On-chip ultra-high-Q microresonators and their applications in the mid-infrared

The mid-infrared wavelength region, where fundamental absorption bands of various molecules exist, is of great importance for many applications to monitor and manipulate molecules, such as molecular sensing, biochemical imaging, time-resolved spectroscopy, and photochemical processing. As an ideal material platform in the mid-IR, chalcogenide glasses (ChGs) have attracted much attention due to their high transparency and large optical nonlinearity in contrast to conventional on-chip optical materials such as silica and silicon nitride, which suffer from significant losses due to multiphonon absorption. However, the loss of on-chip ChG components has remained significantly higher than that of the optical fiber form, preventing the full exploitation of their inherent large optical nonlinearities on a chip in the mid-IR.

In this talk, we present on-chip ChG resonators with Q-factors larger than 60 million, exceeding previous records in the mid-IR by more than 60 times. By exploiting this ultra-high Q-factor together with the controllability of free spectral range provided by microfabrication, we have successfully demonstrated Brillouin lasing in this wavelength region for the first time. Our results exhibit a threshold power of 0.1 mW and a Schawlow-Townes linewidth of 85 Hz, significantly surpassing that of commercialized quantum cascade lasers. We will also present recent experimental results on supercontinuum dispersive wave generation at specific wavelengths corresponding to absorption spectral bands of target molecules to be detected in the mid-IR.