MM 17: Phase Transformations: Microstructural Transformations

Time: Tuesday 10:15–11:15 Location: SCH A 118

MM 17.1 Tue 10:15 SCH A 118

About the transformation speed of martensitic transformations — •Sebastian Fähler[1], Stefan Schwabe[2], Klara Lünser[1], Daniel Schmidt[3], Kornelius Nielsch[3], and Peter Gaal[3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Leibniz IFW Dresden, Dresden, Germany — [3]Leibniz-Institut für Kristallzüchtung (IKZ), Berlin, Germany

Structural martensitic transformations enable various applications, which range from high stroke actuation and sensing to energy efficient magnetocaloric refrigeration and thermomagnetic energy harvesting. All these emerging applications benefit from a fast transformation, but up to now the speed limit of martensitic transformations has not been explored. Here, we demonstrate that a martensite to austenite transformation can be completed in under ten nanoseconds. We heat an epitaxial Ni-Mn-Ga film with a laser pulse and use synchrotron diffraction to probe the influence of initial sample temperature and overheating on transformation rate and ratio. We demonstrate that an increase of thermal energy drives this transformation faster. Though the observed speed limit of 2.5×10^{27} $(Js)^{-1}$ per unit cell leaves plenty of room for a further acceleration of applications, our analysis reveals that the practical limit will be the energy required for switching. Our experiments unveil that martensitic transformations obey similar speed limits as in microelectronics, which are expressed by the Margolus-Levitin theorem.

[1] S. Schwabe, K. Lünser, D. Schmidt, K. Nielsch, P. Gaal and S. Fähler, Science and Technology of Advanced Materials, 23 (2022) 633

MM 17.2 Tue 10:30 SCH A 118

Solving the 3D puzzle of the martensitic microstructure in epitaxial NiTi films — •Klara Lünser[1,2,3], Andreas Undisz[4,5], Kornelius Nielsch[2,3], and Sebastian Fähler[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Leibniz IFW Dresden, Dresden, Germany — [3]TU Dresden, Dresden, Germany — [4]TU Chemnitz, Chemnitz, Germany — [5]Friedrich-Schiller-Universität Jena, Jena, Germany.

The shape memory effect in the most frequently used shape memory alloy NiTi is driven by a martensitic transformation, resulting in a complex martensitic microstructure with a variety of interfaces. As shape memory properties depend on the microstructure, a detailed understanding is crucial. However, the martensitic microstructure is still puzzling, especially how it is built up in 3 dimensions. The analysis of this puzzle is complicated by grain boundaries present in polycrystalline NiTi. Here, we eliminate the influence of grain boundaries by using epitaxial NiTi films in (111)-orientation as a model system. We analyze the films with electron microscopy to identify clusters and interfaces and compare results to the phenomenological theory of martensite. With this approach, we generate a scale-bridging understanding of the martensitic microstructure. Three kinds of twin boundaries on different length scales are required for the complete, hierarchical microstructure. Integral X-ray measurements confirmed our

microstructure model. The results are transferable to NiTi bulk and polycrystalline films, showing that NiTi epitaxial films are important to extend our understanding of the martensitic microstructure.

MM 17.3 Tue 10:45 SCH A 118

Elucidating the nucleation and growth mechanism of {11-22} twin in titanium — Andriy Ostapovets[1], •Ritu Verma[1,2], and Anna Serra[3] — [1]Institute of Physics of Materials, Czech Academy of Sciences, 616 00 Brno, Žižkova 513/22 Czech Republic — [2]Central European Institute of Technology, Brno University of Technology, Purkyňova 656/123 612 00 Brno, Czech Republic — [3]Universitat Politécnica de Catalunya, Campus Nord, C-2, Jordi Girona, 1-3, 08034 Barcelona, Spain

{11-22} Twin is the predominant twinning mode in hcp metals such as Ti, Zr and Mg under $<c>$ axis compression. We analyze the {11-22} twin nucleation in Ti by reverse α-ω-α phase transformation. The twin nucleated by this mechanism can grow by the migration of the {11-22} twin boundary. This migration is mediated by the gliding of line defects with step and dislocation character, i.e. b3/3 disconnection, along with {11-22} twin boundary. Their structure can be interpreted as a pair of disconnections (bt and bt*) i.e. dissociated core of b3/3 disconnection, which contains ω-phase structure inside. These studies reveal the role of ω- phase in the connection with nucleation and growth mechanism of {11-22} twin boundary. These results clarify the uncertainties with the growth of the {11-22} twins.

MM 17.4 Tue 11:00 SCH A 118

Bicontinuous microstructure formation through peritectic melting — •Zhongyang Li[1], Nina Petersen[1], Lukas Lührs[1], and Jörg Weissmüller[1,2] — [1]Institute of Materials Physics and Technology, Hamburg University of Technology, Hamburg — [2]Institute of Materials Mechanics, Helmholtz-Zentrum Hereon, Geesthacht

Recent research has found that when heated above the peritectic line, the intermetallic compound TiAg decomposes into a separated solid Ti phase and a liquid Ag phase, thereby forming a bicontinuous microstructure. This shows that monolithic networks such as porous Titanium, which has potential application in the field of biomedicine, can be produced with simple heat treatment followed by selective removal of other phases. As a novel dealloying method for bulk materials, the underlying mechanism is still not completely understood. It is also unclear if this method could be used in different alloy systems.

In our research we find a similar microstructural phenomenon for CuSn alloys. With the help of electron microscopy and X-Ray diffraction, formation and evolution processes of the bicontinuous structure of both TiAg and CuSn systems are studied. Research on microstructure evolution can help both, setting up the criteria for searching new alloy systems and optimizing thermal treatment parameters. This enables us to further develop this method for porous metal preparation, and also broaden the application of this method from peritectic dealloying to dealloying at crystal-melt coexistence.