S Hunagund[1], J Rosenberg[2], S M Harstad[3], S Gupta[4], V Pecharsky[4,5], A A El-Gendy[6], and R L Hadimani[7,8]

[1]Mechanical and Nuclear Engineering, Virginia Commonwealth University
[2]Florida State University, The National High Magnetic Field Laboratory
[3]Mechanical and Nuclear engineering, Virginia Commonwealth University
[4]Department of Energy, Ames Laboratory, Iowa State University
[5]Dept. of Material Science and Engineering, Iowa State University
[6]Affiliation not available
[7]Department of Mechanical and Nuclear Engineering, Virginia Commonwealth University
[8]University of Texas at El Paso

March 22, 2023

T_1, T_2 and T_2* relaxations in MRI based on Gd_5Si_4 nanoparticles of varying sizes

S. Hunagund[1], J. Rosenberg[2], S.M. Harstad[3], S. Gupta[4], V. Pecharsky[4,5], A.A. El-Gendy[7] and R.L. Hadimani[6]

1. Mechanical and Nuclear Engineering, Virginia Commonwealth University, Richmond, VA, United States; 2. Florida State University, The National High Magnetic Field Laboratory, Tallahassee, FL, United States; 3. Mechanical and Nuclear engineering, Virginia Commonwealth University, Richmond, VA, United States; 4. Iowa State University, Ames Laboratory, US Department of Energy, Ames, IA, United States; 5. Dept. of Material Science and Engineering, Iowa State University, Ames, IA, United States; 6. Department of Mechanical and Nuclear Engineering, Virginia Commonwealth University, Richmond, VA, United States; 7. Physics, University of Texas at El Paso, El Paso, TX, United States

Abstract:

Our previous study has shown that ferromagnetic gadolinium silicide (Gd_5Si_4) nanoparticles (NP) could be potentially efficient T_2 CA for MRI with significantly reduced echo time (TE) compared to Superparamagnetic Iron Oxide Nanoparticles (SPION) [1]. T_2 CA are defined by their relaxivity, r_2, which is dependent on both the saturation magnetization (Ms) and size of the NPs [1,2,4]. In this study, effect of Gd_5Si_4 NPs of varying sizes and concentrations are investigated on T_1, T_2 and T_2* (effective/observed T_2) relaxations times.

Gd_5Si_4 NPs categorized into three fractions (named S1, S2 and S3) based on average sizes of 586 nm, 287 nm and 135 nm respectively as analyzed from SEM images (Fig. 1). XRD analysis on the combined samples shows that Gd_5Si_4 is the major phase while GdSi and Gd_5Si_3 are present as the minor phases in all fractions (Fig. 1). Magnetic properties measured in VSM reveal that the Curie temperature (Tc) decreases for Gd_5Si_4 phase from 312 K for S1 to 304 K for S2 and is undetectable in S3. The M-H curves at 300 K exhibits ferromagnetic behavior descending to paramagnetic as we move from S1 to S3 fraction (Fig. 1).

MR data were acquired on the 21.1 T (900 MHz) magnet. The results shown in Table 1 indicate that higher concentrations of NPs shorten the T_2 and T_2* relaxation times and the contrast disappears rapidly at higher dilutions. The S2 fraction at 1/20 dilution shows notably shortened T_1 and T_2 relaxation times compared to the other two fractions. Although S1 has higher Gd_5Si_4 phase volume fraction and larger average particle size compared to S2, further investigation is needed inorder to establish the reason for shortened relaxation times compared to the S1 fraction.

Acknowledgements

Work at the Ames Lab was supported by DOE (contract No. DE-AC02-07CH11358). Work at VCU was partially funded by NSF, Award No.: 1610967. Work performed at the NHMFL is supported by the State of Florida and the NSF (agreement No. DMR-1157490).

References:

[1] S. G. Hunagund, S. M. Harstad, A. A. El-Gendy, S. Gupta, V. K. Pecharsky, and R. L. Hadimani, "Investigating phase transition temperatures of size separated gadolinium silicide magnetic nanoparticles," *AIP Advances*, vol. 8, no. 5, p. 056428, 2018.

[2] S. Harstad, S. Hunagund, O. Boekelheide, Z.A. Hussein, A.A. El-Gendy, and R.L. Hadimani, Magnetic Nanostructured Materials: from Lab to Fab (New York: Elsevier, 2018), pp. 137–155.

[3] Hunagund, Shivakumar; Rosenberg, Jens; Harstad, Shane M.; Gupta, Shalabh; Pecharsky, Vitalij; Hadimani, Ravi L. "Effect of Gd5Si4 ferromagnetic nanoparticle sizes on T1, T2 and T2* relaxation in MRI". Intermag, Singapore, 2018

[4] S. Hunagund, A. A. El-Gendy, S. M. Harstad, S. Gupta, V. K. Pecharsky and R. L. Hadimani. "Effect of particle size on Curie temperature and coercivity of Gadolinium silicide (Gd5Si4)". APS March Meeting 2018, Los Angeles, 2018

ICM2018
SAN FRANCISCO
JULY 15-20, 2018
21ST INTERNATIONAL CONFERENCE ON MAGNETISM

PROGRAM

MOSCONE CENTER
icm2018sf.org

AIP Publishing
IEEE MAGNETICS
IUPAP

B1-02. Gilbert damping constant in exchange biased ferromagnetic/antiferromagnetic bilayers. *T. Ikebuchi*[1], T. Moriyama[1], H. Mizuno[1], K. Oda[1] and T. Ono[1] *1. Institute for Chemical Research, Kyoto University, Uji, Japan*

B1-03. Manipulation of spin current in antiferromagnetic insulator. *D. Hou*[1] *1. AIMR, Tohoku University, Sendai, Japan*

B1-04. Finite Size Effects in Antiferromagnetic Materials. *S. Jenkins*[1], R. Chantrell[1] and R.F. Evans[1] *1. Department of Physics, University of York, York, United Kingdom*

B1-05. Field-driven antiferromagnetic domain switching in single crystalline CoO(001) film. *J. Xu*[1], M. Jia[2], G. Chen[3], Q. Li[4], A.T. N'Diaye[5], E. Arenholz[6] and Y. Wu[7] *1. Department of Physics, Fudan University, Shanghai, China; 2. Fudan University, Shanghai, China; 3. Lawrence Berkeley National Laboratory, Davis, CA, United States; 4. Physics, University of California, Berkeley, Berkeley, CA, United States; 5. Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA, United States; 6. LBNL, Berkeley, CA, United States; 7. Physics Department, Fudan University, Shanghai, China*

B1-06. X-Ray Linear Dichroism for Probing Magnetic Dynamics in the Low-Damping Ferrimagnetic Insulator Yttrium Iron Garnet. *J. Bailey*[1,2], J. Förster[3], S. Finizio[2], M. Weigand[3], J. Gräfe[3], C. Dubs[4], J. Raabe[2], G. Aeppli[2], G.A. Schütz[3] and S. Wintz[2] *1. Institut de Physique, EPF Lausanne, Lausanne, Switzerland; 2. Paul Scherrer Institut, Villigen PSI, Switzerland; 3. Max Planck Institute for Intelligent Systems, Stuttgart, Germany; 4. INNOVENT e.V, Jena, Germany*

B1-07. Spin-orbit torque of PtMn/CoFeB evaluated by extended harmonic Hall measurement. *R. Itoh*[1], Y. Takeuchi[1], S. Duttagupta[2], S. Fukami[1,3] and H. Ohno[1,3] *1. Lab. for Nanoelectronics and Spintronics, RIEC, Sendai, Japan; 2. Center for Spintronics Research Network, Tohoku University, Sendai, Japan; 3. Center for Spintronics Integrated Systems, Tohoku University, Sendai, Japan*

B1-08. Probing the Energy Barrier for Resistive Switching in Antiferromagnetic Sr Ir O . *M.C. Williamson*[1,2], S. Shen[1,2], G. Cao[3], J. Zhou[2], J. Goodenough[3,2,7] and M. Tsoi[2] *1. Physics, University of Texas at Austin, Austin, TX, United States; 2. Texas Materials Institute, Austin, TX, United States; 3. Physics, University of Colorado, Boulder, CO, United States*

B1-09. Heat Assisted Switching of AFM CuMnAs Memory Cell. *Z. Kašpar*[1,2], K. Olejník[1], V. Novák[1] and T. Jungwirth[1,3] *1. Academy of Sciences of the Czech Republic, Prague, Czechia; 2. Charles University in Prague, Prague, Czechia; 3. School of Physics and Astronomy, Nottingham, United Kingdom*

B1-10. Nanoscale Imaging of Antiferromagnetic Order using Single-spin Magnetometry. *B. Shields*[1], P. Appel[1], T. Kosub[2], N. Hedrich[1], J. Fassbender[2], R. Huebner[2], D. Makarov[2] and P. Maletinsky[1] *1. Physics, University of Basel, Basel, Switzerland; 2. Helmholtz-Zentrum Dresden-Rossendorf e.V., Dresden, Germany*

B1-11. Material Systems for Skyrmions in Co-based Ferro-/Antiferromagnetically Coupled Multilayers. H. Jia[1], *B. Zimmermann*[1] and S. Blügel[1] *1. Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich, Jülich, Germany*

MONDAY MORNING 10:00

SAN FRANCISCO BALLROOM

Session B2
BIOMEDICAL AND NON-BIOMEDICAL APPLICATIONS I (Poster Session)

Ahmed El-Gendy, Chair
University of Texas at El Paso, El Paso, TX, United States

B2-01. Magnetic Design of Multi-Component Nanoprobes for Biomolecular Diagnostics. *H. Brueckl*[1], A. Shoshi[1], M. Haslinger[2], T. Mitteramskogler[2], M. Muehlberger[2], J. Schotter[3] and S. Schrittwieser[3] *1. Department for Integrated Sensor Systems, Danube University Krems, Wiener Neustadt, Austria; 2. PROFACTOR GmbH, Steyr/Gleink, Austria; 3. AIT Austrian Institute of Technology, Vienna, Austria*

B2-02. Optimization of a Biosensor based on Superparamagnetic Particles-labelling by Electromagnetic Simulation. *A. García-Arribas*[1,2], M. Quintana[1,2], E. Fernández[2], J. Feuchtwanger[1], M. Fernández-Gubieda[1,2], J.C. Martínez-García[3] and M. Rivas[3] *1. Departamento de Electricidad y Electrónica, Universidad del País Vasco, UPV/EHU, Leioa, Spain; 2. BCMaterials, Basque Center for Materials, Applications and Nanostructures, Leioa, Spain; 3. Departmento de Física, Universidad de Oviedo, Gijón, Spain*

B2-03. T , T and T * relaxations in MRI based on Gd Si nanoparticles of varying sizes. *S. Hunagund*[1], J. Rosenberg[2], S.M. Harstad[3], S. Gupta[4], V. Pecharsky[4,5], A.A. El-Gendy[7] and R.L. Hadimani[6] *1. Mechanical and Nuclear Engineering, Virginia Commonwealth University, Richmond, VA, United States; 2. Florida State University, The National High Magnetic Field Laboratory, Tallahassee, FL, United States; 3. Mechanical and Nuclear engineering, Virginia Commonwealth University, Richmond, VA, United States; 4. Iowa State University, Ames Laboratory, US Department of Energy, Ames, IA, United States; 5. Dept. of Material Science and Engineering, Iowa State University, Ames, IA, United States; 6. Department of Mechanical and Nuclear Engineering, Virginia Commonwealth University, Richmond, VA, United States; 7. Physics, University of Texas at El Paso, El Paso, TX, United States*

B2-04. Influence of pH on Dynamic Magnetic Susceptibility of Iron-oxide Nanoparticles in a Chitosan Hydrogel Matrix. *M.C. Villamin*[1] and Y. Kitamoto[1] *1. Materials Science and Engineering, Tokyo Institute of Technology, Yokohama, Japan*