Ultrasonic scalpel, market and advantages

Ultrasonic surgical instruments are routinely used in more than 6.5 million laparoscopic and open surgeries, in areas of general surgery, vessel harvesting, gynecologic, colorectal and otolaryngologic surgery. The advantages of the technology are the precise control over coagulation and cutting which allows a minimal lateral thermal spread resulting in reduced tissue damage.

Project aims

The aim of the project was to develop a micro-machined silicon-based piezoelectric driven ultrasonic scalpel. A control system capable of characterizing and driving the piezoelectric structure under load completed the project scope.

System description

The system is composed of:

1) An ultrasonic scalpel formed by a silicon microstructure on which two PZTs (PieZoelectric Transducers) are glued (figure 1).
2) An electronic driver having a power amplifier, a measurement cell and dsPIC with implemented algorithms for control and regulation (figure 2).
3) A PC with two Labview interfaces, one for the piezoelectric actuator characterization, and another for regulation to keep the structure at resonance frequency.

Results after 2 year of collaboration

KOH etched silicon micro-machined ultrasonic scalpels were developed to reach displacements and velocity large enough to cut through tissues confirming performance identical as current HARMONIC® scalpel (figure 3). Without load, a displacement of 35 μm was reached in second mode 75 kHz under 28 Vrms (figure 4). Decrease of size and reduction of cost meet expectation.

A control system (figure 5) has been developed and tested; able to drive the scalpel with voltage span going from 10 V to 370 V (peak-peak) across a frequency range from 50 kHz to 100 kHz. The robustness of the system to high power was successfully tested. The system can provide more than 10W of active power to the actuators. Concerning the regulation speed, the execution time was reduced to 1.5 ms, keeping high measurement accuracy.

Partners

This project is a collaboration between two EPFL laboratories (SAMLAB & ESPLAB), one HES-ARC laboratory and Basel University department of cranio-maxillofacial surgery. The industrial partner is Medos International, a Johnson & Johnson company.