# ALS–MEMS Scanner for Assisted Laser Surgery

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*CSEM has developed a new surgical tool prototype based on a high power laser for cutting tissues and/or coagulating, a MEMS deflecting unit and its associated electronics to position the laser spot; and a user interface for controlled trajectory generation.*

One way to reduce surgery costs is to reduce surgery time. It can be achieved by different ways: improved preparation, experience or new tools. In this development, a new surgical tool was developed. It relies on a high power laser capable of cutting tissues or bones, as well as performing coagulation of bleeds or local optical treatment. Using laser in surgery presents many advantages like scars size reduction and fast recovery. The main limitation to the application of laser surgery inside the human body is the accuracy of the positioning of the laser beam. So far it is only used in contact mode, hence touching the tissues to be removed. This enables very precise and fine cuts, as seen in the eye surgery.

To achieve laser surgery in non-contact mode, it is necessary to control the position of the laser beam, shined by a fiber tip of a typical size smaller than 1 mm. It is then mandatory to integrate an actuation mechanism and an accurate controller.

The solution proposed in this project aims at realizing an endoscope integrating a high-power laser, a millimeter-scale camera for target observation and positioning control, and a MEMS based steering unit (Figure 1).

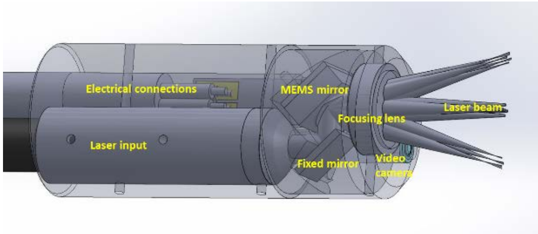


*Figure 1: Endoscope head design.*

The high power laser has a 3 µm wavelength to ensure a very high absorption by water, the most present molecule in the human body. A second laser at low power and visible wavelength (green), is mounted in parallel for the position control of the invisible high power laser. The associated optics are integrated to obtain a laser spot size on the target of 0.3 mm or 0.8 mm (two optical designs), depending of the field of work of the system, respectively of 2.5 mm or 7 mm. So far, only two low power lasers have been used, as the optics for 3 µm wavelength do not exist and shall be custom made, which is too expensive for this prototyping phase.

The MEMS scanner is used for the fine positioning of the laser beam. It consists of a 2 mm diameter mirror attached to a compliant membrane and based on silicon micro machining (Figure 2). The electromagnetic actuation is achieved by fixing a SmCo micromagnet on the compliant membrane (moving magnet design), while mounting the device on a ceramic PCB containing micro coils. The device is capable of +/-15° 2D mechanical tilting and a z motion of at least 50 µm. The final chip size is 2.5 × 3 × 1.8 mm. In addition, a second MEMS scanner (Figure 3) was fabricated to evaluate the possibility of adding a focusing system, integrated in the MEMS and based on microchannel and pneumatic actuation. Theoretically, a focus distance down to 2 mm could be achieved.

The position of the laser beam is controlled using a state-space control algorithm running on a dSpace platform. The position of the main laser is evaluated by measuring the position of the visible laser with a camera (FISBA FISCam™, 2 mm diameter). The algorithm calculates the requested trajectory from the actual position of the laser, and converts it into an output signal feeding the micro coils and hence driving the micromirror.

A prototype of the endoscope head was fabricated (Figure 4) using 3D printing. The optical design was performed with Zemax® software.

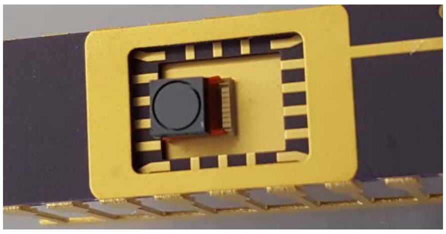

*Figure 2: Fabricated MEMS scanner on a ceramic package for performances evaluation.*

*Figure 3: MEMS scanner with integrated focus.*

*Figure 4: Endoscope head prototype.*

At the current stage, all components have been developed and fabricated. Preliminary results confirm the simulated behavior. The endoscope head is currently under assembly (Figure 4) and tests will follow shortly.

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