Phase Transitions in Co-Doped NiMnGa Magnetic Shape Memory Alloys Probed by Coherent Phonons

Martin Schubert[1], Jan Mayer[1], Mike Hettich[1], Hanjo Schäfer[1], Aleksej Laptev[1], Moritz Merklein[1], Chuan He[1], Martin Großmann[1], Oliver Ristow[1], Yuansu Luo[2], Vitalyi Gusev[3], Jure Demsar[1], Mikhail Fonin[1], Konrad Samwer[2], and Thomas Dekorsy[1]

[1] *Department of Physics and Center of Applied Photonics, University of Konstanz, 78457 Konstanz, Germany*
[2] *I. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany*
[3] *Université du Maine, Institut des Molécules et Matériaux du Mans, UMR CNRS 6283,Le Mans, France*
Author e-mail address: thomas.dekorsy@uni-konstanz.de

Abstract: We investigate undoped and Co-doped NiMnGa magnetic shape memory alloys by ultrafast spectroscopy. The temperature dependence of collective modes is explained on the base of a charge-density-wave excitation shining new light on the phase transition.
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1. Introduction

NiMnGa is a shape memory alloy which is characterized by a reversible and diffusionless structural transition from a high-temperature austenitic phase to a low-temperature martensitic phase, induced by stress or temperature [1]. NiMnGa is ferromagnetic and has a great potential for applications due to the magnetic-field-induced shape memory effect with large reversible strains of up to 9% [2]. Details of the phase transitions in magnetic shape memory alloys are not fully understood. Here we demonstrate that femtosecond spectroscopy reveals the presence of several collective modes characteristic for charge-density-wave (CDW) physics. Our observations on the temperature dependence of collective modes can be consistently accounted for by considering strong electron-lattice coupling and suggesting a complex CDW ground state in Ni-Mn-Ga.

2. Pump-probe spectroscopy on Co:NiMnGa by asynchronous optical sampling (ASOPS)

In this work we investigated off-stoichiometric NiMnGa thin films with and without Co-doping by asynchronous optical sampling (ASOPS). ASOPS is an optical pump-probe measurement technique for ultrafast time domain spectroscopy with femtosecond resolution based on two femtosecond Ti:sapphire lasers with GHz repetition rate [3]. By measuring the change in reflectivity, coherent acoustic phonon spectra can be acquired. The transition temperature depends strongly on the composition. A wide range of different compositions is investigated by either cooling or heating the sample depending on the exact transition temperature.

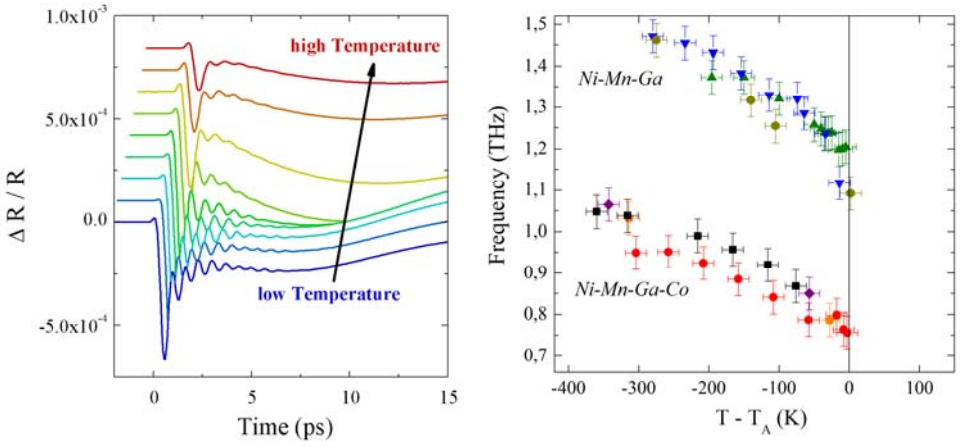

Figure 1: Left: Time-dependent changes in reflectivity for a NiMnGa sample at different temperatures; Right: Change of frequency over relative martensite-austenite phase transition temperature of the dominant acoustic phonon mode for Co-doped and undoped NiMnGa samples.

The results presented in Fig. 1 show a distinct softening of the dominant acoustic phonon mode when the temperature approaches the phase transition for all samples that were investigated. The softening cannot be explained by a structural change due to heating and indicates a strong electron-phonon interaction similar to a CDW system. Previous experiments have shown the existence of a CDW in stoichiometric NiMnGa films [4], but have not been observed in off-stoichiometric films. Our investigations significantly expand the previous observation of coherent acoustic modes in undoped NiMnGa [5].

3. References

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