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:** X-ray Analysis of Ferromagnetic Semiconductor Nanowire Arrays	**Experiment number**: MA 120
Beamline: BM 26A	**Date of experiment**: from: 05 April 2006 to: 11 April 2006	**Date of report**: 1 March 2007
Shifts: 18	**Local contact(s)**: Dr Gianluca Ciatto	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

We have synthesised high density arrays of $GeCo_x$ (x = 0.01- 0.05) nanowires and $GeCo_x$/Ge (x = 0.01- 0.05) core-shell heterostructured nanocables within the pores of anodic aluminium oxide (AAO) membranes. Magnetic measurements performed on $GeCo_x$ nanowires indicate a Curie temperature (T_c) greater than 300 K. Moreover it is possible to tune the magnetic properties of $GeCo_x$ by forming a $GeCo_x$/Ge core-shell nanocable structure. In order to determine the exact position of the Co atom within the Ge lattice we conducted EXAFS/XANES experiments in fluorescence (Co K edge) and transmission (Ge K edge) mode using beamline BM29 on the following materials, $GeCo_x$ (x =0.01 - 0.05) nanowires and $GeCo_x$/Ge (x = 0.01 - 0.05) core-shell nanocables. In this report we have discussed specifically the data collected for the $GeCo_{0.05}$ nanowires and $GeCo_{0.05}$/Ge core-shell nanocables. However, analysis of all experimental data collected for these materials showed good correlations between the experimentally observed data and their respective theoretical models suggesting that Co occupies an interstitial site within the Ge lattice.

Co K edge: A broad peak at 2.3 Å is observed in the fourier transform (FT) of the EXAFS data along with peaks at 3.15 Å and 3.9 Å respectively (Figure 1a). These are attributed to Co-Ge inter-atomic distances for a Co atom occupying an interstitial site within the Ge lattice. Although ideally we should have observed separate peaks at approximately 2.03 Å, 2.29 Å 2.42 Å and 2.64 Å showing various Co-Ge distances for the interstitial site the broad peak at 2.3 Å encompasses these distances and gives an average value for the various Co-Ge inter-atomic distances. Fitting of the Co K edge EXAFS data yielded a good corelation between the experimental data and the theoritical model (Figure 1b). It is significant that we do not observe any evidence for the formation of Co-Ge alloys or phase separated Co clusters even at a Co concentration ofn 5 %. It is worth noting that even in the core-shell nanocables the Co atom occupies the same interstitial position as in the nanowires. Thus it can be concluded that the position of the Co atom in the Ge lattice is not responsible for the change in the magnetic properties in $GeCo_x$ based nanowires and nanocables.

Ge K edge: The Ge K edge EXAFS data suggests that the Ge-atoms are sorrounded by a shell of O atoms at a distance of 1.74 Å, which implies that the Ge atoms are anchored to O atoms from the AAO membrane. The next-nearest neighbours to the Ge central atom were other Ge atoms at a distance of 2.46 Å corresponding to the Ge-Ge bond distance in Ge nanowires (figure 1c). Although Ge atoms near the AAO membrane are in an oxidised state the Ge-Ge distance of 2.46 Å confirms the presence of a Ge host lattice. As observed from the fitted data the experimental model again is in good agreement with the theoritical model **(**Figure 1d).

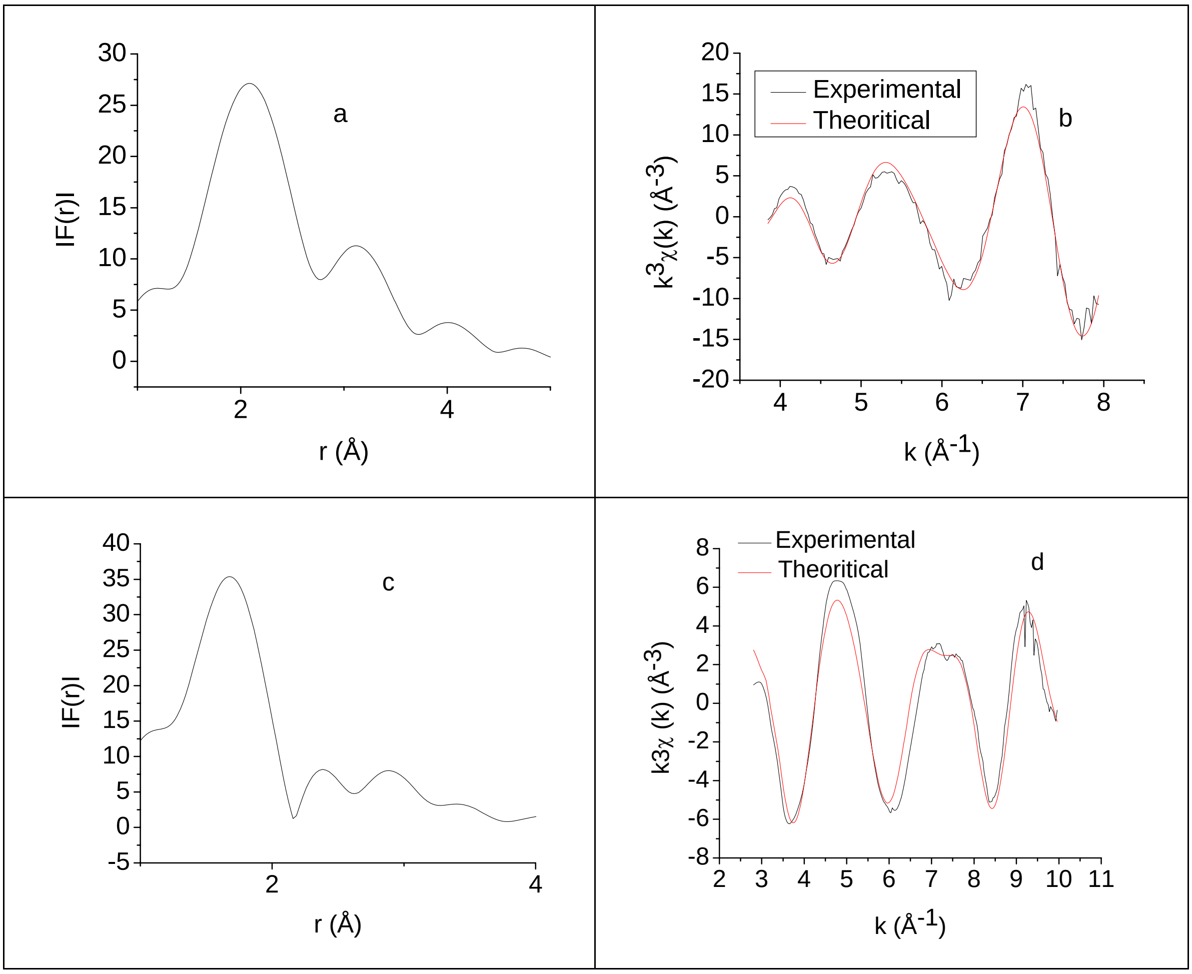

Figure 1: Absolute values of fourier transform of $k^3\chi(k)$ into r space for (a) Co K-edge and (c) Ge K-edge and typical experimental $k^3\chi(k)$ and the corresponding theoretical fit for (b)Co K-edge and (d) Ge K-edge for $GeCo_x$ nanowires and $GeCo_x$/Ge core-shell nanocable arrays..

In conclusion experiments conducted at the ESRF clearly emphasise the power of EXAFS to investigate the structural environment of dilute magnetic semiconductor (DMS) nanostructures. These results clearly prove the presence of Co in an interstitial site within the Ge lattice. These results show no evidence for the formation of Co-Ge alloys or Co clusters in the materials further confirming that the unique magnetic properties observed do not originated from undesired secondary phases but are intrinsic to the DMS structure. These experiments have been essential in understanding the complex structural and magnetic interactions exhibited by these systems.