Fabrication of interdigitated electrodes for electronic tongue using laser pulses

D. S. Corrêa, L. Misoguti, C. R. Mendonça
Instituto de Física de São Carlos - USP - São Carlos, SP, Brazil

A. Riul
Departamento de Física, Química e Biologia, FCT-UNESP, Brazil

Abstract

We have used laser pulses from a Nd:YLF, Q-switched laser in a micromachining setup to produce small sensors for "electronic tongue". Such "electronic tongue" system is designed to distinguish the basic tastes (sour, salty, sweet, umami and bitter) below the human threshold. The sensor is basically composed of gold interdigitated electrodes on a glass substrate, characterized by more than one thin metallic finger separated by a small gap, where, above such array, it is covered by ultra-thin films of different polymeric materials, acting as individual sensing units in a taste sensor. To generate a designed electrode, the Nd:YLF, Q-switched laser, which delivers pulses at 532 nm with 200 ns pulse duration at 1 KHz repetition rate, was used to cut (remove) the gold from the glass where a gap is necessary. The focussed laser beam was able to remove the deposited gold from the electrode surface at focal point with high degree of precision, leaving the neighbour region intact. Interdigitated electrodes with 10 digits, each of which 100 μm wide and 3 mm high, being 100 μm apart from each other were produced.

✔ Experimental setup

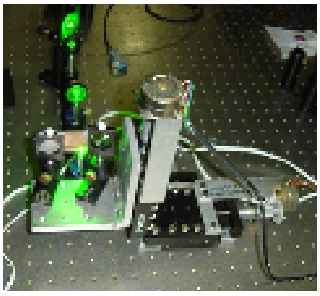
The experimental micromachining setup employs two linear translation stages (x and y directions) to move (scan) the samples, perpendicularly to laser beam direction. These stages are moved by step motors coupled to micrometers.

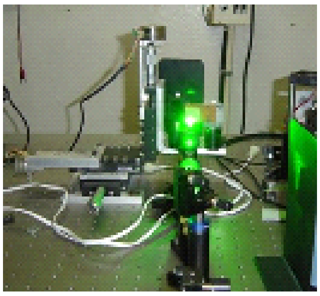
The motors are controlled by a computer with a data acquisition board and a program made with LabView software. This program also processes the drawing to be printed.

The laser beam, in terms of spot size and power, is adjusted to remove the gold from the top of glass substrate in order to draw a track as the sample is scanned.

Here we have used lens with 1 cm focal length, which are fix during the cutting process in order to assure uniform tracks with constant thickness (interdigitated electrodes). This tracks provide better sensor response.

The electrode, after covered with a thin layer of a specific conducting polymer, is used as a sensor known as "electronic tongue".

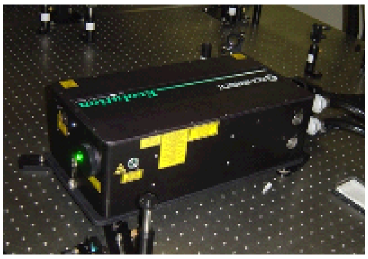




The picture shows the translation stages, the step motor coupled to micrometer and the laser beam focussed at the sample. The resolution of our system is ~4,8 μm, nevertheless, the thickness of the tracks is defined by the spot size of the focussed laser beam.

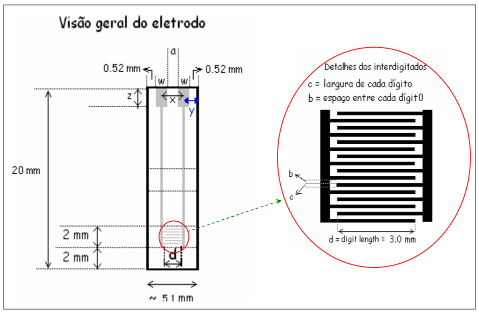
✔ Q-switched Nd:YLF laser

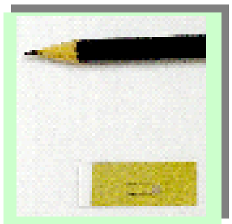
The laser used in our system is a Nd:YLF, *Q-switched,* Evolution 30 of Coherent, which delivers pulses at 527 nm and ~200 ns pulse duration. The repetition rate is adjustable from 1 KHz to 20KHz, with a maximum average power of 30 W, although, generally, much less power is employed in the electrodes production.



✔ The electrode design

The interdigitated electrode design basically depends on the number of digits and the separation among them. The electrodes are produced in a glass substrate and are later coated with gold. The traditional way to produce such type of electrodes is based on lithography using synchrotron radiation, which made their production quite expensive and time consuming.





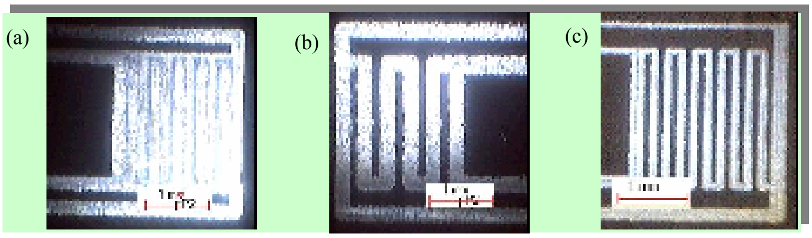
The time spent to generate a electrode depends fundamentally on the speed in which the sample is moved by the step motors. Also important aspect is the complexity of the electrode design, number of digits and space between the digits.

In order to save time and optimize the eletrodes production, its desirable to set the beam waist as large as the size of the digit separation, making the entire process in just one run.

Experimentally, we spend 20 minutes to generate one sensor with ten pair of digits like the one shown in the picture above (electrode with pencil).

✔ Electrodes obtained by employing laser pulses

Several tests were made to optimize the spot size of the laser. It was found that shortest focal length is necessary to fulfill the typical separation between the digits. For example, using 300 mW of average power at 1 KHz repetition rate, we have made some electrodes with digits separation and thickness of nearly 100 μm. As expected, the focal position is critical to obtain the desired spot size. In the picture below, its shown several track thickness produced using the same experimental apparatus, but using distinct positions concerned the focal point. The tracks range from (a) 250 μm, (b) 200 μm and (c) 100 μm. At the correct focal position (c), good quality digits could be obtained.



✔ Conclusions

In summary, a new method to produce electrodes for electronic tongue using laser beam was demonstrated. Electrode with 10 digits with thickness and space of 100 μm were produced in 20 minutes. In this apparatus, we have used a Q-switched, Nd:YLF laser to remove the gold at the top of glass substrate. More studies should be done to improve the quality of the digits and to reduce the time spent to produce an electrode. Furthermore, tests with use of these electrodes in electronic tongues are already on course.