DESIGN AND OPTIMISATION OF PIEZO-STACK BASED MICRO-ACTUATOR WITH MOTION AMPLIFIER

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This paper presents results from design, optimization and final performance of piezo stack based micro-actuator with motion amplifier. Piezoelectric actuators, including those with motion amplifiers, are commonly used for precise positioning of samples (e.g. AFM microscopy) or optical elements (optical benches). The challenge and purpose of this work was to develop a solution in a miniature version in relation to the existing solutions. The result of the work is a piezoelectric micro-actuator enabling positioning in the range of up to 120 µm with high accuracy and resolution.

Piezo stack actuators are electromechanical devices, that exhibits geometrical change under applied voltage. The displacement is in the range of µm but the maximum forces depend on the piezo stack and reach up to hundreds of N. In order to increase the displacement value, movement amplifiers are necessary [1].

To achieve that, specific geometrical shapes have to be designed. The structure is based on the concept of compliant mechanisms. This kind of devices have no moving parts and no conventional hinges. The movement is realized thanks to bending in specific regions in the device. The deflection is reversible due to the operation of the mechanism in terms of elastic deflections. The safety factor, specific for the material used (stainless steel 1.4307), was the main criteria in optimization method for the geometry. The optimization was conducted in Inventor 2021 software (Autodesk, USA).

In our work we present new, optimized piezo stack based micro-actuator with motion amplifier. The device consisting of stainless steel amplifier, and piezo stack actuator P-885.51(Physik Instrumente (PI, Germany), exhibits movement gain equal to 8 and maximum displacement equal to 120 µm. The simplicity of design and small form factor (23.9 mm x 9.2 mm x 5 mm) increase their wide range of potential applications.

Piezo amplifiers were measured on a custom measuring system. The measuring apparatus is based on strain gauge beam integrated with precise nanometric single-axis stage. In following paper, the measuring procedure will be described. Additionally, results from measurements and simulations will be also presented.

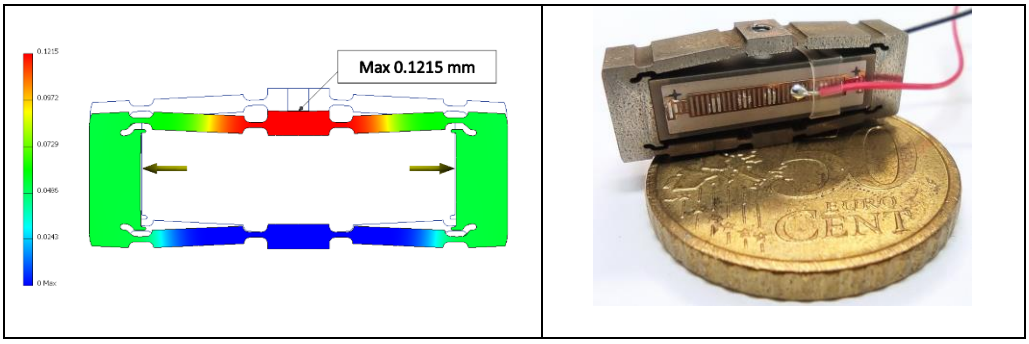

Fig 1. Piezo stack amplifier simulation result example (left), actual fabricated structure with integrated piezo stack actuator (P-885.51)(right).

[1] Aggogeri, F., Borboni, A., Faglia, R., Merlo, A., de Cristofaro, S. Precision Positioning Systems: An Overview of the State of Art. AMM 336–338, 1170–1173, 2013