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Development of a compact X-ray source

Since their discovery by Wilhelm Röntgen in 1895, X-rays have become a valuable tool for characterising the composition and structure of matter. The X-ray tube has long been central to techniques such as X-ray fluorescence (XRF) and X-ray diffraction (XRD) analysis. However, the external high-voltage power supply, size and costs associated with X-ray tube technology have limited the wider application of X-ray analysis. There has recently been a renewed interest in using materials exhibiting coupling mechanisms such as pyro- and piezoelectricity to generate X-rays [1, 2]. The surfaces of these materials inherit an intrinsic charge due to a spontaneous polarisation, induced by either temperature change or mechanical stress. This can be exploited to generate a high voltage in a low pressure gas, capable of both ionising the gas and accelerating the liberated electrons into a target to produce X-rays. This allows more portable X-ray sources to be built, with power supply voltages dramatically reduced from over 10 kV to a few volts [3-5].

The compact X-ray generator is being developed based around the pyroelectric effect. A vacuum chamber testbed has been constructed for the characterisation and optimisation of these novel X-ray generators. Mass flow controllers are used in conjunction with a turbo-molecular and diaphragm pump to control the gas pressure in the chamber. An Arduino microcontroller is employed to operate a thermoelectric cooler, which cycles the temperature of the pyroelectric crystal under-test. The microcontroller is also used to record temperature and pressure readings. A silicon drift detector is installed to characterise the X-ray output. Along with the details on the experimental apparatus, initial measurements using LiNbO3 crystals will be presented.

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Primary author(s) : Ms YAP, Emily Wern Jien (UNSW Australia/CSIRO Mineral Resources)

Co-author(s) : Dr TICKNER, James (CSIRO Mineral Resources); Dr DANIELS, John (UNSW Australia); Dr PRESTON, Rhys (CSIRO Mineral Resources)

Presenter(s) : Ms YAP, Emily Wern Jien (UNSW Australia/CSIRO Mineral Resources)