

T₁, T₂ and T₂* relaxations in MRI based on Gd₅Si₄ nanoparticles of varying sizes

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Abstract:

Our previous study has shown that ferromagnetic gadolinium silicide (Gd₅Si₄) nanoparticles (NP) could be potentially efficient T₂ CA for MRI with significantly reduced echo time (TE) compared to Superparamagnetic Iron Oxide Nanoparticles (SPION) [1]. T₂ CA are defined by their relaxivity, r₂, which is dependent on both the saturation magnetization (M_s) and size of the NPs [1,2,4]. In this study, effect of Gd₅Si₄ NPs of varying sizes and concentrations are investigated on T₁, T₂ and T₂* (effective/observed T₂) relaxations times.

Gd₅Si₄ 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 Gd₅Si₄ is the major phase while GdSi and Gd₅Si₃ are present as the minor phases in all fractions (Fig. 1). Magnetic properties measured in VSM reveal that the Curie temperature (T_c) decreases for Gd₅Si₄ 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 T₂ and T₂* relaxation times and the contrast disappears rapidly at higher dilutions. The S2 fraction at 1/20 dilution shows notably shortened T₁ and T₂ relaxation times compared to the other two fractions. Although S1 has higher Gd₅Si₄ phase volume fraction and larger average particle size compared to S2, further investigation is needed in order to establish the reason for shortened relaxation times compared to the S1 fraction.

Acknowledgements

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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
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B1-02. Gilbert damping constant in exchange biased ferromagnetic/antiferromagnetic bilayers. *T. Ikebuchi¹, T. Moriyama¹, H. Mizuno¹, K. Oda¹ and T. Ono¹ 1. Institute for Chemical Research, Kyoto University, Uji, Japan*

B1-03. Manipulation of spin current in antiferromagnetic insulator. *D. Hou¹ 1. AIMR, Tohoku University, Sendai, Japan*

B1-04. Finite Size Effects in Antiferromagnetic Materials. *S. Jenkins¹, R. Chantrell¹ and R.F. Evans¹ 1. Department of Physics, University of York, York, United Kingdom*

B1-05. Field-driven antiferromagnetic domain switching in single crystalline CoO(001) film. *J. Xu¹, M. Jia², G. Chen³, Q. Li⁴, A.T. N'Diaye⁵, E. Arenholz⁶ and Y. Wu⁷ 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. Förster³, S. Finizio², M. Weigand³, J. Gräfe³, C. Dubs⁴, J. Raabe², G. Aeppli², G.A. Schütz³ and S. Wintz² 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. Itoh¹, Y. Takeuchi¹, S. Duttagupta², 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. Cao³, J. Zhou², J. Goodenough³ and M. Tsoi^{1,2} 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. Olejník¹, V. Novák¹ 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. Shields¹, P. Appel¹, T. Kosub², N. Hedrich¹, J. Fassbender², R. Huebner², D. Makarov² and P. Maletinsky¹ 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. Jia¹, B. Zimmermann¹ and S. Blügel¹ 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. Brueckl¹, A. Shoshi¹, M. Haslinger², T. Mitteramskogler², M. Muehlberger², J. Schotter³ and S. Schrittwieser³ 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. Fernández², J. Feuchtwanger¹, M. Fernández-Gubieda^{1,2}, J.C. Martínez-García³ and M. Rivas³ 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. Departamento de Física, Universidad de Oviedo, Gijón, Spain*

B2-03. T₁, T₂ and T₂* relaxations in MRI based on Gd Si

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nanoparticles of varying sizes. *S. Hunagund¹, J. Rosenberg², S.M. Harstad³, S. Gupta⁴, V. Pecharsky^{4,5}, A.A. El-Gendy⁷ and R.L. Hadimani⁶ 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. Villamin¹ and Y. Kitamoto¹ 1. Materials Science and Engineering, Tokyo Institute of Technology, Yokohama, Japan*