Mid infrared optical waveguide couplers

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Integrated optical components for mid-infrared wavelengths are in high demand due to the rapid progress in mid-IR light generation, detection and manipulation that has been made over the past several years. While fiber-based sources capable of delivering high-energy few-cycle laser pulses in the 3 μm range have recently been demonstrated, these systems either rely on the use of bulk optical components or on nonlinear frequency-upconversion from near-infrared sources. Fiber-coupled optical components like couplers and splitters are readily available in the near-infrared, in particular at telecommunications wavelengths, but equivalent devices for the important mid-infrared spectral region are still missing as standard silica glasses are not transparent at these wavelengths. In the current work, the femtosecond laser direct write technique was used to fabricate mid-infrared (mid-IR) compatible waveguide couplers into Suprasil® 3001 fused silica glass, having an OH-content of as low as $\leq$1 parts per million, and into a compositionally engineered fluoride glass. Specific care was taken to ensure compatibility with current mid-infrared fiber architectures. Waveguides were optimized for the 3.1 μm wavelength range and evanescent 4-port couplers with coupling ratios ranging from 5:95 to 50:50 were designed and demonstrated for the first time. Results from both the materials are compared and contrasted to find specific application regimes. This work marks the end of a long wait for such integrated devices and will now enable the fabrication of sensitive, compact and lightweight mid infrared sensors.

[1] T Toney Fernandez, B Johnston, S Gross, S Cozic, M Poulain, H Mahmodi, I Kabakova, M Withford and A Fuerbach *Scientific Reports* **In press**, arXiv preprint arXiv:2203.00215 (2022).

[2] T Toney Fernandez, B Johnston, H Mahmodi, K Privat, I Kabakova, S Gross, M Withford, A Fuerbach, *Thermally stable and high numerical aperture mid-infrared waveguide couplers* **To be communicated** (2022).