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PROPERTIES OF RF SPUTTERED Co/Pt and Co/Pd MULTILAYERS

S. de Haan, J.C. Lodder, P. de Haan, [1]T. Katayama

MESA Research Institute, University of Twente, Enschede, The Netherlands
[1]Electrotechnical Laboratory (ETL), Materials Science Division Tskuba, Ibaraki, Japan

Series of Co/Pt and Co/Pd multilayers have been prepared by RF sputtering (Leybold Z-400) using Ar and Kr as sputtering gas. In this case we used one target position on which two small targets were fixed. The background pressure was typically $1*10^{-7}$ mbar. The substrates were positioned below the targets on a rotating table. The thickness was determined by measuring exposure time combined with Dektak and low angle x-ray measurements. The number of bi-layers is 25. The hysteresis loops were measured by VSM and MOKE tracer.
The effective anisotropy has been measured by Torque measurements and further characterisation has been made by low and high angle x-ray diffraction. All films have been prepared on Si (100) substrates and a comparison is made between MLs with and without a 20 nm seedlayer.
Some basic properties of the Co/Pt and Co/Pd multilayers are given in table 1.

Special attention has been paid on the characterisation of the various MLs with the anomalous Hall effect (AHE) from which we detected the hysteresis loops. The Hall measurement set-up has been described earlier [1].

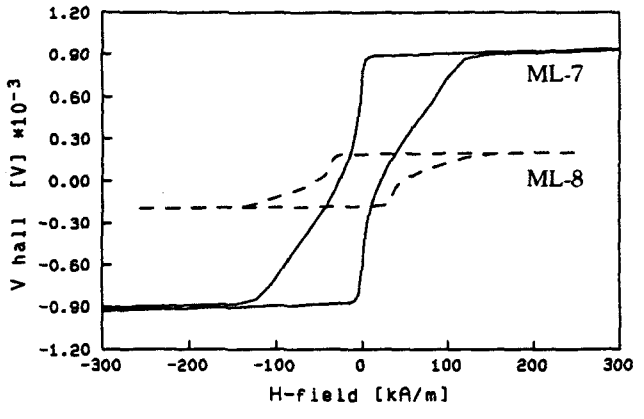

Figure 1: Anomalous Hall hysteresis loops of a Co/Pt multilayer without (ML-7) and with a seedlayer (ML-8)

These results confirm that the highest coercivity is obtained for the films prepared on a seedlayer (see figure 1). In this figure both multilayers are measured with the same current. Due to the shunting effect of the Pt seedlayer the dashed curve has a smaller Hall signal.
To study the anisotropy in Co/Pd films the sample was rotated over angle α and the anomalous Hall voltage was monitored [2] (α is the angle between the applied field and the film normal). Figure 2.a shows 3 curves for a Co/Pd multilayer with a thin Co-layer for different values of the applied field. At low applied fields he influence of the rotation over 360° on the Hall signal is small but at high fields the magnetisation shows a behaviour close to the cosines form indicating that the magnetisation in the film follows the direction of the field.

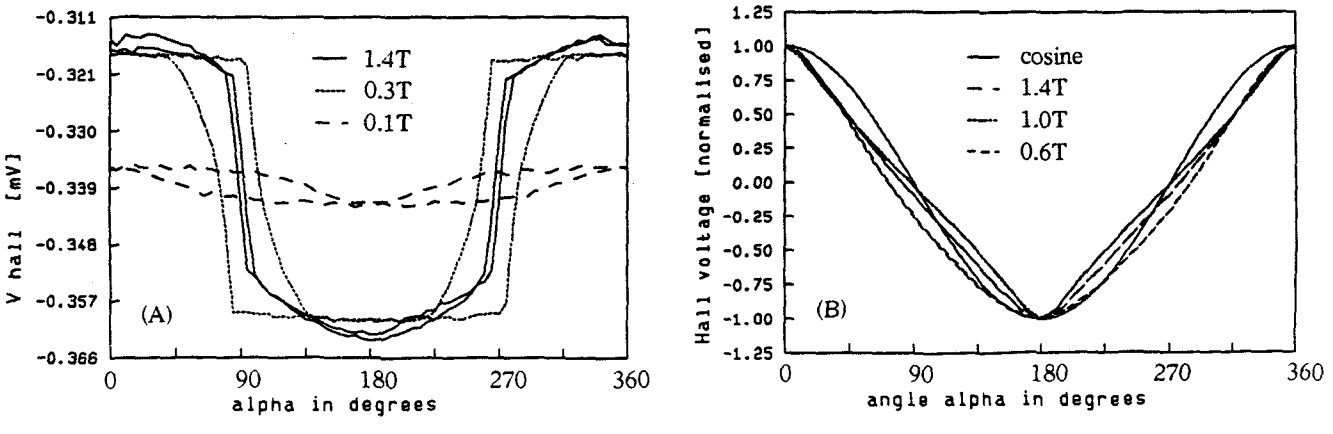

Figure 2: The anomalous Hall voltage as a function of the angle α for different field strengths for ML-10 (a) and for ML-13 (b)

In figure 2.b the same experiment has been repeated with a thicker Co-layer and it shows that the magnetisation in this film follows more or less the cosines form also for lower field strengths. A cosine has also been drawn in this figure.
Similar results have been found for the other multilayers in table 1 and this confirmes that the perpendicular anisotropy is much better for the MLs with the thinner Co-layers, which was also found by Torque measurements (see table 1).

Table 1: Properties of the Co/Pt and Co/Pd multilayers

Co/Pt	Sputter gas	t_{Co} [nm]	t_{Pt} [nm]	t_{sl} [nm]	M_s [kA/m]	H_c(vsm) [kA/m]	K_{eff} [kJ/m^3]	H_c(ahe) [kA/m]
ML-1	Ar	0.56	1.83	20	1514	28	380	23
ML-2	Ar	0.56	1.83	---	1522	16	450	10
ML-3	Ar	0.35	1.14	20	1509	28	230	34
ML-4	Ar	0.35	1.14	---	1514	16	280	14
ML-5	Kr	0.34	1.23	20	1624	88	450	89
ML-6	Kr	0.34	1.23	---	1565	28	380	25
ML-7	Kr	0.26	1.27	20	1588	52	540	52
ML-8	Kr	0.26	1.27	---	1462	28	320	25
Co/Pd	sputter gas	t_{Co} [nm]	t_{Pd} [nm]	t_{sl} [nm]	M_s [kA/m]	H_c(vsm) [kA/m]	K_{eff} [kJ/m^3]	H_c(ahm) [kA/m]
ML-9	Ar	0.21	1.36	20	2426	165	2000	166
ML-10	Ar	0.43	1.43	20	1581	88	1548	85
ML-11	Ar	0.68	1.43	20	1570	18	530	15
ML-12	Ar	1.05	1.43	20	1500	8	-74	10
ML-13	Ar	1.66	1.43	20	1385	12	-373	10
ML-14	Ar	2.27	1.43	20	1340	12	-486	10

t_{sl} = thickness of the seedlayer (Pt for the Co/Pt MLs and Pd for the Co/Pd MLs)
t_{Co}, t_{Pt} and t_{Pd} = thickness of the Co, the Pt and the Pd layers respectively
M_s = saturation magnetisation of Co measured by VSM corresponding to the total Co volume
H_c (vsm), H_c (ahe) = coercivity measured by VSM and with the anomalous Hall effect
K_{eff} = effective anisotropy constant of the Co layers measured by Torque

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