Preparation of ferromagnetic Gadolinium foils for g factor measurement using Transient Field Technique

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Introduction

Measurements of nuclear magnetic moments [1] play an important role in investigating nuclear structures. The magnetic moment gives direct and definite information on nuclear structures of excited states.

To perform a g factor experiment using the transient field technique one of the most important and crucial ingredient is the preparation of ferromagnetic target with a uniform magnetization property. In such experiments the nuclei experience an intense magnetic field while traversing through the polarized ferromagnetic layer by a magnetic field induced by an electromagnet. As the nucleus moves along the polarized ferromagnetic layer it experiences a transient magnetic field and the nuclear precession around the direction of the polarizing magnetic field takes place. The magnitude of the precession is proportional to the g factor value.

In earlier experiments iron was used as the ferromagnet but now gadolinium is used. Gadolinium has a higher magnetization value than iron and has lower stopping powers so potentially thicker targets can be made. This increases the sensitivity and allows for an improvement in the measurement of g factor.

Several references show that in order to achieve good magnetization gadolinium foils were prepared using evaporation-condensation technique [2,3]. But it is very difficult to prepare thick foils of the order of ~10mg/cm^2 using the evaporation – condensation technique. The technique of rolling has also been used by several groups. Thus we have employed the process of rolling and annealing to prepare our ferromagnetic foils.

In the present paper we report the preparation of such foils.

Preparation of the ferromagnetic Gadolinium foils

Gadolinium foils of varying thickness from 6mg/cm^2 to 10mg/cm^2 have been prepared using the rolling and annealing procedure. Firstly an etchant (1% H_2SO_4) was used to remove the monolayer of gadolinium oxide from the surface .After treating it with the etchant it was cleaned using a universal cleaner and was subsequently washed with alcohol and water. But better results were obtained by carefully scraping off the oxidized layer by a scraper and then cleaning it with alcohol.

The foils were then put in a stainless steel sandwich and carefully rolled with uniform pressure to maintain the uniformity of the foils.

Annealing of the foils

After completing the rolling procedure it was necessary to anneal these foils The annealing process is done to cure the lattice defects caused by the rolling procedure A certain difficulty in annealing of the Gd foil arises from the fact that Gadolinium is an excellent getter of residual gases at the typical annealing temperatures of 1000K. The chemical bonding of these gases can drastically reduce the magnetization of such foils.

Therefore for annealing purpose, the gadolinium foils were placed in a vacuum chamber between tantalum foils. The system was evacuated to a pressure of the order of 10-6 torr. Then a current was passed through the foils until the foil temperature reaches around 1000K (cherry –red heat). The foils were then annealed for about 10 to 15 minutes at the same temperature and pressure.

The magnetization of these Gd foils was investigated using a Vibrating Sample Magnetometer at University of Delhi. The instrument provides a signal directly proportional to the component of the magnetization in the direction of the polarizing field, $M_{eff} = M. B_{ext} / B$. A standard Ni sample was used for absolute calibration purposes.

Representative results for effective magnetization versus the polarizing field at different temperature for one of the foil are shown in fig.1 and fig.2

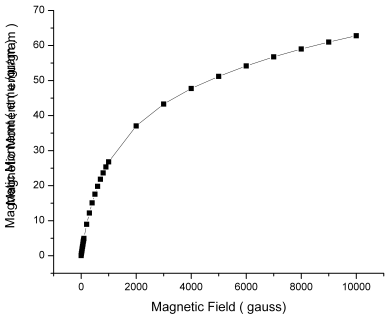

Fig. 1 Magnetization vs. polarizing fields for Gadolinium foil at room temperature.

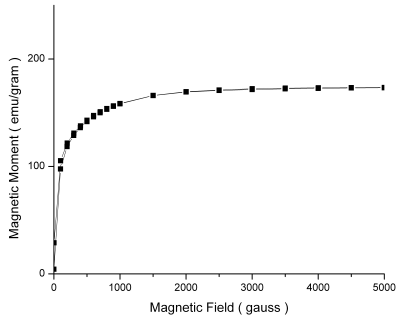

Fig. 2 Magnetization vs. polarizing fields for Gadolinium foil at 100K.

The magnetic moment observed for one of the Gd foil is ≈ 5 μ_B / atom and the standard value is ≈ 7.2 μ_B / atom.

Summary

The ferromagnetic gadolinium foils thus prepared show good magnetization property. They will be further used in a experiment at Inter University Accelerator Centre to measure the g factor of nuclei using the transient field technique.

One of the authors (MS) greatly acknowledges the financial support from CSIR, New Delhi for this research work. She would also like to acknowledge DAAD –DST for the financial support as a part of the research work was carried out at GSI.

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