ESRF	**Experiment title:** GIANT MAGNETOSTRICTION OF GALFENOL COMPOSITES	**Experiment number**: **MA-3721**
Beamline: ID18	**Date of experiment**: from: 22.08.2018 to: 26.08.2018 from 09.02.2018 to:13.02.2018	**Date of report**: 28.02.2018
Shifts:	**Local contact(s)**: CHUMAKOV Alexander	*Received at ESRF:*

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Report:

We proposed to investigate the reason and the mechanisms of enhanced magnetodeformational effect in new functional magnetoactive polyurethane based composite material containing high magnetostrictive anisotropic flake like particles of Galfenol by Nuclear Resonance Small Angle X-ray Scattering using NFS and SMS. The application of this methods to the samples of scientific interest becomes possible since known published works [1] on Fe thin layers and only nowadays due to the strong increase of the flux at 3rd generation synchrotrons.

The increased up to threefold magnetostriction value for the Galfenol-polyurethane composite observed in our recent work was preliminary addressed to comes from the several possible causes, namely, either *(i)* from the properties of individual grains, *(ii)* from the spatial arrangement of the grains into the chains, or *(iii)* from the reorientation of the grains in the polymer under external magnetic field [2-3]. Additionally, the resulting value of the composite magnetodeformational effect can be influenced by the structure of the polymer itself, which is as proposed locally ordered along the chains during composite preparation, leading to the formation of a layer of another density and mechanical properties. We aimed to extract both the structural and the magnetic factor, which would provide insight of their contribution into the magnetoactive functional composites behavior.

We planned to investigate composites by NRSAXS using Nuclear Forward Scattering (NFS) and the Synchrotron Mossbauer Source (SMS). Both methods have advantages and drawbacks. NRSAXS using NFS provides higher flux allowing to measure the nuclear and electronic state of the small particles as its behavior in applied magnetic field (rotation or elongation). Corresponding Mossbauer spectra on time scale give opportunity to determine the hyperfine field's distributions and spatial direction of magnetic moments in grains with its behavior in applied field. At the same time SMS allows to measure directly particular hyperfine structure and its field dependant activity. For the Galfenol particles, synthesized by mechanochemical alloying technique the SMS setup is the most promising one, because resonant response

from different iron nonequivalent states presenting in particles as the result of phase composition in grains and interfaces so as its disordering should differ well but in NFS will rather lead to the complication of spectral information and require careful analytical model for calculation.

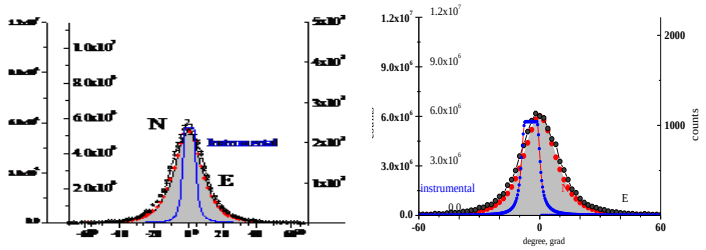

Figure 1. Rocking curves for nuclear (N), electron (E) small angle nuclear scattering from small **1 μm** Galfenol particles in chains inside 25%FeGa/Pu composite, where particles arranged in chains lies in perpendicular dirction to synchrotron radiation rays (*a*) and the same curves after applying external magnetic field B_{ext}=1.2 mT (*b*).

The first part of the measurement was performed with NFS in August 2017, selected data is depicted in Fig.1. and Fig.2 (a). We observed a slight difference between the electronic (prompt) and nuclear (delayed) scattering only about several angular seconds. Performed preliminary analytical calculation with deconvolution of instrumental line profile from the experimental one let us to resolve real line profile peculiarities associated with the properties of the sample and its alteration with applying of external magnetic field in direction of maximal magnetostriction effect in composite sample.

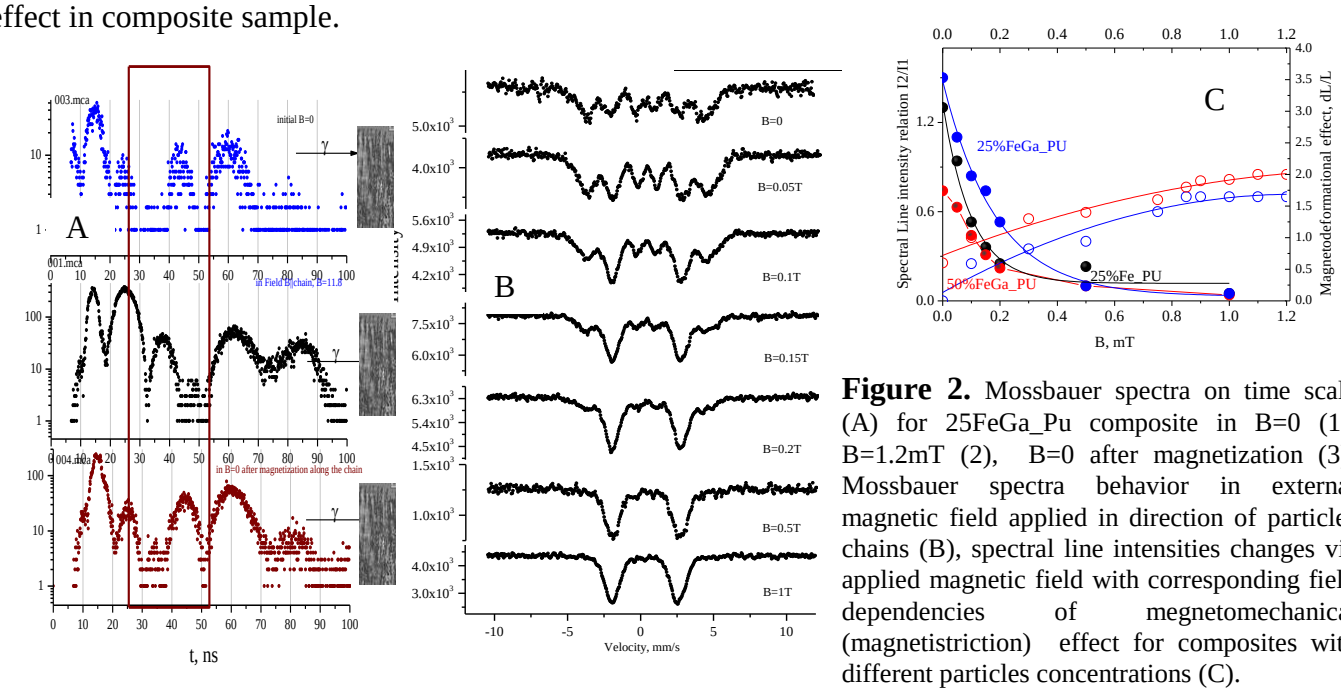

Figure 2. Mossbauer spectra on time scale (A) for 25FeGa_Pu composite in B=0 (1), B=1.2mT (2), B=0 after magnetization (3); Mossbauer spectra behavior in external magnetic field applied in direction of particles chains (B), spectral line intensities changes via applied magnetic field with corresponding field dependencies of megnetomechanical (magnetistriction) effect for composites with different particles concentrations (C).

Preliminary analysis of the obtained data let us to support that particle do not rotate significantly when magnetic field is applied, the angle of rotation no more than 0.06 grad. Our data make it possible to obtain preliminary information about the ch anged polymer density along the surface of particles in chains. Mossbauer spectra at time scale shown on Fig.2 let us to determine the angle of the averaged magnetic moment in particles in chains. The oscillation frequency changes in the highlighted regions with increasing field. This is related to the expected alignment of the spins parallel to the magnetic field.

The second part of the measurements was performed in February 2018. We switched to investigate the behaviour of particles in external magnetic at the temperature below the glass transition temperature of the polymer substance. So we observe only the behavior of the particles themselves and domains inside. The obtained data is depicted in Fig.2 (B, C). The applied magnetic field strongly influence corresponding line intensities indicating the rotation of magnetisation in magnetic domains. The kinetics of this behavior is different for composites with varied particles concentration and orientation in polymer volume as well as the onset of saturation that does not coincide with the onset of saturation of the magneto-deformational effect. In addition to above we measured a number of effects that must be accurately fitted and analyzed in order to explain functional properties of our composite materials. Manuscript on the main materials of the experiment is under preparation.

References.

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