ESRF	**Experiment title:** Hydrogen induced change in the exchange coupling in Ho/Y multilayers.	**Experiment number**: HE-404
Beamline: ID10A	**Date of experiment**: from: 28/09/98 to: 13/10/98	**Date of report**: September 1999
Shifts: 27	**Local contact(s)**: Detlefs Carsten (PLUO D)	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

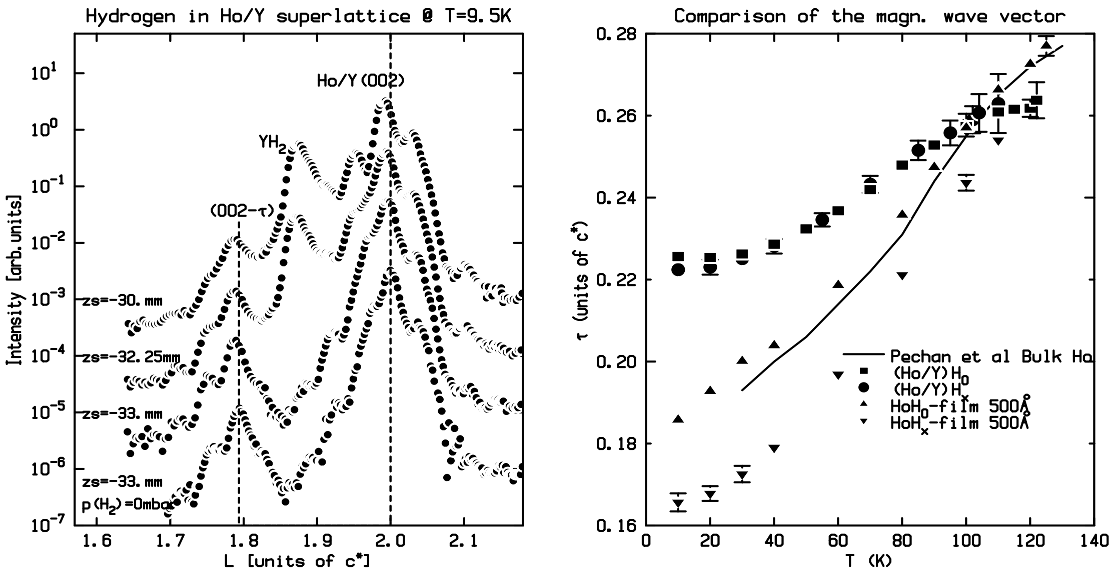
* Christoph Sutter, Ruhr-Universität Bochum
* Danielle Labergerie, Ruhr-Universität Bochum
* Vincent Leiner, ILL-Grenoble
* Arndt Remhof, Ruhr-Universität Bochum
* Harmut Zabel, Ruhr-Universität Bochum
* Carsten Detlefs, ESRF
* Gerhard Grübel, ESRF.

Report:

Hydrogen in thin metal films and superlattices has gained renewed interest in the last years because of the recently discovered reversible switching of magnetic, optical and electrical properties. For example, it has been demonstrated in Fe/Nb and Fe/V superlattices that the spin orientation of the ferromagnetic layers coupled through nonmagnetic metal spacers can be switched from parallel to antiparallel by adjusting the hydrogen content inside the nonmagnetic layers.

In one of our previous measurement on a 500 Å single Ho film [1] we have determined the influence of hydrogen on the magnetic properties of the single Ho film. Knowing this influence, the aim of this experiment was to study the effect of hydrogen in Ho/Y superlattices. From both results we wanted to extract the change of the magnetic coupling between Ho layers through Y.

A Ho/Y superlattice has been grown epitaxially at 260°C by the MBE method on a 1000Å Y(00.1) and 500Å Nb(110) buffer layer on a-plane sapphire. The sample was capped by 50Å Y and 50Å Nb to prevent it from oxidation. One half of the 10*20mm sample was covered by a Pd layer to allow a fast uptake and release of the hydrogen. This architecture has already been used successfully to obtain a lateral hydrogen concentration gradient that can be probed by scanning the sample with a 0.5mm synchrotron beam. The sample was loaded at room temperature once and than cooled down to 150K to keep the gradient stationary.



The figure shows on the left side radial scans through the (002) Bragg reflection and the (002-τ) magnetic satellites taken at different positions on the sample (different hydrogen concentrations) at T=9.5K. High zs correspond to the highest hydrogen concentration in the sample. The two bottom curves are taken at the same position before ($p(H_2)$= 0 mbar) and after loading the sample.
With increasing hydrogen concentration the Ho/Y superlattice reflection is shifting to lower L values which indicates that the superlattice has absorbed hydrogen and is in the α-phase.
At the same time an YH_2-reflection (β-phase) appears. This reflection does not come from the superlattice but from the buffer layer because at the same time the intensity of the YH_0-buffer layer reflection decreases. The difference in hydrogen uptake of the Y in the buffer and the superlattice is probably due to strain inside the superlattice.
The figure on the right side shows the turn angle as a function of the temperature for the thin Ho film and the Ho/Y superlattice with and without hydrogen. In contrast to the single film, the turn angle as well as the Néel temperature of the Ho/Y superlattice do not change with hydrogen, whereas the shift in the Bragg reflections, HoH_x(002) and HoH_y/YH_z(002) ($y \ll z \approx x$), is about the same. This could be an indication that the hydrogen preferently goes into the yttrium spacer layer and holmium absorbs much less of it: the magnetic intralayer properties of Ho are not changed. The effect of hydrogen in the Y-layer is probably twofold: the lattice expands and the electronic properties are changed. Both effects seem to compensate each other so that there is no resulting influence on the interlayer exchange coupling.

[1] C. Sutter et al., experiments report HE-187, 1998.