Abstract

Hollow core photonic crystal fibers (HC-PCFs) have promising applications in high power beam delivery, chemical sensing and gas-based nonlinear optics. According to the waveguide mechanism, HC-PCFs are typically classified into two kinds. One kind guide light via a two dimensional photonic bandgap while the other through anti-resonant reflection. The former one is so called hollow core photonic bandgap fibers (HC-PBGFs) while the latter is commonly named hollow core anti-resonant fibers (HAFs).Compared to HC-PBGFs, HAFs can have much broader transmission windows and more flexible fiber designs. As a result, HAFs are currently more popular than HC-PBGFs. Hence the topic of this thesis is focused on HAFs.

HAFs have already been demonstrated to have potential on the application of gas filled fiber lasers. In 2002, the first demonstration of the Raman scattering emission had been observed with an H_2 filled HAF. During the past decades, a lot of efforts have been devoted to the gas filed HAF laser. However, so far there is no demonstration of an all HAF based fiber laser because there exist two restrictions. The first restriction is that hollow core fibers are favored in long wavelength regions where solid core glass fibers suffer high material loss, besides, a small cavity cross section (i.e., fiber core size) is preferred to reduce the lasing threshold. However, the confinement loss of a HAF (i.e., cavity loss) increases fastly when core size gets smaller or wavelength gets longer. The second restriction is there is no hollow core fiber based fiber coupler to build an all hollow core fiber based laser ring cavity. Therefore, the task of this thesis is to get rid of these two restrictions to make our contributions to all HAF based fiber lasers.

Firstly, we develop the hollow core fiber fabrication technique based on our local facilities which is the prerequisite to come true any hollow core fiber design. Secondly, we design, fabricate, and characterize a HAF which can have relatively low transmission loss in small core and long wavelength conditions. Thirdly, we design, fabricate, and characterize a HAF based fiber coupler whose power splitting ratio is tunable by adjusting the fiber strain. At last, we used the HAF based fiber coupler to build a ring cavity in a fiber laser system, where the tunable feature of the fiber coupler helps to optimize the conversion efficiency. Moreover, the HAF based fiber coupler is experimentally proved to be able to split and deliver the ultra fast laser pulse without degradation.