

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.



	Experiment title: Chemical long-range ordering in self-organized CoPt ₃ (111) nanostructures grown on WSe ₂ (0001)	Experiment number: HS-1245
Beamline: BM02	Date of experiment: from: 22/11/00 to: 27/11/00	Date of report: 19/01/2001
Shifts: 12	Local contact(s): J.M. Tonnerre	<i>Received at ESRF:</i>
Names and affiliations of applicants (* indicates experimentalists): Albrecht Manfred*, Maret Mireille*, Maier Andreas* University of Konstanz, Department of Physics, P.B. M621, D-78457 Konstanz		

Report:

X-ray diffraction measurements in 30-50 Å thick nanostructured films of CoPt₃ were performed successfully on the 7-circle diffractometer of the CRG-BM02 beamline using a photon wavelength of 1.6137 Å (i.e. at an energy below the Co-K edge). Due to the van der Waals-type of the WSe₂(0001) surface, the high mobility of the adatoms leads to the formation of self-organized monocrystalline nanostructures with an 111-oriented fcc structure, a hexagonal prism shape and a narrow lateral size distribution on the order of a few nanometers, as observed from RHEED and STM measurements in 1ML deposits. For thicker deposits (30-50 Å), these films consist of dense assemblies of such nanostructures.

The main objective of these experiments was to confirm a bulk L1₂-type chemical ordering in films deposited at relatively low temperatures, typically occurring at 150°C, which is a growth temperature considerably lower than that required to obtain ordered continuous films (higher than 500°C). This chemical ordering was observed from in-situ RHEED observations. Due to the nanostructured shape of these films, we have measured 3D-RHEED patterns, where the occurrence of L1₂-type ordering was clearly indicated by the presence of intermediate RHEED spots (superstructure spots). However, due to the highest surface sensitivity of the RHEED technique, it was important to use a volume sensitive technique like x-ray diffraction to measure the chemical ordering in the whole film.

To determine the chemical ordering parameter, *S*, we have thus measured the 113 and 112 reflections with their rocking curves for different samples grown at 200, 300, 400, 500 and 600°C, accessible in reflection geometry.

The ratio of their integrated intensities corrected for absorption and Lorentz factors lead to the values of *S*, which are given in Fig.1 as a function of the growth temperature. For comparison the values deduced from the ratio of the raw intensities of superstructure and fundamental spots corresponding to the 021 and 111 reflexions, observed by RHEED (taken along the [11-2] azimuth) are also reported.

It turns out that the growth temperature dependence of the bulk order parameter measured by x-ray is quite similar to that deduced from the qualitative RHEED order parameter. The formation of L1₂-ordered

nanostructure of CoPt_3 already occurring at growth temperatures as low as 200°C is thus confirmed. This low onset temperature of chemical ordering compared to that observed in continuous films grown on $\text{Pt}(111)/\text{Al}_2\text{O}_3(0001)$ is attributed to their nanostructured shape which enhances the possibilities of atomic arrangements available on both top and side-wall facets during the co-deposition process.

Other important results obtained from this series of x-ray diffraction measurements are the following ones.

- 1) A decrease of chemical ordering by increasing the deposit from 30 to 50 Å was observed for nanostructured films deposited at 200°C . As could be expected, a gradual approach towards the behaviour of the continuous films is therefore observed. However, above 50 Å, the monocrystalline quality of the nanostructured films seems difficult to preserve as a consequence of the large misfit between the substrate and the CoPt_3 alloy, as it was observed for films deposited at RT and 200°C .
- 2) The normal coherence lengths deduced from the widths of the 222 reflections give estimates of the heights of the nanostructures (such analysis from the 111 reflections was prevented by the vicinity of the very strong reflection 0006 coming from the substrate). Provided that the monocrystalline quality is similar in the differently grown nanostructured films, the average height, first roughly constant around 40 Å for nanostructures grown between RT and 300°C increases then markedly up to a value of 85 Å for the film grown at 600°C .
- 3) A complete description of these nanostructured films would require to perform transmission measurements in order to obtain in-plane structural information. Due to the long measurement times necessary for recording the 112 reflections (100 s/pt on a large angular range), transmission measurements were performed on only two samples grown at RT but exhibiting different thicknesses, 30 and 50 Å. The measurement of the 2-20 reflections has allowed to precise the small tensile strain in the film plane, already expected from the position of the 113 reflection. For the 30 Å thick sample the parameters of the rhombohedral unit cell, which describes the distorted fcc stacking, are equal to 3.83 Å and 90.32° . Furthermore, the length of the a-axis allows to check the average composition of the film, based on the variation of the lattice parameter with the alloy composition known precisely in bulk $\text{Co}_x\text{Pt}_{1-x}$ alloys. The lateral coherence length deduced from the width of the 2-20 reflection, equal to 85 Å in both films, is in good agreement with the lateral size of the nanostructures deduced from STM analysis.

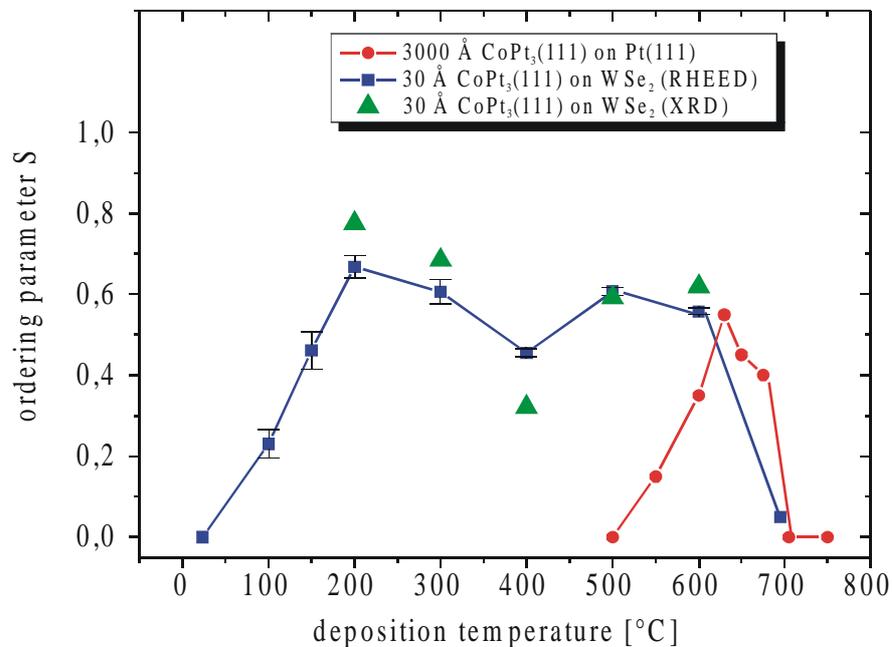


Figure 1: Variation of the chemical order parameter as a function of the growth temperature deduced from x-ray diffraction (triangles) and RHEED (squares) measurements in 30 Å thick nanostructured films grown on $\text{WSe}_2(0001)$ (the lowest values obtained at 400°C would be related to a bad monocrystalline quality of this film since the RHEED value was not reproduced in another sample grown at 400°C). For comparison, the values measured by x-ray diffraction in continuous films (circles) are reported (P.W. Rooney et al., Phys. Rev. Lett. 75 (1995) 1843).