ESRF	**Experiment title:** **X-Ray Structure Analysis of the EuS/Bi2Se3 Interface**	**Experiment number**: HC-3820
Beamline:	**Date of experiment**: from: 16.10.2018 to:23.10.2018	**Date of report**:
Shifts:	**Local contact(s)**: Dr. J. Rubio-Zuazo	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

(1) H. L. MEYERHEIM *(MPI f. Mikrostrukturphysik, D-06120 Halle (Germany)*
(2) K. MOHSENI (MPI-Halle)*

Report:

It was the aim of the experiment to carry out SXRD experiments to study the atomic structure of the EuS/Bi_2Se_3(0001) interface. The experiments could be carried out very successfully, and the data analysis still in progress. In detail: The (0001) surface of a

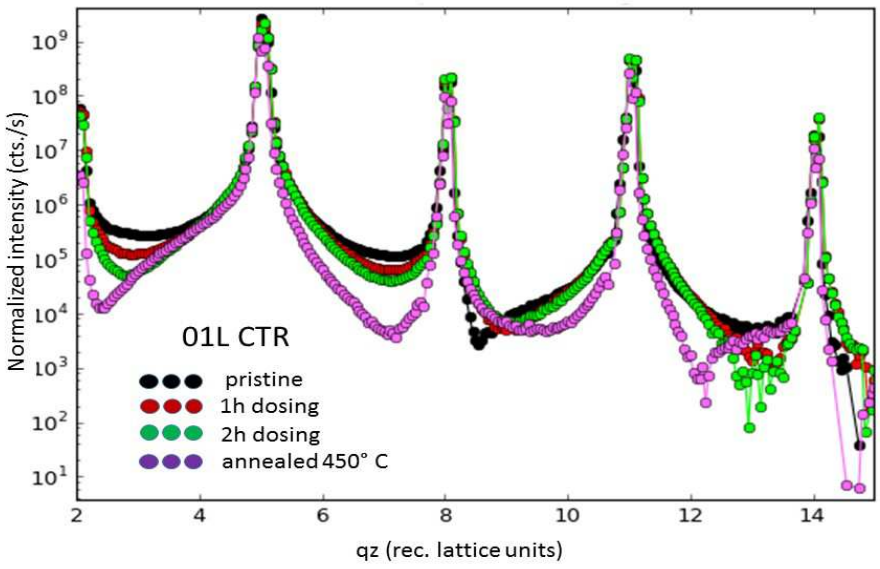

Fig.1 Comparison of intensities collected for clean and EuS covered Bi_2Se_3(0001) along the (01L) CTR.

bulk single Bi_2Se_3 crystal was first prepared by sputtering and annealing as done previosuly [1,2]. The intensity distribution along several symmetry independent crystal truncation rods (CTRs) was collected for the pristine surface first.
In the next step, EuS was deposited in the ultra-thin film thickness range using a Knudsen cell loaded with EuS powder This takes about 2 hours at a temperature of 840°C. According to our in-house experiments (see STM image below) this leads to a film thickness of about 1 unit cell along the (111) direction of cubic EuS (a_0=5.97 Å)

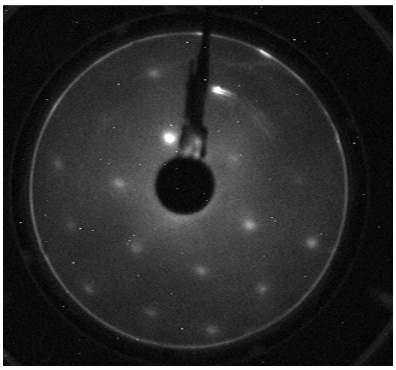

Fig.2: LEED (E_{kin}=123eV) pattern after EuS deposition on Bi_2Se_3(0001). Only (1x1) spots related to the substrate are observed according to the good lattice matching of EuS to Bi_2Se_3 (4.22 vs. 4.14 Å).

which is equal to 10.34 Å. Fig. 1 shows for comparison the (01L) CTR collected for the clean and EuS covered Bi2Se3 (0001) surface, respectively. It can be seen that there is a substantial modification of the CTRs related to adsorption of EuS. LEED investigations (see Fig.2) has shown that there is only a (1x1) pattern present and no superstructure forms.

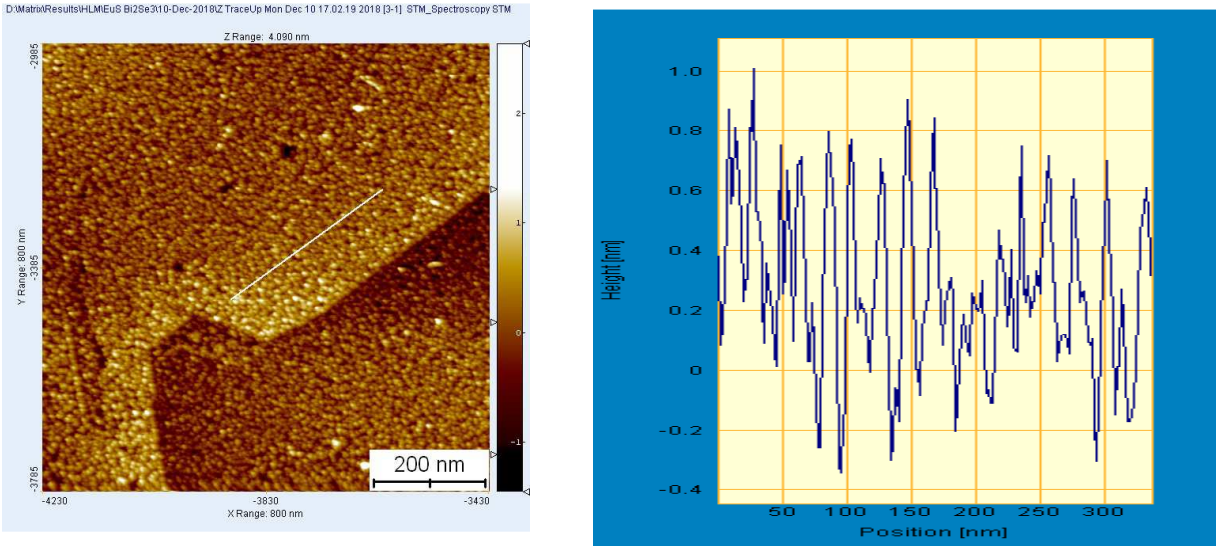

Fig.3: (left) STM image (U=1 V, I=500 nA) taken from the in-house experiment closely related to the SXRD experiments showing a fully EuS covered Bi_2Se_3(0001) surface, in which two substrate terraces are separated by a step. (Right side): The profile along the white line indicates an apparent maximum height of the EuS islands of about 1 nm related to one unit cell along the [111] direction of cubic EuS.

Until now, no completely satisfying fit of the CTR instensities is available which would allow a clear-cut statement of the film and interface structure. Preliminary analysis suggests however, that there is substantial atomic intermixing across the EuS/Bi_2Se_3 interface. This observation might be important to understand the recently observed unusual magnetic properties [3]. The data anaylsis is still in progress.

References:

[1] Sumalay Roy, H. L. Meyerheim, A. Ernst et al., Phys. Rev. Lett. 113, 116802 (2014)
[2] H. L. Meyerheim and C. Tusche, Physica Status Solidi RRL, 1800078 (2018)
[3] F. Katmis, V. Lauter, F. S. Noguera, et al., Nature 533, 513 (2016)