

## Analysis of the magnetic properties of $RFe_{11}Ti$ and $RFe_{11}TiH$ ( $R=Tb, Ho$ )

Xu Shuwei, Yan Yu\*, Jin Hanmin, Wang Wenquan, Su Feng

Department of Physics, Jilin University, Changchun 130023, P.R.China

\*Corresponding author: e-mail: jhm@mail.jlu.edu.cn, Phone:+86-0431-8499047, Fax:+86-0431-8499073

### Abstract

During the last few years, many experimental investigations has been reported for the magnetic properties of  $RFe_{11}TiH_x$  hydrides [1-3]. Nikitin et al evaluated the values of Ho-Fe exchange field  $2\mu_B H_{ex}$  and crystalline-electric-field (CEF) parameters  $A_{nm}$  in  $HoFe_{11}TiH_x$  ( $x=0,1$ ) by fitting calculations to the magnetization curves along the crystal axes at 4.2 K [1] and concluded that hydrogenation leads to about 10% increase of Ho-Fe exchange field. Inelastic neutron scattering (INS) experimnts show that insertion of C or N, D (deuterium) element reduces the exchange field at Gd site in  $Gd_2Fe_{17}$  [4] and insertion of N element reduces the exchange field at R site in  $RFe_{11}Ti$  ( $R=Gd, Er$ ) [5]. This work analyses the magnetic properties of  $RFe_{11}TiH_x$  ( $R=Tb, Ho$ ) ( $x=0,1$ ) on the basis of the single-ion model.

The value of the exchange field  $2\mu_B H_{ex}$  in  $RFe_{11}TiH_x$  ( $R=Tb, Ho$ ) ( $x=0,1$ ) were estimated as follows. The value dirived by INS experiment is about 470 K, 343 K and 250 K for  $SmFe_{11}Ti$ ,  $GdFe_{11}Ti$  and  $ErFe_{11}Ti$ . The value of  $2\mu_B H_{ex}$  decrease monotonically from Pr to Er in many Rare-earth-Fe intermetallic compounds [6]. From such a variation of  $2\mu_B H_{ex}$  across the  $RFe_{11}Ti$  series and the value of  $RFe_{11}Ti$  ( $R=Sm, Gd, Er$ ), the extrapolated value of  $2\mu_B H_{ex}$  for  $TbFe_{11}Ti$  and  $HoFe_{11}Ti$  are 285 K and 260 K, respectively. We assume that the decrease of  $2\mu_B H_{ex}$  for N insertion is about five times of the decrease for H insertion in  $RFe_{11}Ti$  as in  $R_2Fe_{17}$  copounds [4]. For  $RFe_{11}Ti$ , N insertion leads 14% decrease of  $2\mu_B H_{ex}$  [5]. The value of  $2\mu_B H_{ex}$  for  $TbFe_{11}TiH$  and  $HoFe_{11}TiH$  is estimated to be about 277 K and 253 K. The values of CEF parameters  $A_{nm}$  were evaluated by fitting calculations to the magnetization curves at 4.2 K for the single crystals of  $RFe_{11}TiH_x$  ( $R=Tb, Ho$ ) ( $x=0,1$ ). Table 1 lists the fitted values. The magnetization curves at high temperature for the single crystals of  $RFe_{11}TiH_x$  ( $R=Tb, Ho$ ) ( $x=0,1$ ) were well reproduced by using fitted parameters.

Table 1 The fitted values of CEF parameters  $A_{nm}$

	$A_{20}$	$A_{40}$	$A_{44}$	$A_{60}$	$A_{64}$
$TbFe_{11}Ti$	-90 K	-4 K	-100 K	2 K	-87 K
$TbFe_{11}TiH$	-160 K	-110 K	34 K	20 K	-25 K
$HoFe_{11}Ti$	-61 K	-122 K	-176 K	432 K	-13 K
$HoFe_{11}TiH$	-130 K	-85 K	-80 K	62 K	-10 K

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