EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

ESRF

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**: SI-1699
Beamline: BM28	**Date of experiment**: from: 23/04/08 to: 29/04/08	**Date of report**: 24/08/08
Shifts: 18	**Local contact(s)**: Peter Normile	*Received at ESRF:*

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The light actinides exhibit some of the most intriguing properties of all the elements. Uranium is the only element to exhibit a charge-density wave (CDW) in the bulk, typified by a rearrangement of charge at low temperature. This appears as a minimum in the relative *d* spacing, along with satellite peaks corresponding to new periodicities in the solid. Previous work on beamline ID20 at the ESRF showed the presence of the CDW in a 5000 Å film, but with important differences to that seen in the bulk. An open question regards the dimensionality effects on the CDW as the film thickness is reduced — is there a critical thickness at which the CDW fails to appear, or does the effect reduce in intensity slowly with decreasing thickness?

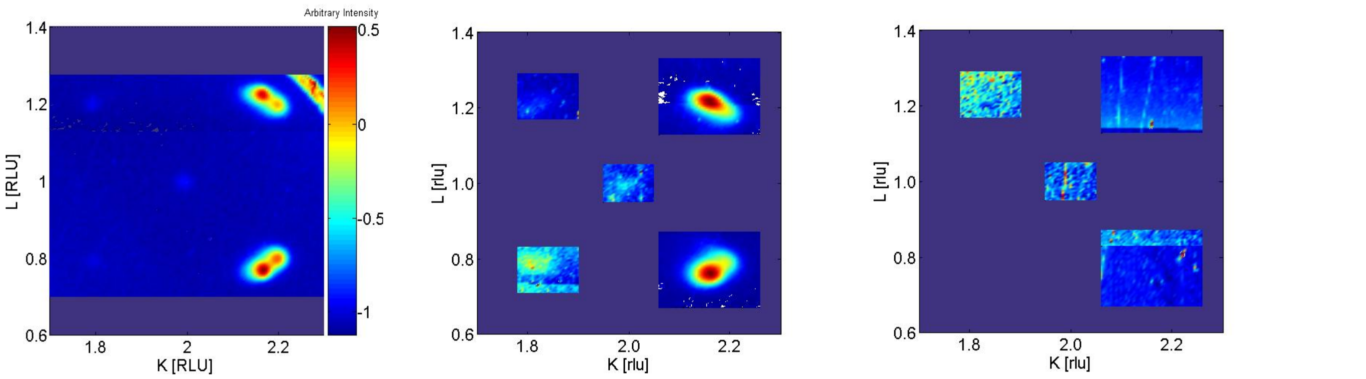

Figure 1: Charge-density wave satellites in α-U films. From left to right: 1000, 500, 50 Å films.

Three samples of differing thickness were investigated: 1000, 500 and 50 Å epitaxial uranium films were prepared at the Clarendon Laboratory in the University of Oxford, UK, using DC magnetron sputtering in UHV. The substrates were epipolished single crystal sapphire plates, oriented (1 1 -2 0). Buffer layers of *bcc* (1 1 0) niobium, grown as a single orientation, were used to seed the growth of the uranium. Nb capping layers were employed to protect the samples from oxidation. X-ray diffraction measurements have shown that the uranium is orthorhombic, oriented with the (1 1 0) plane purpendicular to the growth direction.

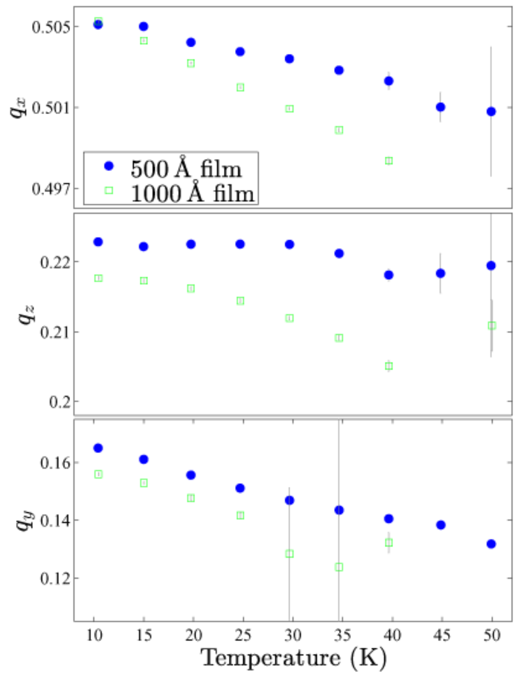

Figure 2: Components of the CDW wave-vector, *q*, in 1000 Å and 500 Å films of α-U as a function of temperature.

Rocking curves of the diffraction peaks exhibit widths of about 0.15 degrees, which indicates small crystalline mosaicity.

After alignment at base temperature (8.7 K) the first-order CDW satellites around (2.5 2 1) were found in the 1000 Å film . To verify that the satellites resulted from the charge-density wave, the temperature dependence of the (2 + 2 + 1 -) and (2 + 2 + 1 +) satellites were measured. The disappearance of the peak above 35 K confirmed the presence of the CDW in this film. As in earlier work, there is a very large contrast between the intensities of the (2 + 2 + 1 ±) and (2 + 2 - 1 ±) peaks. For the two satellites, the q z component of the lattice distortion vector remains almost constant with temperature, whereas the q y component changes significantly, by 1.6 %, between 10 and 50 K.

In the 500 Å film the first- and third-order CDW satellites were also found at base temperature , with the (2 + 2 + 1 -) peak 430 × weaker than the (2 2 0) charge peak. Changes in the vector of the lattice displacements with temperature are less marked in this sample, when compared to those in the 1000 Å film. No satellites were seen in the 50 Å film. This means that the long range reordering necessary for the formation of the charge-density wave is not possible in a film of this thickness. Suppression of the CDW in this way might affect the superconducting transition temperature.

A signature of the electron-phonon coupling that drives the CDW can be observed in the temperature-dependence of the lattice parameters. A minimum in the *d*-spacing is seen in both the 500 and 1000 Å films, but in the 50 Å film there is no clearly defined minimum, although there is a marked decrease in gradient.

The trend in going from the bulk to a 5000 Å film seen in earlier work, with the mini- mum in the lattice parameter becoming smaller, more rounded and occurring at a lower temperature, is mirrored in this work, when comparing the 500 and 1000 Å films. The large experimental uncertainty of the measurements for the 50 Å film makes it difficult for conclusions to be drawn.

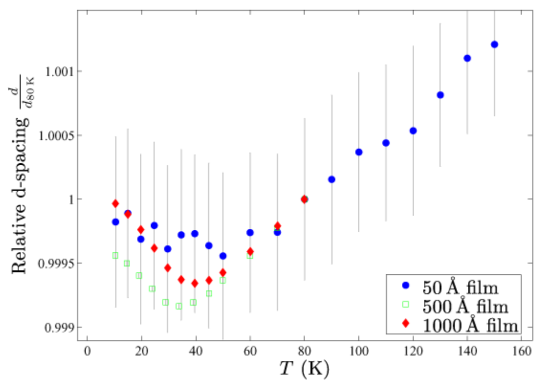

Figure 3: The change in the lattice parameter of α-U of differing thickness as a function of temperature.

Further work will aim to determine the critical thickness needed for the presence of the charge-density wave with greater accuracy, through the characterisation of films of thickness intermediate between 500 and 50 Å.