Enayet Rahman et al., J Laser Opt Photonics 2017, 4:2(Suppl)
DOI: 10.4172/2469-410X-C1-011

Optical waveguide properties of myelinated and unmyelinated nerve axons from ultraviolet to NIR wavelengths

Enayet Rahman and **Iasonas F Triantis**
University of London, UK

Statement of the Problem: Infrared Nerve Stimulation (INS) is becoming popular because of its potential to provide targeted stimulation. Recently it was claimed that myelin sheath can guide light (200 nm – 1300 nm), however propagation characteristics were not reported for wavelengths $\lambda > 1500$ nm, common in INS. We present them here for λ up to 2000 nm for both myelinated and unmyelinated nerve fibers.

Methodology & Theoretical Orientation: Modal analysis was performed on the cross-section of the nerve fiber by solving Maxwell's equations. The effective index (n_eff) of the first three modes was determined and the single mode operating wavelength range was determined for both myelinated and unmyelinated nerve fibers, using a 4-um diameter axon. The overall diameter of the myelinated fiber was 6.66 um. The refractive indices of the fiber cytoplasm, the myelin sheath, and the outside medium were set as 1.34, 1.44 and 1.38 respectively.

Findings: The optical power propagating through unmyelinated fiber is confined by the index of the fiber's cytoplasm (1.38) being higher than its surrounding (1.34). The effective indices of the first three propagating modes were determined and plotted in for $200\text{nm} \le \lambda \le 2000\text{nm}$. It was found that the unmyelinated fiber is single-mode for $\lambda > 1700$ nm. In the myelinated fiber, optical power is confined within the myelin sheath (1.44). The effective indices of the myelinated fiber indicate that it supports more modes than the unmyelinated one and the myelin sheath operates in a single-mode condition for wavelengths longer than 1980 nm. This article determines light propagation characteristics of nerve fibers for a range of wavelengths, making it very useful for future INS designs. This study can also be useful in the field of interfacing brain using light.

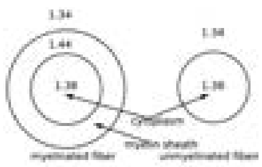

Figure1: Cross-section of myelinated and unmyelinated nerve axons

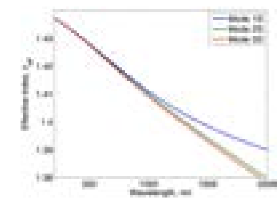

Figure2: Propagation characteristics of unmyelinated nerve axon with axon diameter = 4 um

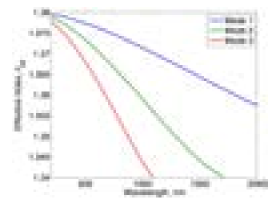

Figure3: Propagation characteristics of myelinated nerve axon with diameter including the myelin sheath = 6.66 um

Biography

Enayet Rahman did his PhD in Photonics from City, University of London, United Kingdom. He has expertise in light tissue interaction, ultrasound and biphotonics. He is currently developing novel techniques on stimulation of nerve using combining electrical and optical stimulus. He is currently working as a Research Associate in the Research Centre for Biomedical Engineering in City, University of London, United Kingdom.

enayet.rahman.1@city.ac.uk

Notes: