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Defect induced magnetic interaction in highly oriented pyrolytic graphite (HOPG): A local investigation using TDPAD method.
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Defect induced magnetism in carbon based systems have long been the subject under extensive investigation, not only for the nature of magnetism in s, p electron systems but also for its potential to practical applications. The discovery of ferromagnetism at room temperature in pure carbon materials has given a new impetus for magnetic studies in graphite and other carbon materials [1,2]. It has been suggested that defects play a key role for the ferromagnetic ordering observed in graphite.
Here, we present magnetic hyperfine field of 19F measured by time differential perturbed angular distribution technique. The 19F probes were produced via the heavy-ion reaction 12C(12C,αp)19F using pulsed 12C beam at an energy of 40 MeV. The energetic 12C beam impinging on a 1 mm thick HOPG sample, used as the stopper, also creates high concentration of defects. The approach adopted here, thus serves the dual purpose of creating defects and studying the magnetic interactions arising thereof. For the detection of hyperfine fields we have used the 5/2 isomeric state in 19F with half-life T1/2=88.5 ns, g-factor gN = 1.44 and, quadrupole moment Q = -0.12 b which offers high sensitivity towards magnetic interactions. Typical spin rotation spectra R(t) measured for 19F in HOPG are shown in Fig 1. The R(t) spectra show superposition of two frequencies having L = 64 and 93 MHz and intensity ratio of 45:55 at 15 K. Fig 2 shows the temperature dependence of the magnetic hyperfine field Bhf derived from the expression Bhf = (L/gNNBext)-Bext. The L for the two components show distinctly different temperature dependence yielding Bhf ˜5 kG and 0.8 kG at T = 0. The observed results indicate the presence of strong magnetic interaction in HOPG. Supported by ab-initio calculations performed for a number of defect configurations around a F impurity in graphite, we assign the high field component to substitutional site with single vacancy/interstitial C, and the low field component to F at substitutional/interstitial sites without any vacancy in its neighborhood.

Fig 1. Spin rotation spectra at 15 and 35K . Fig 2. Hyperfine field as a function of temperature.

References

[1] T. Makarova et al., Carbon based magnetism, Amsterdam: Elsevier; p. 371-96 (2006).
[2] P. Esquinazi et al., Phys. Rev. B 66, 024429 (2002).

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