EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

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:** **Thickness effects on the CDW in thin-film alpha-U**	**Experiment number**: 28-01862
Beamline: BM28	**Date of experiment**: from: 22/07/09 to: 28/07/09	**Date of report**: 23/03/2010
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. 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.

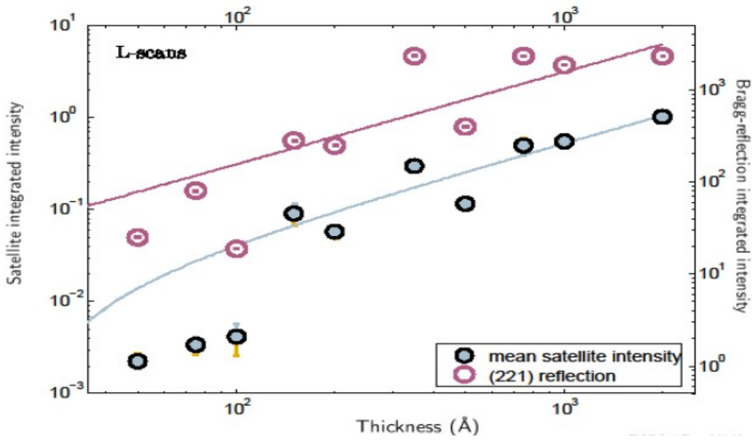

Figure 1: The mean integrated intensity of the $(2^+2^+1^+)$ and $(2^+2^+1^-)$ CDW satellites and the integrated intensity of the (221) Bragg reflection as functions of U thickness. The solid lines represent best fits to a linear behaviour in both cases.

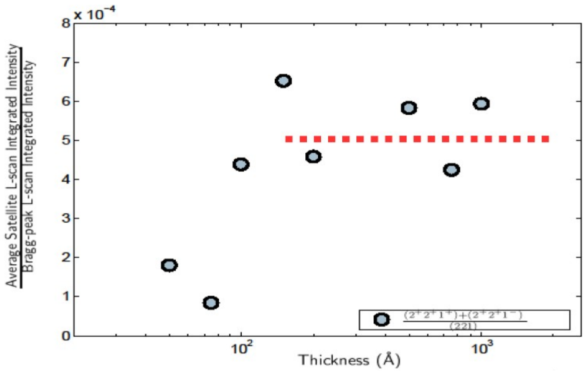

Figure 2: The mean integrated intensity of the $(2^+2^+1^+)$ and $(2^+2^+1^-)$ CDW satellites relative to the integrated intensities of the nearest Bragg-reflections as a function of U thickness.

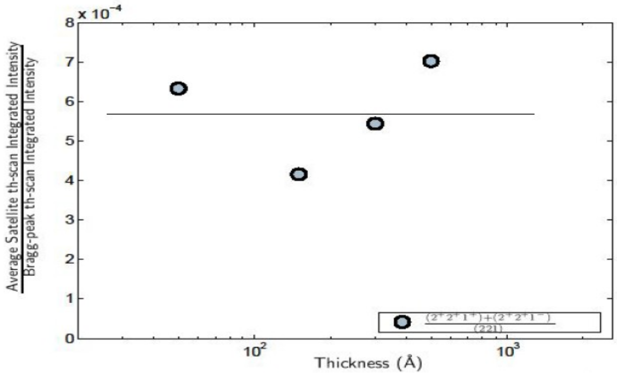

Figure 3: The mean integrated intensity of the $(2^+2^+1^+)$ and $(2^+2^+1^-)$ CDW satellites relative to the integrated intensities of the nearest Bragg-reflections as a function of Nb buffer-layer thickness. U thickness is 150 Å.

The present experiment 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.

Treating the films as a two phase system, we suppose that the atomic displacements necessary for the formation of the CDW state are not possible in the pseudomorphic (ie highly strained) film portion. Therefore, by increasing the proportion of pseudomorphic material in each sample we aim to suppress the formation of the CDW

We notice that rocking curves at the U(110) Bragg-reflection from films with thinner uranium layers show a smaller component of scattering from the relaxed portion of the film. Hence, thinner films are composed of a greater proportion of pseudomorphic phase.

The integrated intensities of the CDW satellites show a marked drop-off at low uranium thicknesses [Figure 1]. Scans were made along the L-direction ([001]) which lies in the film plane. Shown are straight-line fits to the data, with the satellite intensities apparently tending to no intensity at ~30 Å of uranium. (These films had a Nb buffer-layer thickness of 350 Å.)

The intensities of these satellites relative to the closest charge-reflection is shown in Figure 2. A large and unsystematic variation is seen between samples, which suggests that sample quality is an important factor. However, there is a significant decrease in the relative intensity at U thicknesses below 100 Å. Little dependence on uranium thickness is seen above ~300 Å.

For similar U thickness, films with a thinner buffer layer show greater pseudomorphic proportion. Changing only the buffer layer thickness avoids other effects of changing uranium thickness. Little dependence of the relative integrated intensities of the CDW satellites on Nb buffer layer thickness is seen in 150 Å U films [Figure 3], suggesting that the charge-density wave state exists in both pseudomorphic and relaxed regions of the films, in contrast to the above hypothesis.