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THE ALKALI-METAL PHOTOCATHODE PREPARATION FACILITY AT DARESBURY LABORATORY: FIRST CAESIUM TELLURIDE DEPOSITION RESULTS

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1) Introduction

Fourth generation light sources require high brightness electron beams. These can be delivered using caesium telluride (Cs_2Te) photocathodes. They have high quantum efficiency, low intrinsic emittance and long lifetimes [1].

The Photocathode Research Group at Daresbury operates a number of systems including:

- Multiprobe, which supports extensive surface characterisation and surface preparation [2];
- Transverse Energy Spread Spectrometer (TESS), which measures the mean transverse energy of photocathodes across a wide range of illumination wavelengths [3].

Daresbury Laboratory have designed and constructed an Alkali-metal Photocathode Preparation Facility (APPF). The APPF will grow Cs_2Te photocathodes that will be extensively characterised using TESS and Multiprobe, before eventually producing photocathodes for use in the CLARA accelerator [4]. We present an overview of the APPF and details of the first Cs-Te deposition.

2) APPF Overview

Figure 1a

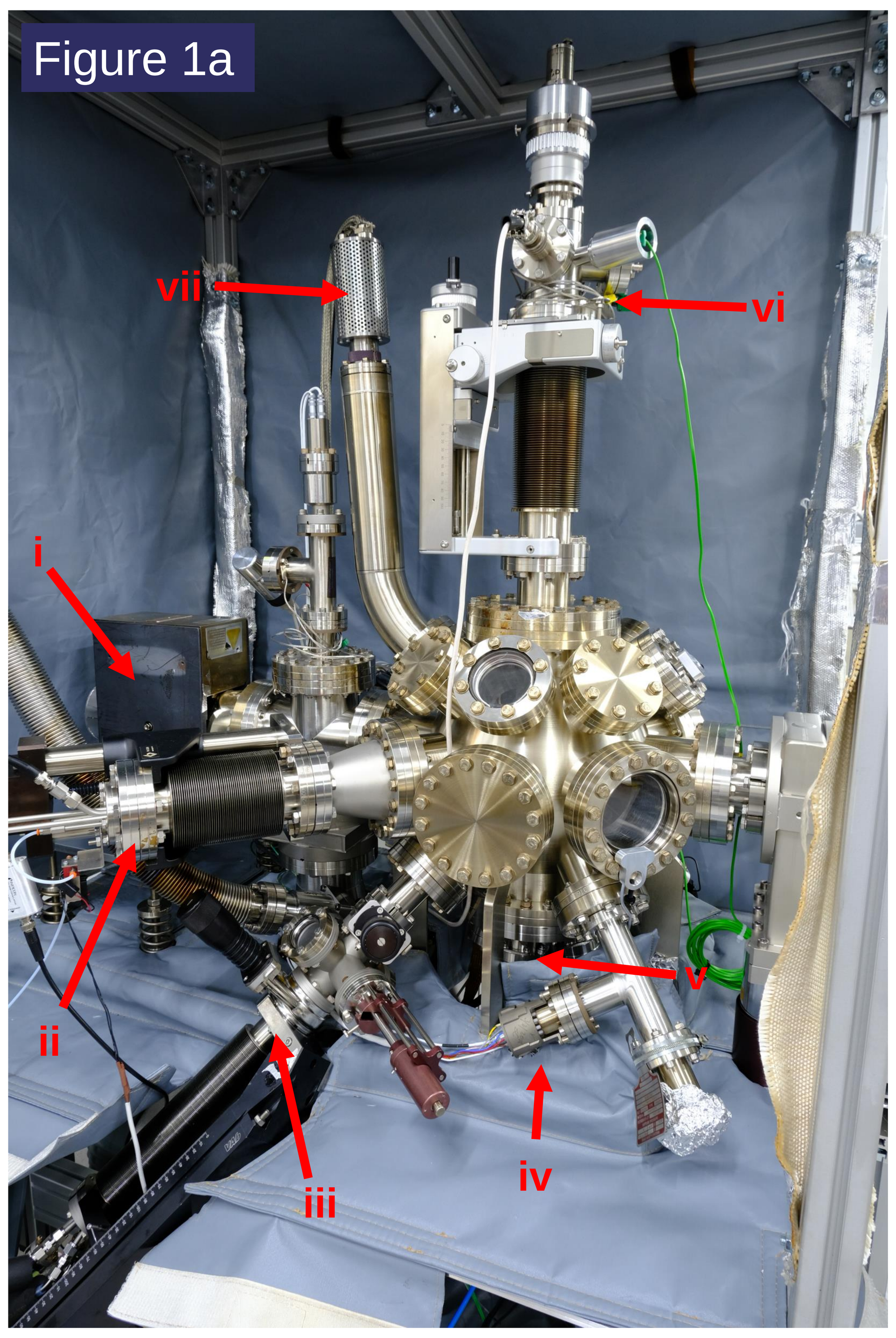

Figure 1b

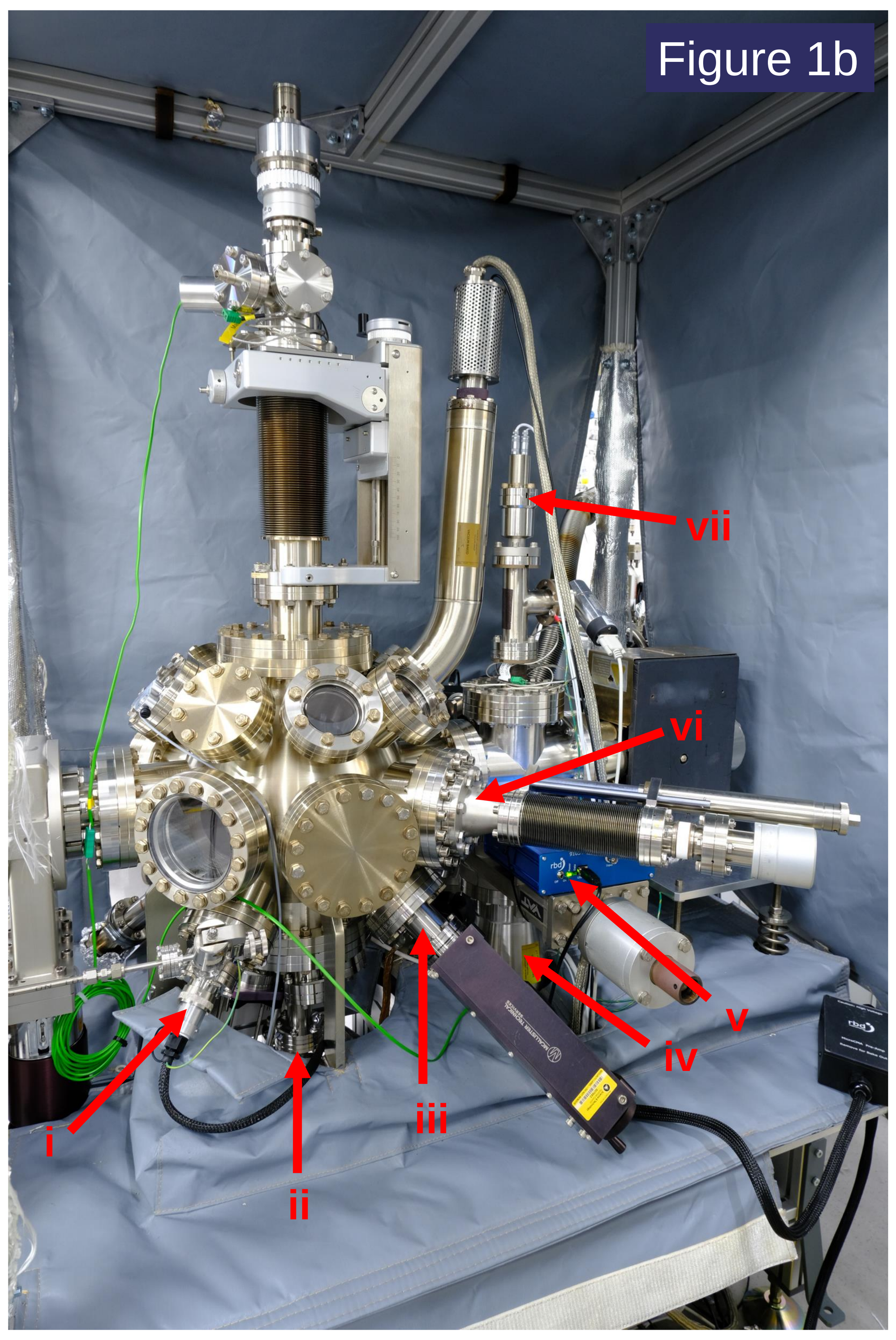

Figure 2

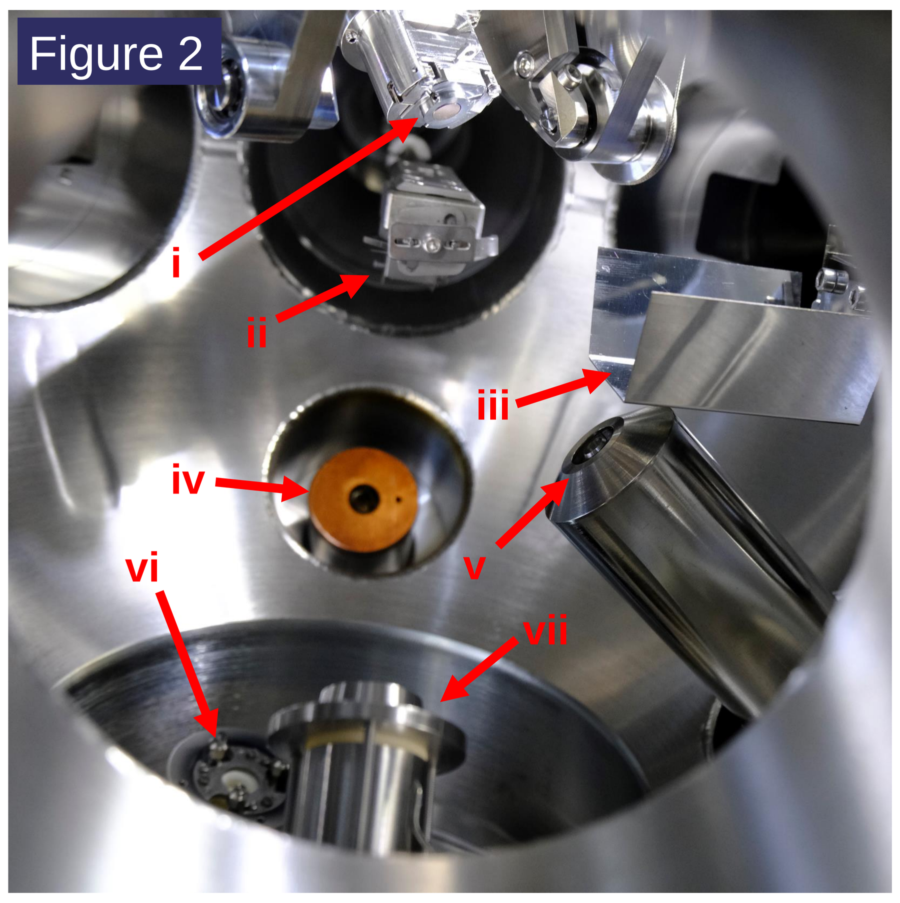

Figure 1a: Left side view of the APPF showing: i) an ion pump, ii) the quartz crystal microbalance, iii) the caesium deposition source, iv) an XHV extractor gauge, v) the tellurium deposition source, vi) the goniometer and vii) a residual gas analyser.

Figure 1b: Right side view of the APPF showing: i) the argon sputter gun, ii) the sample viewports, iii) the cylindrical mirror analyser, iv) a turbo-molecular pump, v) a picoammeter, vi) the mask and vii) a cold cathode pressure gauge.

Figure 2: View inside the APPF showing: i) the sample, ii) the quartz crystal microbalance, iii) the mask, iv) the caesium source, v) the cylindrical mirror analyser, vi) the tellurium source and vii) the argon sputter gun.

- The loading chamber has a base pressure of 3×10^{-9} mbar and the deposition chamber has a base pressure of 5×10^{-10} mbar.
- The goniometer provides 3–axis translation, along with rotation and sample tilt.
- Compatible with Omicron 19 mm flag style holders and INFN style pucks.
- Sample cleaning by argon ion bombardment using a PSP ISIS 3000 Ion Source.
- Electrically isolated sample allows DC bias and drain current measurement using a picoammeter.
- Sample heating to approximately 400 °C using an yttria coated tantalum foil filament.

3) Caesium Telluride Deposition

Alkali Metal Deposition Sources

- Caesium Source: Createc ULTC model using 99.99% pure caesium.
- Tellurium Cracker Source: Createc V-CRC model using 99.99% pure tellurium.
- Deposition flux monitored using an Inficon Quartz Crystal Microbalance.

Sample Characterisation

- Surface characterisation: Auger Electron Spectroscopy using a RBD Instruments Cylindrical Mirror Analyser.
- In-situ QE measurements: A 265 nm UV LED is focused on the -18 V biased sample with a measured power of 0.1 mW on the sample and the drain current is measured.

A deposition test was perform on a polycrystalline copper substrate (Fig. 3).

The sequential deposition parameters were:

- Tellurium source at 320 °C and the tellurium cracker at 445 °C for 1 hour.
- Caesium source at 80 °C until the measured QE peaked.
- Substrate temperature held at approximately 120 °C.

A Cs:Te ratio of 0.74:1 (Fig. 4) was achieved.

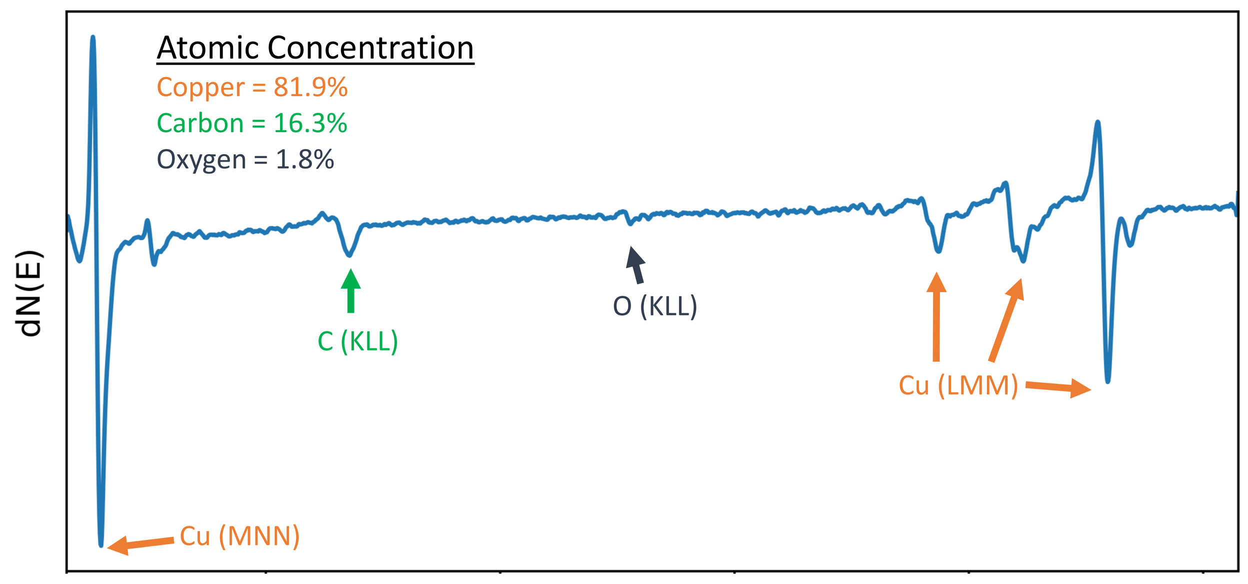

Figure 3: An Auger Electron Spectroscopy survey of poly-crystalline copper. Surface composition is 81.9% copper, 16.3 % carbon and 1.8% oxygen.

An initial QE of 7.6×10^{-5} was measured.

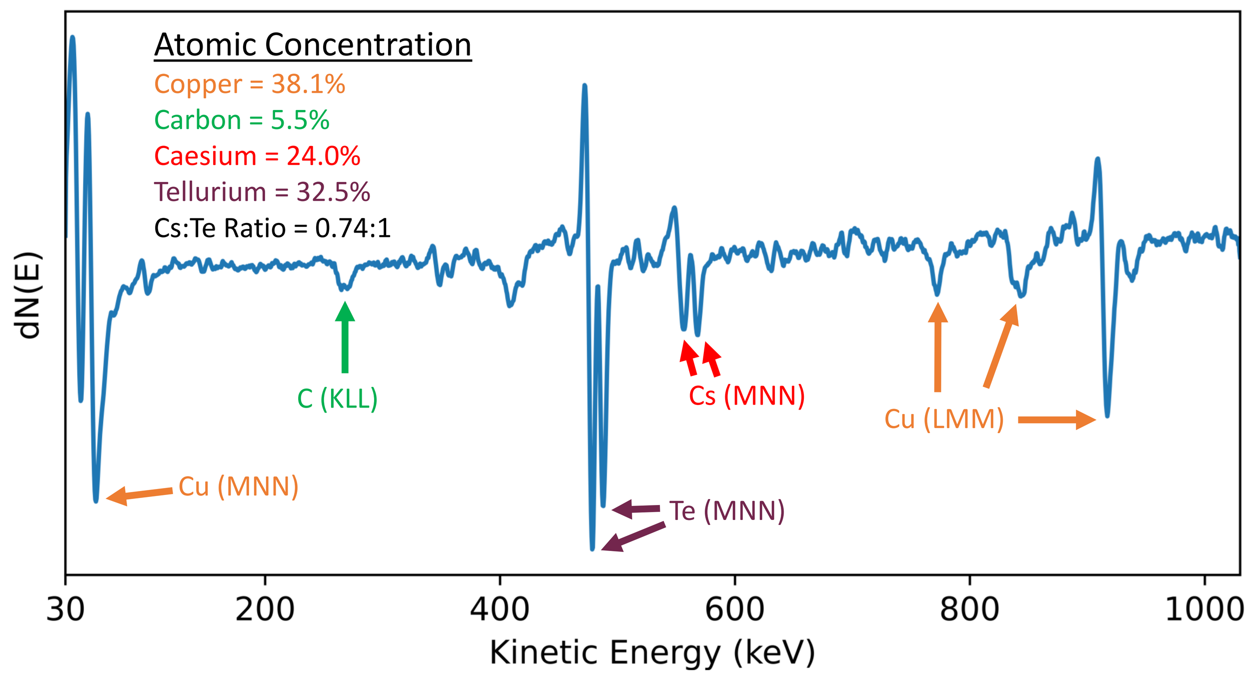

Figure 4: An Auger Electron Spectroscopy survey of copper following the deposition of caesium and tellurium. The surface composition is 38.1 % copper, 5.5 % carbon, 24.0 % caesium and 32.5 % tellurium. The ratio of caesium to tellurium is 0.74:1.

The new QE is 2.7×10^{-3} (or 0.27%), a factor of 35 increase over the clean copper shown in Fig. 3.

	Cu (Poly)		$Cs_{0.74}Te$
Quantum Efficiency	7.6×10^{-5}	35x Increase →	2.7×10^{-3}

4) Conclusion and Further Work

- We are in the final stages of testing the Alkali-metal Photocathode Preparation Facility (APPF) which is designed to grow caesium telluride (Cs_2Te) photocathodes.
- We have successfully deposited a photo-emissive Cs-Te photocathode. A stoichiometry of $Cs_{0.74}Te$ was achieved and a factor of 35 increase in QE over the copper substrate was measured.
- We will explore different growth recipes and characterise them using Multiprobe and TESS.
- We plan to grow a Cs_2Te photocathode on an INFN style molybdenum puck for CLARA.

5) References

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