Diamond Detectors for Dose Rate Measurements in Highly Active Environments

Research area: Waste and Fuel Management

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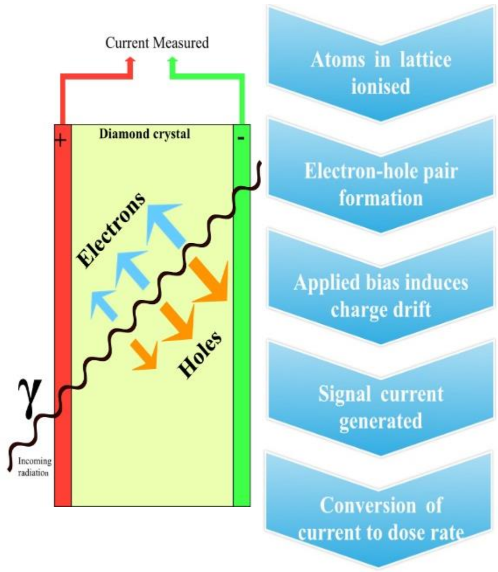
The Challenge

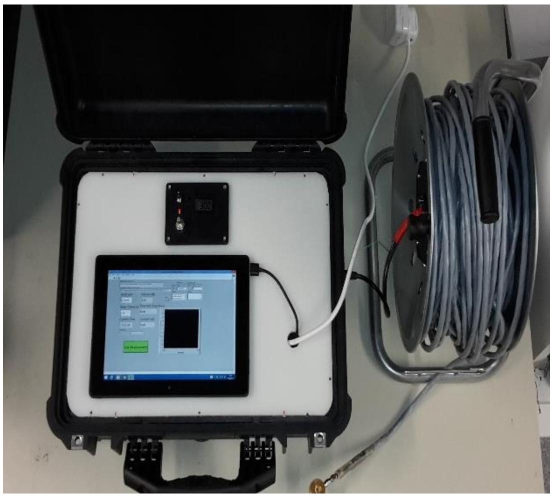
Decommissioning legacy nuclear facilities requires innovative characterisation technologies due to extreme levels of radioactive hazard, which destroys or saturates conventional detectors. Such technologies will be required to map multiple sources of radioactivity in facilities which have small access ports, contain complex networks of pipes and vessels, and have a high radiation hazard. This can either be in an operational plant that is heading towards decommissioning or following a nuclear incident.

Figure 1



Principle of dose rate measurement in diamond detectors

Figure 2

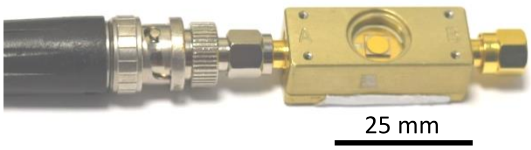


Portable dose rate measurement hardware and software

The Solution

Diamond based radiation detectors offer a novel technology allowing the non-destructive assay of highly radioactive environments in the civil nuclear sector. The miniature diamond detector system developed at Bristol allows real time dose rate measurements to be made remotely from inside difficult to access areas, creating maps of radioactivity in facilities which have small access ports, contain complex networks of pipes and vessels, and have a high radiation hazard.

Figure 3



Diamond detector device

Compared with conventional technology diamond detectors are radiation tolerant, miniature, and can measure an extraordinary range of dose rates. Controlled testing of the device's response to radiation has allowed detector calibration, enabling previously impossible dose rate measurements to be made inside nuclear plant. This new tool for characterisation of radiologically hazardous environments is a game-changer, improving the availability and quality of dose rate data used in safety case justifications.

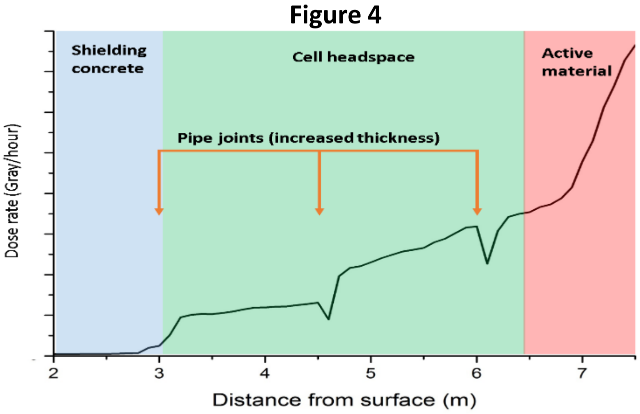
The Impact

Following testing in controlled environments the diamond detector system has been successfully deployed in an active cell on the Sellafield Site. The diamond detector was lowered into an active cell on Sellafield Site, and its calibrated response plotted in real time, showing how radiological contamination was concentrated toward the bottom of the cell (Figure 4). Further deployments are planned to characterise other highly radioactive cells where data collection has been previously difficult to obtain.

The system's ease of use was commended and the real-time display allowed the operators to maximise data collection in areas of interest. Custom-built software ensured the data and statistics collected from the device during deployment was output in a form appropriate for decision makers and safety case authors.

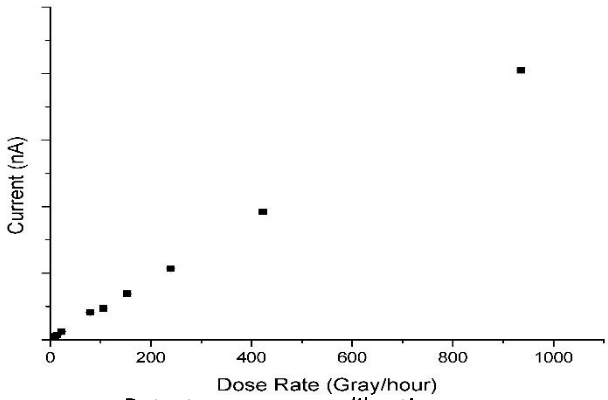
The response of the diamond detector as a function of radiation dose rate has been measured using a high activity Co-60 available through a collaboration with Kyoto University Research Reactor Institute, Japan (Figure 5). The continuous generation of charge carriers within the diamond crystal leads to a small but measurable current, and this signal is proportional and calibrated to the dose rate experienced by the detector.

Figure 4



Detector response with distance from surface recorded in an active cell at the Sellafield site.

Figure 5



Detector response calibration

University of BRISTOL