State the objective of the project

The main goal of the proposed research program is to establish a general model for Heusler alloys with a composition of Ni-Mn-(Ga, Sn, In, Sb, Fe) describing the orientation relationship between the parent phase and the product phase that is formed upon diffusionless, first order, displacive martensitic transformation. This particular group of alloys is chosen due to the thermoelastic nature of martensitic transformation having its origin in crystallographic reversibility. The main problem appears to be the discrepancies in orientation relationship if comparing the theoretical models and measured values. As the transformation proceeds both the lattice Bain distortion and this which is achieved by a lattice invariant deformation lead to final microstructure and variant orientation. On the one hand the Bain distortion is commonly accepted in literature and it can be easily proved by comparing the crystal structure of austenite and martensite phase. The situation is completely different when it comes to orientation relationship between the parent and product phase. Depending on the model used, type of alloy, crystal structure, complex microstructure or level of twinning stress smaller or larger deviations from these models are observed. In fact none of the given models describe this relation satisfactory. Nevertheless, due to a more completed description of the microstructure and the associated with that lattice rotation more fitting modelst which based on the physical ground can be proposed. Therefore, in order to determine the orientation relationship and the critical role of particular parameters alloys which differ in transformation mechanism, crystal structure, microstructure and twinning stress will be studied. For this purpose both single and polycrystalline, ferro- and paramagnetic Heusler-based alloys with different crystal structures and exhibiting different twinning stresses will be used. It is hypothesized that these parameters play a crucial role during martensitic transformation and as a consequence lead to the final orientation of martensitic variants.

Research plan

The research plan assumes a thoughtful examination of the microstructure of initial material and proper determination of orientation relationship between the austenite and martensite variants. To achieve this goal a numerous advanced techniques such as transmission and scanning electron microscopy will be applied. This study will be supported by a synchrotron radiation measurements which provide information from the bulk. The orientation relationship between austenite and martensite will be directly measured using a heating stage, EBSD (*electron backscatter diffraction*) technique and synchrotron radiation. The in-situ microstructural and crystallographic investigations will be correlated with differential scanning calorimetry (DSC) to measure the heat of transformation. By means of DSC charts the critical transformation temperatures such as As, Af , Ms, Mf and transformation enthalpy will be determined. This will allow for more efficient use of the programing functions of this material.

Reason for choosing the research topic

The modern research techniques such as *in-situ* EBSD or synchrotron radiation combined with a heating stage device and a specific software offer a very high angular resolution in misorientation determination. This method seems to be most suitable to verify and complete the existing models devoted to this relation. On the other hand taking into account recent results reported in literature, which considerable differ from the above mentioned models it encourages to verify this relation and find better assumptions. The main reason for such a deviation is the fact that these models do not include all mechanism such as multiple twinning, detwinning and orthogonal shear process which cause an additional rotation upon martensitic transformation. From more particle point of view the proposed research program will give rise to determine critical parameters such as crystal structure, microstructure level of twinning stress which affect the martensitic transformation and as a consequence the functional properties of this material. Therefore the research program not only attempts to explain and expand the knowledge of the fundamental issues but also leads to practical applications.