

Functional Microneedles : A multimodal sensory platform.

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We report recent progress to develop a multi-modal sensory needle capable of measuring both electrical properties and physical tissue change concurrently. Such signals are of great importance in health care and disease monitoring with examples including but not limited to Motor Neuron Disease¹, inflammation² and peripheral arterial disease³. Many health care diagnostics require more than one measurement with electrical, physical, chemical and visual changes being amongst some of the key modes. Current techniques employ single point measurements, whereby many diseases need to be tracked over time in order to produce an effective diagnosis. We aim at developing a multi-modal, minimally invasive tool allowing continuous measurements.

The sensory needles presented here have been fabricated from standard fused silica telecoms optical fibres (SMF-28E) with a cladding diameter of 125 microns via a combination of fibre tapering (reducing the overall size) and pico-second laser (Trumpf TruMicro 5x50 operating at 515nm) micro milling of the tip (reducing the insertion force required). The final dimensions of the needle are 2mm in length with a tip diameter of 20 microns and 45 degree laser machined tip. The needles then have a Fabry Perot cavity inscribed into the fibre about 200 microns from the tip to monitor cavity length changes induced by blood pressure just below the Epidermis. These is also an electrical track running through the needle, that can be used for neural electronic measurements.

We present the results from the laser micro milling of the tapered tips, the tested tip geometries and their performance with insertion into soft tissue, together with preliminary pressure test results. We also present the full process flow for fabrication of the complete device.

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[2] Li, Z., Navarro-Alvarez, N., Keeley, E. J., Nowell, N. H., Goncalves, B., Huang, C. A., & Evans, C. L. (2017). Non-invasive monitoring of skin inflammation using an oxygen-sensing paint-on bandage. *Biomedical optics express*, 8(10), 4640–4651.

[3] Hankey GJ, Norman PE, Eikelboom JW. Medical treatment of peripheral arterial disease. *JAMA*. 2006 Feb 1;295(5):547-53.