that there is little space between them to enable visual inspection.

Newbury Electronics (www.newburyelectronics.co.uk) previously used an endoscope to access and view areas of interest, which was effective for small, basic devices, but time-consuming. Unfortunately, the technique was becoming ever more impractical, as it was increasingly difficult to position the endoscope without it being blocked by the components that invariably surround a BGA. In addition, the smaller sizes sometimes meant that the inspection equipment could not be used at all. Even if the device could be positioned well, seeing far enough down the rows of balls was also becoming more challenging.

In some instances, faulty boards would be returned by a customer and had to be sent by Newbury Electronics to a bureau for X-ray analysis. This typically took three days and cost around £100 for the board

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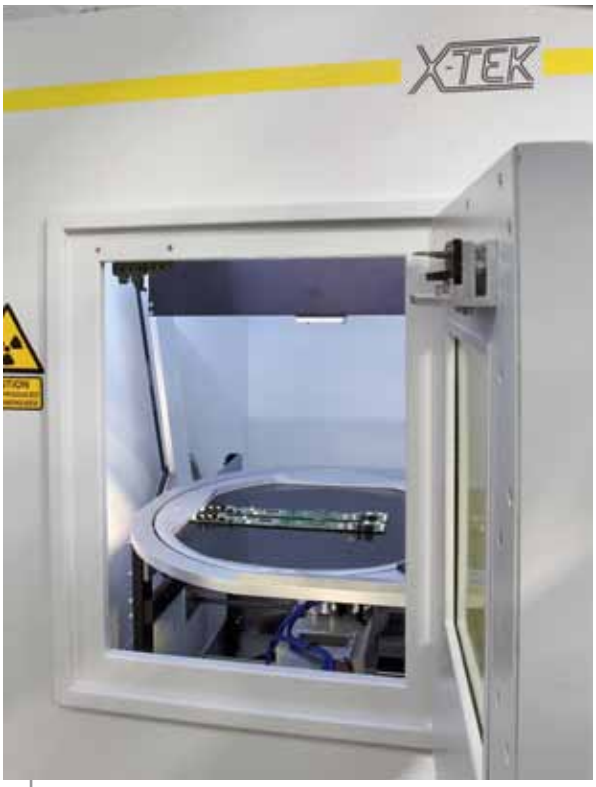
>
> *Philip King, managing director of Newbury Electronics*



PCBA assemblies positioned above the X-ray source, ready for inspection

to undergo X-ray inspection, the fault to be fixed and another X-ray analysis to confirm that the board was fully corrected.

Philip King, managing director of Newbury Electronics commented, "As a subcontractor, we handle 10 to 15 different product lines every day and often do not know what we will have to produce next. PCBAs should be designed for easy inspection, but they rarely are".

"Accurate inspection is important not only after repair, but also during series manufacturing so that results can be used for process control to maintain quality. The larger the production run, the more potential there is for faulty boards, wasting time and money."

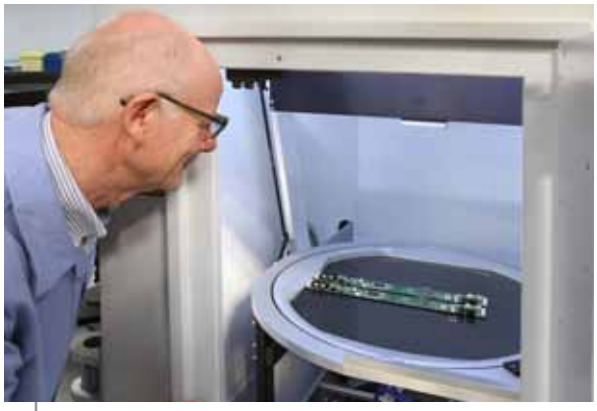
While one-off prototype boards are frequently produced at Newbury and five-off is typical, recent contracts received by the company have involved much larger volumes. For example, Bare Conductive is a design and technology spin-off from the Royal College of Art and Imperial College London, which has developed Electric Paint. Multi-channel PCBAs are needed to enable human interaction with the paint and Newbury Electronics is producing 15,000 boards this year for the product launch. For Senceive, a University College London (UCL) spin-off producing radio-linked sensors that detect movement in the ground and buildings, used extensively in the construction of Crossrail, PCBAs are needed in annual quantities of 1,000s.

An X-ray machine was the only realistic solution for quality control of these larger volumes of boards and Mr King had been researching the market for several years. It was the manufacture of a particularly problematic batch of PCBAs with BGAs that triggered the investment in the XT V160 from Nikon Metrology (www.nikonmetrology.com), following a visit to the factory in nearby Tring, Hertfordshire. This X-ray machine provides a generous 400 mm x 400 mm scan area, large enough for most PCBAs, and its comprehensive specification included control and analysis software.

Mr King continued, "Low-end X-ray equipment, while cheap, provides such a poor image as to be virtually useless, especially given the increasing miniaturisation of BGAs.

"We knew we would only buy one X-ray machine in the foreseeable future, so decided to select a very capable model from Nikon with variable magnification, a tilting flat panel detector and a powerful, 160 kV / 20W X-ray source, which is at the higher end commonly used for PCBA inspection."

The machine has to be operated at the highest power to generate a useable image only on the densest multi-layer PCBAs, such as those with multiple copper layers or high copper weight. An example is the backplane board manufactured by Newbury Electronics for controlling



The PCBAs are for the Seaboard GRAND, an evolution of the piano invented by ROLI in London (www.roli.com), which allows per-note vibrato, volume change and glissando - www.youtube.com/watch?v=8n-bEy9ISpM

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> *David Roe, Senior Production Technician at Newbury Electronics*

the hydrogen fuel cells on an electric motorbike being developed by an R&D firm. With 2,500 parts, the boards are particularly sensitive to quality issues and are 100 per cent inspected using the Nikon Metrology system.

Although it has a high performance-to-price ratio, this was not the only factor that needed to be considered before the machine was purchased. The X-ray output also had to be exceptionally stable, otherwise noise degrades the image. One of the reasons Mr King chose the XT V160 was its nanofocus X-ray spot source and advanced image processing capabilities. Focus of the electron beam is maintained by a computer-controlled, electromagnetic lens that ensures the target does not overheat whilst maintaining a nanometer spot size, even at high kV settings. In his view, these features are essential if potential defects are to be identified, especially in next generation interconnects and packaging technology.

BGA inspection assisted by locked region-of-interest movements

When looking at BGA solder joints, an operator needs to gain a clear view of the ball interconnect under inspection. This is normally achieved by combining tilt and rotate movements and scanning down the rows, ball by ball. The XT V 160 enables this function using single-axis control rather than the usual method of having to manipulate three axes. The operator can therefore concentrate on the inspection process rather than on guiding the machine. True concentric imaging makes it easy to rotate the view point through 360 degrees around the area of interest, which is intelligently locked onto.

Once a region on the PCBA has been identified and positioned in the centre of the screen, it remains fixed in position no matter what tilt, rotation or magnification is applied. This is a great benefit when inspecting BGA balls and requires no special skills or training.

Excellent resolution and magnification lead to superior defect identification. The X-ray source is designed for a PCBA to be placed within 250 microns of the focal spot, allowing magnification up to x2400. The board can be viewed at steep angles of up to 75 degrees, enabling clear views of solder joints and through-holes while maintaining sufficient X-ray energy. Special analysis functions are available for inspection of semiconductor package voids, wire bonding and BGA solder bumps.

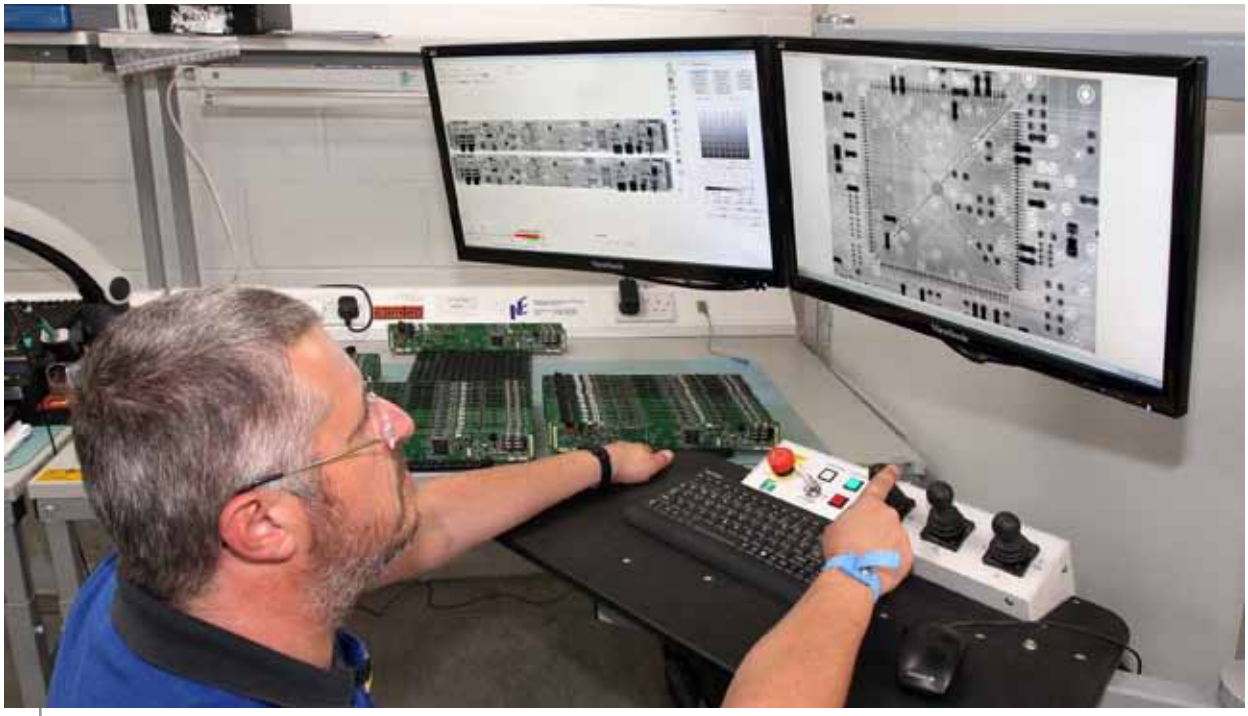
Low cost of ownership

Once the level of capability that was required by Newbury Electronics had been established, the search was narrowed down to just a handful of potential X-ray machine suppliers. The feature of the Nikon Metrology equipment that clinched the choice of the XT V 160 was that although it is a high power machine, it is of open-tube design. The latter means that the electron beam-producing filament can be replaced every six to nine months for a cost of under £10 each time. With closed-tube designs, the manufacturer has to be called in to renew the tube every couple of years at a potential cost of up to £15,000, which was unacceptable considering the lifetime cost. Carrying out filament replacement in-house reduces downtime to a matter of minutes rather than days.

Mr King said, "We have been pleased with this aspect of the XT V 160. It is no problem to replace the filament, which takes five minutes and requires little training.

"Nikon Metrology's business model is not to lock the customer in to repeatedly replacing an expensive tube and we calculate that our machine will have very competitive lifetime costs."

Not only are the PCBA manufacturers costs reduced, but so too are those of its customers. Mr King indicated that Newbury Electronics' ability to place complex devices like BGAs and QFNs just like any other component, with the confidence that its X-ray tests will reveal any errors, has reduced its in-house overheads and allowed the company



Dave Roe checking the X-ray results. The dual display facilitates combined measurement and real-time analysis.

to cut its charges for such boards by up to 70 per cent. To prove his point, he drew attention to the company's online PCBA cost calculator at www.PCBtrain.co.uk

Computed Tomography extends versatility

The XT V 160 X-ray machine's flat panel was supplied fitted with optional CT (computed tomography) inspection capability. CT re-constructs a 3D image from multiple 2D X-rays taken from a controlled angular rotational scan, allowing the operator to virtually rotate and slice the 3D image.

The extra functionality future-proofs the investment in case full 3D graphic displays are required, or if PCBA complexity becomes so high that a standard 2D image on the screen is not sufficient for quality control purposes. In other words, with this investment, Newbury Electronics is ready for the next generation of electronics devices and packaging technologies, regardless of complexity.

Zero-fault PCBA deliveries

Dave Roe, Senior Production Technician at Newbury Electronics said, "We have not had a single board with a mounted BGAs returned as faulty since we started using the XT V 160.
"The system is just as good at picking up QFN solder joint faults and shorts, which are difficult to check as the leads are hidden under components."

Mr King added, "Our engineers were initially sceptical but became converts very quickly, as they were able to see results in seconds rather than spend days waiting to get results from a bureau."

Non-destructive testing applications for XT V systems extend beyond surface mount technology to include through-hole boards, integrated circuit bonding and wafer level interconnectivity. Besides electronics inspection, the machines are also suitable for X-ray and CT inspection of a variety of small components, such as micro-electro-mechanical systems used in consumer electronics including smartphones, as well as accelerometers, pressure sensors and gyroscopes. Inspection of small cables, harnesses, plastic parts, LED lights, switches and medical parts is also straightforward.