Optical Microfiber Tactile Sensor

A V Ivanov[1], A I Korbashov[1], K I Mironova[1], N Kuznetsov[1], and A I Lvovsky[1,2]

[1] *Laboratory for Quantum Optics, Russian Quantum Center, Skolkovo, Bolshoy Bulvar 30c1, Moscow, Russia.*
Contact Phone: + 74952801291
[2] *Department of Physics, Oxford University, Clarendon Laboratory Parks Road, Beecroft 1st floor, Oxford, UK.*
Contact Phone: +4401865272275
Contact Email: artl2sch@gmail.com

Tactile sensing is an essential component in academic and industrial robotics. There exist a great variety of tactile sensors with different working principles. Yet, cheap and scalable electronic skin with human-like performance has not been developed yet [1]. We have built and tested a tactile sensor based on a single tapered optical microfiber submerged in silicone (Fig. 1). Based on the acquired results, we anticipate that an electronic skin based on multiple such microfibers could show human-like performance.

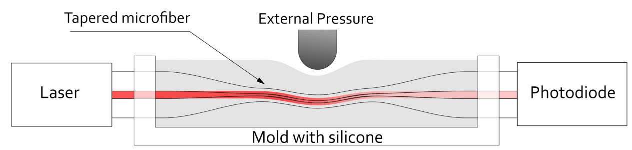

Figure 1: Scheme of the microfiber tactile sensor

The working principle of our tactile sensor is different from previously proposed optical micro/nanofiber sensors [2,3]. In the SM (single mode) fiber, the fundamental mode is localized in the core. A high gap in refractive indices results in low transition rates between the fundamental and higher-order modes when external perturbation (bending) is applied [4]. However, as the diameter of the taper becomes smaller, the fundamental mode penetrates the cladding, and its effective refractive index drops. At a specific diameter of approximately 40um (for standard SMF-28 optical fiber) the effective refractive indices of the fundamental and first excited fiber modes become close to each other. At this point, external perturbations (bendings) cause high transition rates between these modes. Only the fundamental mode propagates further in the SM fiber and reaches the photodetector, which registers the resulting drop in transmissivity.

To measure the sensor characteristics, we used a tension gauge with a spherical (1mm in diameter) tip connected to three linear translation stages with piezoelectric actuators. The sensor showed high sensitivity (0.1 g) and spatial resolution (1 mm). We observed an approximately flat spectral response from 0 to 3 kHz. These numbers (0.1 g, 1 mm, >3 kHz) prove that the performance of our sensor) is comparable to the one of the human skin (0.05 g, 1 mm, 1 kHz) [5].

To extract the information about an arbitrary pressure distribution over some area we propose an architecture, which consists of several layers of microfiber grids submerged in silicone at slightly different depths. This architecture is easily scalable and therefore it allows one to build large-area tactile sensors with both high spatial resolution and readout frequency, which is a known issue for conventional electrical architectures [1].

References

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