Surface Treatment of Conical-Shaped Optical Fiber Deflectors by Using CO_2 Laser

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The usage of fiber optical probes for medical treatment gives an opportunity for minimally invasive surgery applications, as they possess a smaller size and efficiently transmit the laser light with different shapes and directions by manipulating their deflector's geometry. Different deflector designs have been proposed and several types are currently used for tissue ablation. One of the most popular deflector types is radial design. Radial fiber optic deflectors with conically shaped optical fiber end transmit the laser energy radially and the laser energy is homogeneously distributed into a ring-shaped beam. These deflectors are especially used in endovenous laser ablation [1]. The fiber optical deflectors are fabricated by mechanical polishing process. The deflector geometry is first formed by mechanical polishing process with rough lapping film. Then, the surface roughness of the deflector is gradually smoothed by polishing with smoother lapping films. This process is composed of several steps to obtain high quality surface structures and a well-prepared fiber deflector surface eliminates the optical losses such as scattering and back reflection. However, the mechanical fining process of the fiber deflectors takes very long time and it is laborer dependent.

In this work, we develop a surface treatment technique for polishing conical shaped optical fiber deflectors by combining rough mechanical polishing and CO_2 laser treatment (Fig.1). Nanoscale roughness is achieved at conical-shaped 3D surfaces with modulated CO_2 laser treatment. In the literature, there are reports on glass processing by controlling the glass viscosity below the ablation threshold using a CO_2 laser beam. These works provide an improvement of the surface damage resistance in fused silica optics [2], localized repairing of damages in fused silica optics [3], laser polishing of conventional glasses [4] and optical fiber end surfaces [5]. In the literature, it was reported that the bare fiber end could be polished down to 100 nm surface roughness by continuous wave CO_2 laser exposure [6]. In our approach, the modulated CO_2 laser exposure permits the control of thermal loading issue on a thin surface layer and volume melting, surface reflow, deformation of deflector shape could be avoided. A very smooth surface roughness approximately 4.07 nm can be achieved by using this approach. This also provides less-time consuming and laborer independent procedure. In this study, the conical fiber deflector requiring meticulous design and fabrication process was investigated in terms of design, surface roughness profile and light deflection measurements.

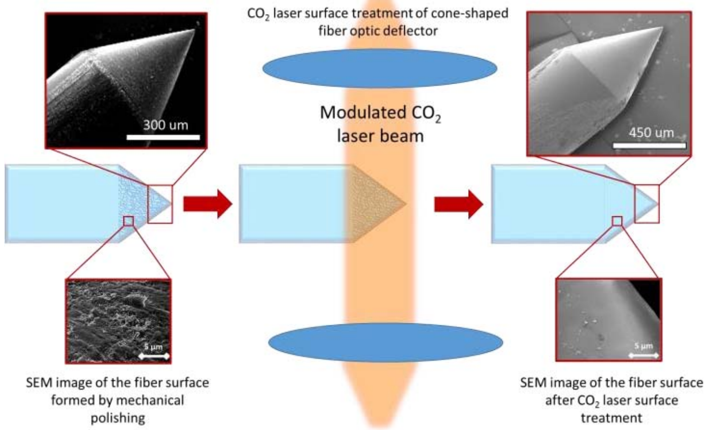

Fig. 1 Schematic representation of CO_2 laser polishing process and Scanning Electron Microscope (SEM) images of mechanically polished and laser polished fiber deflector.

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