Laboratory of Ultrasonic Methods
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Review on the Bc thesis by Gabriel Bruno Parreira

Bc student Gabriel Bruno Parreira presents Bc thesis on the topic *Design and characterization of magnetic shape memory-based micropump*. The thesis is dedicated to development of a new concept of microfluidic device – a pump which uses magnetic shape memory alloy (MSMA) NiMnGa and its large magnetic field-induced strain for manipulating small quantities of fluids. The main goals of the thesis were:
- to show effect of surface modification by shot peening of NiMnGa samples on mechanical response and twin structure and to optimize parameters of this surface treatment with respect to performance of MSMA in pump application;
- to design and construct working prototype of the pump which would be suitable for testing of MSMA samples allowing their simple replacement.

In the introductory parts, the author summarizes basic properties of MSMAs and introduces parameters of MSMA which then play important role in sample optimization – the twinning stress related to mobility of twin boundaries, magnetic induced strain associated with twin reorientation and magneto-stress given by high magnetic anisotropy of 10M martensite in NiMnGa. Here, the need for a proper setting of sample twin microstructure is also highlighted which is known as so called sample 'training'. In the case of MSMA in micro-pump applications, there is a need for a very fine martensitic microstructure allowing local strain manipulation with suitable fatigue properties. This part motivates the first goal of the thesis – to optimize surface treatment of MSMA samples in order to 'freeze' desired fine twin microstructure. The author also presents basic techniques in microfluidics and the concept of MSMA-based micro-pump as it was originally introduced by Ullakko.

The second part (starting with the chapter 3.3. Experimental) brings detailed description of experiments performed by the author on MSMA samples. He tested effect of several parameters of shot-peening process (pressure, nozzle geometry) in order to optimize sample response. Two sample characteristics were mainly evaluated – the twinning stress and the spring-back strain. It was shown that the shot peening in general increases both twinning stress and spring-back strain and compromise can be found to maintain low twinning stress (below maximal magneto stress) while reaching a suitable spring-back strain. The possibility to reset surface treatment by electropolishing was also demonstrated.

The last part of the thesis describes the design and construction of working prototype of microfluidic pump. Modern 3D printing techniques were used for the pump construction and performance of the working prototype was demonstrated. Here, the author offers several further design improvements which can be realized in future work.

The presented study is of very high quality both from formal and scientific point of view. The number of realized experiments and effort dedicated to the micropump design and construction is admirable and exceeds standard requirements for Bc. thesis. The main goals of the thesis were fulfilled. Based on the above mentioned, I recommend the thesis for defense with qualification **A-excellent (výborně)**.

Questions:

- The shot peening is a cold work process which induces compressive surface residual stress by generating plastic deformation in metals. Did you consider mechanisms of plastic deformation in 10M martensite of NiMnGa? Did you control whether the shot peening produces only plastically deformed zone of it generates also some microcracks? Do you have an evidence that the shot peening in NiMnGa increases the fatigue life?
- The MSMA sample inside the micropump is surrounded by soft elastic material. These boundary conditions differ from uniaxial compression in which all material tests were performed. Can it affect material response and could we optimize MSMA embedding to e.g. increase the spring-back strain?

Minor points:

- Institute of Physics instead of Physics Institute
- P. 39 - … it is possible to observe that samples S2 and S5 have a lower twinning stress when compared to the other samples – the sample S2 has higher twinning stress than S3 and S4 (Tab.3)

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