Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** **Thin α-U films: Search for charge-density waves**	**Experiment number**: HE-3190
Beamline: ID20	**Date of experiment**: from: 17/11/09 to: 24/11/09	**Date of report**: 10/02/2010
Shifts: 18	**Local contact(s)**: Helen Walker	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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The light actinides exhibit some of the most intriguing properties of all the elements. Bulk alpha-uranium is rare in being a single-element system exhibiting a charge-density wave (CDW) ground-state. The rearrangement of charge at low temperature is accompanied by a periodic lattice displacement, and observed by the appearance of satellite-peaks in the diffraction patterns obtained from neutron or X-ray scattering. CDW-like stripe order is seen in high-transition-temperature superconducting cuprates, and the CDW ground state is thought to compete with the superconducting transition. As the transition involves a distortion of the lattice, the epitaxial constraint in thin-film systems is likely to suppress the CDW transition, and might then lead to an increase in the superconducting transition temperature.

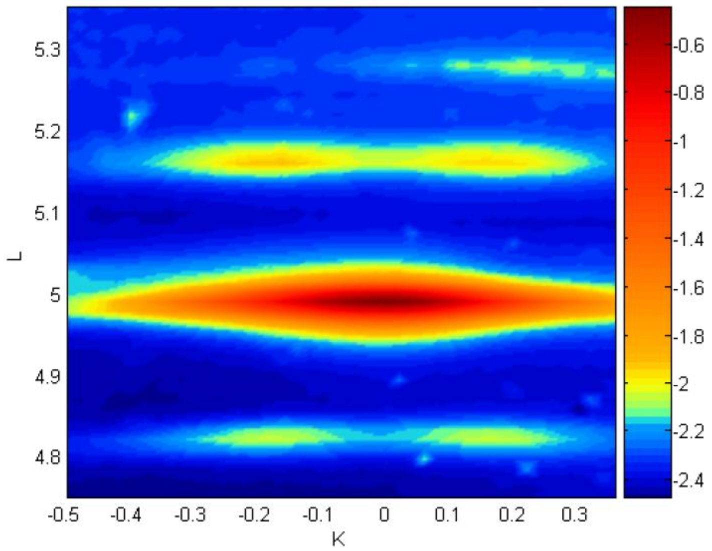

Figure 1–A section of the (2.5 K L) plane in the reciprocal lattice of a 2000 Å alpha-uranium sample grown in the [002] orientation on W. CDW satellites are visible at K=±0.18 and L=±0.16. A large unidentified peak is present at the (2.5 0 5) position.

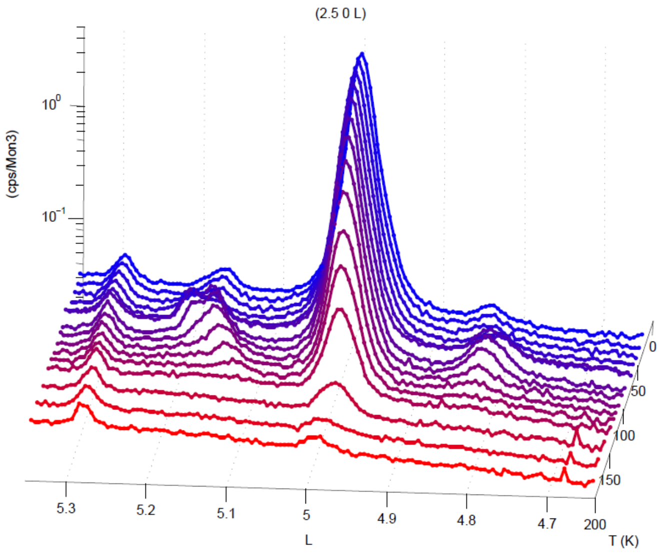

Figure 2—The temperature dependence of the peak at the (2.5 0 5) of reciprocal space.

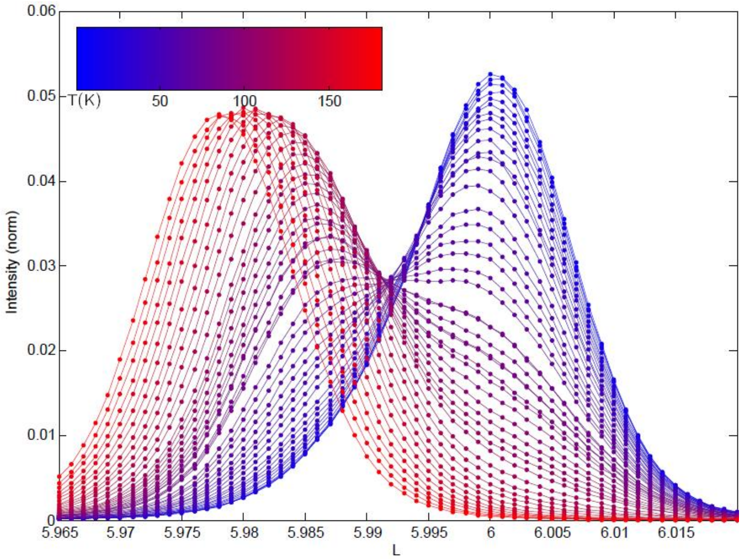

Figure 3—The anomalous behaviour with temperature of the uranium (006) charge reflection.

Previous experiments on the XMaS beamline (BM28) at the ESRF have investigated the effect of thickness on the CDW observed in thin-films of alpha-uranium grown with the [110]-direction perpendicular to the substrate surface. The films were grown by magnetron sputtering in UHV at Oxford University, with a Nb buffer layer used to seed growth of alpha-uranium on the A-plane of sapphire substrates. No CDW had previously been observed in films grown [002] on a W buffer.

A mesh-scan in the K-L plane around the (2.5 0 5) lattice position on revealed the presence of CDW satellites in a 2000 Å [002]-oriented film at (2.5 0±0.18 5±0.16), along with a large feature at (2.5 0 5) [Figure 1]. This central feature appears at an unallowed position in reciprocal space, but its clear temperature dependence [Figure 2] is persuasive evidence that it is not merely spurious.

The thermal expansion of alpha-uranium exhibiting a CDW shows a minimum in the lattice parameter at the onset of the CDW state. The temperature-dependence of the (006) lattice peak [Figure 3] shows no lattice contraction on heating, but exhibits an anomalous expansion around the temperature of the expected CDW transition. Further diffraction experiments are planned to investigate the transition responsible for the anomalous thermal expansion of the lattice, along with the presence of the disallowed peak.

Further to alpha-uranium films, single-crystal films of UO_2 have been grown by RF-sputtering on substrates of CaF_2. Due to the excellent lattice match between the substrate and the film, the presence and crystallinity of the oxide film is difficult to verify using X-ray diffraction. By scanning in energy around the uranium M4 absorption edge, it is possible to differentiate between scattering from the uranium and from the substrate. Observation of diffraction anomalous fine-structure (DAFS) from the uranium shows that the broad feature in

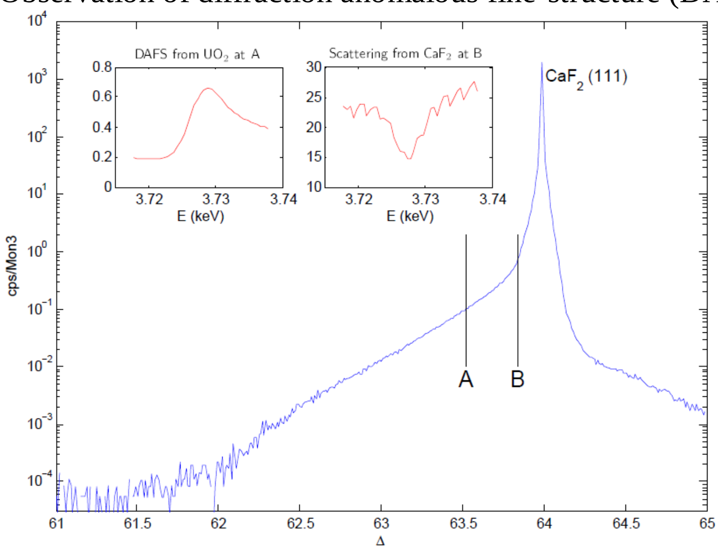

Figure 4—A longitudinal scan around the coincident peaks at (110) of UO_2 and (111) of CaF_2. The presence of DAFS is seen at position A indicating the presence of uranium.

a longitudinal scan around the expected lattice position is due to the uranium, and that the crystallinity of the UO_2 layer is too poor to observe magnetic scattering [Figure 4].