Design of Next Generation Mid-infrared Fiber Optics

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Abstract

The mid-infrared (λ~3-8μm) and long-infrared (λ~8-15μm) wavelengths ranges are of tremendous importance for materials research as well as sensor technologies due to the vibrational resonances that yield unique chemical signatures of materials. The wavelength range is also finding increasing importance in sensors, night vision, automotive and airline industry, non-destructive testing and process monitoring, free-space communications, biology and health care such as in endoscopy and imaging. Semiconductor optical fibers are an emerging platform for optoelectonics, photonics, and imaging. The wide infrared transmission window, high refractive index (n~4), and high carrier mobility of germanium make it a very attractive material for electronic and infrared imaging applications. Specific applications of germanium fiber waveguides include the development of mid-infrared endoscopes and photodetectors. Here, we try to investigate and design small core diameter germanium core silica cladding optical fibers with low optical loss at mid-infrared. Theoretical loss measurements were calculated using COMSOL Multiphysics® software with the RF Module. The results show that the loss can be minimized between wavelength of 2-4 micron with a 6 micron core diameter fiber, which is suitable for applications ranging from bioimaging to nonlinear optics at the mid-infrared.

Reference

1. X. Ji et al., Mid-infrared spectroscopic imaging enabled by an array of Ge-filled waveguides in a microstructured optical fiber probe, Opt. Express, 22, 28459(2014)

Figures used in the abstract

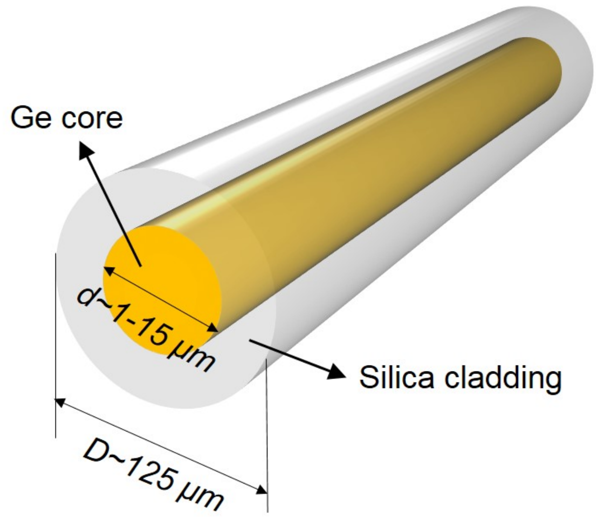

Figure 1: Schematic of the germanium core silica cladding optical fibers.

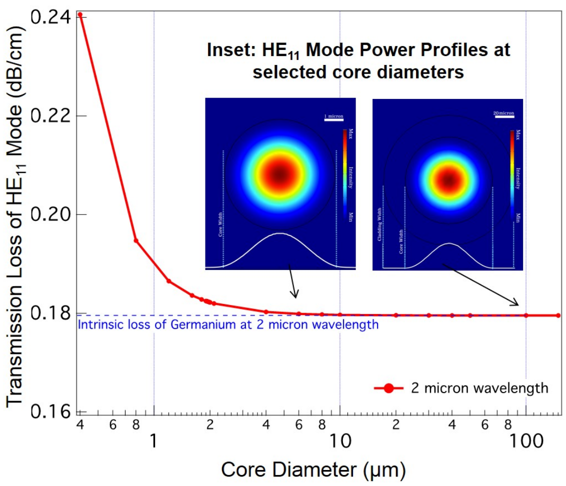

Figure 2: Transmission loss of HE11 fundamental mode approaches the intrinsic loss of Ge as the core diameter increases.

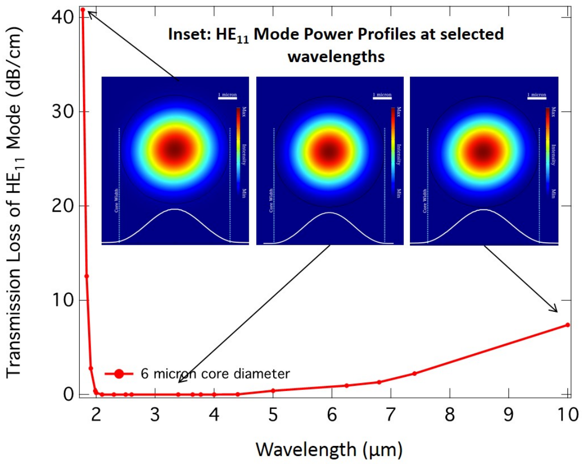

Figure 3: Transmission loss of HE11 mode as a function of wavelength is minimized in the 2-4 micron region for a 6 micron diameter fiber.

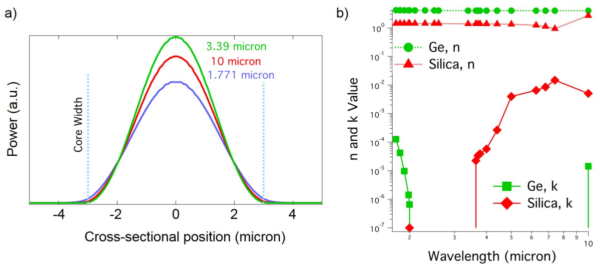

Figure 4: Power confinement of the HE11 mode along the fiber diameter at various wavelengths indicated by the arrows in Figure 3.