Targets for Transient Magnetic Field Measurement

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For experiments with the combined technique of transient magnetic fields with projectile Coulomb excitation in inverse kinematics multilayer targets with Gd as ferromagnetic layer are applied. Best ferromagnetic properties which means highest saturation magnetic moment per mass unit can only be reached for Gd films prepared by a special evaporation condensation technique as described in [1-3]. During heavy ion beam bombardment the Gd film must be cooled sufficiently below its Curie point of 289 K. This is performed by thermally coupling of the target to a liquid nitrogen reservoir. For such target cooling devices some technical effort is required to implement them in 4 π detector setups like the MINIBALL spectrometer or at the RISING experiment at the GSI. The lead time was too short for the complicated design. Therefore Fe layers were chosen. They have a 12.5 % lower saturation magnetic moment per mass unit compared to Gd but the high Curie point of 1043 K guaranties save experimenting even at high currents of heavy ions.

The required Fe layer thickness for a MINIBALL experiment in Köln was 3 mg/cm^2 and for the RISING experiment 70 mg/cm^2 . Both values belong to the comfortable range for rolling procedure, but experience demonstrates that rolled Fe foils don't have a narrow hysteresis curve and need more external field for magnetic saturation. On the other hand thick layers prepared by the thermal evaporation condensation process often show a high granularity which might prevent good magnetization. In case of the 3 mg/cm^2 Fe film a Cu backing of 2.5 mg/cm^2 was required. This was prepared by rolling. Copper frames were used in order to avoid magnetic influence of the target frame material. The Cu foils got substrate heating of 650 K during the Fe deposition with a deposition rate of 0.5 μg cm^{-2} s^{-1}. The saturation magnetization of these Fe layers reached values close to the theoretical one, the hysteresis curves measured with a magnetometer showed a small width. The evaporation for the 70 mg/cm^2 Fe layer onto a 50 mg/cm^2 Au backing could not be performed with the same low deposition rate, because the process would have lasted nearly 39 hours without knowing if the thickness dependent granularity would overwhelm the positive effects of a low deposition rate. Therefore for the first preparation the quite high deposition rate of 7 μg cm^{-2} s^{-1} was chosen. Nevertheless the magnetic properties of these thick Fe-layers on Au backings are practically the same as for the thinner ones on Cu backings. The adherence of both backing materials to the Fe layers was perfect due to a good high vacuum and the substrate heating, no flight peak could be detected.

For these experiments in inverse kinematics a carbon film as low Z element had to be deposited onto both types of ferromagnetic layers Gd and Fe. First preparations revealed a lack of adhesion between the Gd or Fe film and the vacuum deposited C layer of up to 0.5 mg/cm^2 thickness. Several different procedures failed after the try of standard evaporation: substrate heating up to 500 K presented an excellent adhesion during deposition, but after cooling down the carbon flaked off. An intermediate layer of thin carbon deposited by laser plasma ablation did stick excellently but the subsequently deposited carbon evaporation failed in the same way as before. In case of a complete deposition of the 0.5 mg/cm^2 C by laser plasma ablation the adherence was excellently but the complete target crumpled in the heavy ion beam spot area thus drastically reducing the resolution. The breakthrough was reached with a 5 μg/cm^2 Ti film as adhesion layer between the ferromagnetic film and the C film of 0.5 mg/cm^2. Details of this procedure are described in [4].

References

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