Review of the thesis

Characterization of Martensitic Phases in Ni-Mn-Ga Based Heusler Alloys

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The thesis deals with studies of phases of Ni-Mn-Ga-based Heusler alloys. Today, the topic is of high scientific interest.

The thesis consists of several logical parts. Introduction (about 20 pages), Experimental conditions (about 10 pages), Methodology (over 20 pages), Results and discussion (over 25 pages), Conclusions and outlook (2 pages) and two appendices. The thesis contains 129 references.

The Introduction is well-structured relatively brief, and it very nicely presents an overview of basic structural features of X_2YZ Heusler alloys and especially martensite transformations leading to different variants of martensites like twinned martensites and different types of modulations. It follows already from this part that the problem of structural studies of these compounds may be quite far from being simple. An interesting feature of these martensites is the effect of magnetically induced reorientations. The end of the section already critically discusses suitable methods for characterization of the martensites of Ni-Mn-Ga based alloys.

In next section – Experimental, this continues in an overview of instruments, different geometries, and scans applied. It is interesting that not always high-resolution setup is more beneficial for characterization than divergent lower-resolution geometry. This is true, for example, for domains. In this part, one contribution of the author is included: a program for XRD profile fitting that was intensively used for a great part of evaluation of the diffraction data in thesis (separation of diffraction maxima), and it is available upon request. The author decided to write it in Visual Basic for Applications in MS Excel. This choice has been criticized, since this calculation is not the fastest, but the system is widely available, and the program is user-friendly. There are not many free programs for this task. I think this contribution for the public is useful.

The third part is Methodology. The combination of structural features for the samples studied probably belongs to one of the most difficult – twins, modulations, large grains (i.e., poor statistics for powder diffraction), i.e., oligocrystals, etc. Therefore, the author tried to apply several diffraction methods for more complex structural characterization such as Laue diffraction and different experiments with powder diffractometers, which he more properly calls multipurpose diffractometers. In addition to conventional powder diffraction (Bragg-Brentano scans), pole figures were measured, and reciprocal space maps of selected diffractions. Complete pole figures were also measured for the positions of potential diffractions of other phases to prove their absence. I appreciate the methodological contributions of the student in several aspects, especially for oligocrystals and modulated martensites, which may be useful as obtaining specific results.

The fourth part Results and discussion contains the basic results obtained for several types of samples. The total number of samples studied that are listed in Appendix II is amazing. Studies for several selected types of samples are presented in this part – single crystals, oligocrystals, textured polycrystalline samples, nonmodulated, 10M and 14M modulated martensites. Probably, the most important were studies of 10M modulated martensite where temperature evolution of the structure, modulation vector and related physical characteristics like electrical resistivity and

elastic modulus were studied. The transition of a commensurate martensite to an incommensurate martensite transition was found, and hysteresis of the transition was identified. Neutron diffraction was also used to determine whether there are differences. That means, if the findings are also correct for bulk and not only for thin layers on surface obviously studied by XRD.

The last part, Conclusions and outlook, is clearly written and also presents some future plans.

According to the list on page 104, the results were published in 12 publications. Some of them are more abstracts (still containing results), but at least 5-6 were published in high quality international journals.

The form of thesis that includes the quality of the figures is very good. The level of English of the student is also more than acceptable, but, in some places, I think there could still be improved. It seems to me that definitive articles are overused. Has the text been checked by some system as Writefull or Grammarly?

I know Petr Veřtát for quite a long time mainly from conferences organized by the Czech and Slovak Crystallographic Association (Krystalografická společnost) – Struktura. He has always been an active participant, and he also participated in several regular student symposia and competitions for the students in the Czech and Slovak Republics. The first time as a master student and then he won the competition (in one of the two sections there, physics and materials) three times. No one has been so successful in the history of 15 such competitions. This was due to his excellent presentations and the high level of scientific content of his lectures.

In my opinion, all the goals of the thesis were successfully achieved, and it is well written and readable. I have no critical comments. There may be some questions, though.

In the Introduction, different phases are listed, and their lattice parameters are also shown. There are no explicit comments on the comparison of the obtained values of the lattice parameters with the literature data. Can any conclusions be drawn?

Comments to Fig. 54 are saying that this is a mixture of small and large grains that is not completely clear to me how this was derived from the figure.

In section 4.1.1. a set of samples with different substitutions in Ni-Mn-Ga was studied. I am missing sa ummary and/or discussion to this part.

In the thesis, several different phases in the system Ni-Mn-Ga were studied, characterized, and many new findings obtained. Could this be commented on with respect to the practical applications of the materials?

There is no doubt about its quality and novelty as well as a significant contribution of the student to all individual parts of the research mentioned in the thesis. The thesis is well supported by several publications. I recommend to the Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University to accept the thesis for defense and to give a Ph.D. degree to Petr Veřtát, if the defense is successful.

In Prague 10. 2. 2023

prof. RNDr. Radomír Kužel, CSc.