

**Keywords:** neutron diffraction; polarized neutrons; X-ray magnetic circular dichroism

#### FA2-MS09-O4

**Structural, Magnetic and Electric Properties of  $\text{GaFe}_{1-x}\text{Mn}_x\text{O}_3$ .** M.Bakr<sup>a</sup>, A. Senyshyn<sup>a</sup>, H. Wang<sup>a</sup>, G. Parzych<sup>b</sup>, L.Dobrzynski<sup>b,c</sup>, K.Szymański<sup>c</sup>, H. Fuess<sup>a</sup>. <sup>a</sup>Institut für Materials Science, Darmstadt University of Technology, D - 64289 Darmstadt, Germany. <sup>b</sup>The Soltan Institute for Nuclear Studies, Poland. <sup>c</sup>Faculty of Physics, University of Białystok, Poland. E-mail: [mbm1977@yahoo.com](mailto:mbm1977@yahoo.com)

Gallium iron oxide ( $\text{GaFeO}_3$ ) is a member of a multiferroic family which exhibits ferrimagnetic and piezoelectric properties below room temperature [1-2]. This material has orthorhombic (double HCP Closed-Pack) crystal structure with space group  $Pc2_1n$  with four different cation sites labeled Ga1, Ga2 (mostly occupied by gallium) and Fe1, Fe2 (mostly occupied by iron) [3-5]. The different physical properties of  $\text{GaFeO}_3$  are strongly dependent on the distribution of cations within the structure. The magnetic properties of  $\text{GaFeO}_3$  strongly depend on the preparation method which affects the cations distributed over different sites. Polycrystalline  $\text{GaFe}_{1-x}\text{Mn}_x\text{O}_3$  materials have been prepared by a traditional solid state reaction (SR) and sol-gel (SG) methods. Structural analyses showed that the maximum Mn content is 10% and 50% for samples prepared by SR and SG, respectively. All samples crystallise in the orthorhombic system with  $Pc2_1n$  space-group. The Curie temperature ( $T_C$ ) for  $\text{GaFeO}_3$  (SR) is about 190K and increases or reaches room temperature when the temperature of preparation is decreased from 1400°C to 700°C. The Curie temperature for SG reaction is slightly above room temperature. With increasing the Mn content the transition temperatures as well as the coercive field decrease. Dielectric investigations revealed a temperature independent anomaly at around 255 K with frequency dispersion of dielectric constant only for  $\text{GaFeO}_3$  prepared at 700°C (SG) and Mn doped samples prepared by both methods. It follows from the neutron powder diffraction and Mössbauer spectroscopy revealed that  $\text{GaFeO}_3$  exhibits a ferrimagnetic order with spins parallel to c-axis. Both, the cation and magnetic, orderings depend strongly on the preparation conditions.

[1] J.P. Reimeka, *J. Appl. Phys.* 31 263S, 1960, [2] E.A. Wood, *Acta Cryst.* 13, 682, 1960, [3] S.C. Abrahams, J.M. Reddy and I.L. Bernstein, *Chem. Phys.* 42, 3957-3968, 1965, [4] G.T. Rado, *Phys. Rev. Lett.* 13, 335-337, 1964, [5] T. Arima, D. Higashiyama, Y. Kaneko, J.P. He, T. Goto, S. Miyasaka, T. Kimura, K. Oikawa, T. Kamiyama, R. Kuumai, and Y. Tokura, *Phys. Rev. B* 70, 064426, 1-8, 2004.

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#### FA2-MS09-O5

**Neutron Diffraction Study of  $\text{DyVO}_3$  and  $\text{HoVO}_3$ .** Manfred Reehuis<sup>a</sup>, Clemens Ulrich<sup>b</sup>, Jun Fujioka<sup>c</sup>, Shigoki Miyasaka<sup>c</sup>, Yoshinori Tokura<sup>c</sup>, Bernhard

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Vanadates with the formula  $R\text{VO}_3$  ( $R = \text{Y}$  or rare-earth element) exhibit many exciting properties, which can be related to orbital or spin rearrangements [1], [2]. In order to provide a more complete basis for the theoretical description of the electronic properties of these compounds we have started to carry out a comprehensive investigation of the crystal and magnetic structures of  $\text{YVO}_3$ ,  $\text{NdVO}_3$  and  $\text{TbVO}_3$  [3], [4]. In the room-temperature lattice structure the influence of the relative ionic sizes leads to tilts of the  $\text{VO}_6$ -octahedra. From  $\text{La}^{3+}$  to  $\text{Lu}^{3+}$  the distortions show a continuous increase due to the well-known lanthanide contraction. With decreasing temperature the vanadates show a structural phase transition at  $T_{S1}$ , where the orthorhombic structure ( $Pbnm$ ) changes to a monoclinic structure with the space group  $P2_1/b$  due to the onset of the cooperative *Jahn-Teller* effect and the onset of orbital ordering. In the monoclinic phase the magnetic moments of the  $\text{V}^{3+}$ -ions show antiferromagnetic ordering with the modes  $C_x$ ,  $C_y$  and  $G_z$ , where the  $z$ -component is the weakest. A second structural phase transition ( $T_{S2}$ ) could be observed for vanadates containing smaller  $R^{3+}$ -ions ( $R^{3+} = \text{Y}^{3+}$ ,  $\text{Ho}^{3+}$  –  $\text{Lu}^{3+}$ ) [1]. Below  $T_{S2}$  the crystal structure changes back to the orthorhombic structure and the vanadium moments are purely  $G$ -type ordered along  $z$  [3], [4]. In  $\text{DyVO}_3$ , where the  $R^{3+}$ -ion is slightly larger than  $\text{Ho}^{3+}$ , a critical phase competition between different spin-orbital-ordered states was observed only recently [5]. Our neutron diffraction experiments of  $\text{DyVO}_3$  showed that the transition to the pure  $G$ -type ordering sets in at  $T_{S2} = 63(1)$  K. For  $\text{YVO}_3$ , where  $\text{Y}^{3+}$  is only slightly smaller than  $\text{Dy}^{3+}$ , this transition sets in at considerably higher temperature  $T_{S2} = 77(1)$  K. As found earlier for  $\text{YVO}_3$  the  $G$ -type ordering in  $\text{DyVO}_3$  remains stable upon cooling from  $T_{S2}$  down to 6 K. But with increasing temperature the monoclinic  $C$ -type phase surprisingly appears in  $\text{DyVO}_3$  between 13 and 23 K. For  $\text{HoVO}_3$  this intermediate phase could not be observed. On the other hand the second phase transition of this vanadate sets in (cooling process) at the strongly reduced temperature  $T_{S2} = 26(1)$ . With increasing temperature it sets in at the higher value  $T_{S2} = 36(1)$  K, indicating the presence of strong hysteresis effects. Further it is important to note that both the magnetic moments of the  $\text{Dy}^{3+}$ - and  $\text{Ho}^{3+}$ -ions show a long-range ferrimagnetic order up to the unusually high temperatures 23(1) K and 36(1) K, respectively. Our study clearly showed that strong exchange interactions between the magnetically ordered V-moments and the magnetic  $\text{Dy}^{3+}$ - and  $\text{Ho}^{3+}$ -ions lead to a reduction of the transition temperature  $T_{S2}$  as well as to an increasing of the magnetic ordering temperature of the  $R^{3+}$ -ions.

[1] Miyasaka S.; Okimoto Y.; Iwama M.; Tokura Y., *Phys. Rev. B*, 2003, 68, 100406(R). [2] Blake G.R.; Palstra T.T.M.; Ren Y.; Nugroho A.A.; Menovsky A.A., *Phys. Rev. Lett.*, 2001, 87, 245501. [3] Ulrich C.; Khaliullin G.; Sirker J.; Reehuis M.; Ohl M.; Miyasaka S.; Tokura Y.; Keimer B., *Phys. Rev. Lett.*, 2003, 91, 257202. [4] Reehuis M.; Ulrich C.; Pattison P.; Ouladdiaf B.; Rheinstädter M.C.; Ohl M.; Regnault L.P.; Miyasaka S.; Tokura

Y.; Keimer B., *Phys. Rev. B*, **2006**, 73, 094440. [5] Miyasaka S.; Yasue T.; Fujioka J.; Yamasaki Y.; Okimoto Y.; Kumai R.; Arima T.; Tokura Y., *Phys. Rev. Lett.*, **2007**, 99, 217201.

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