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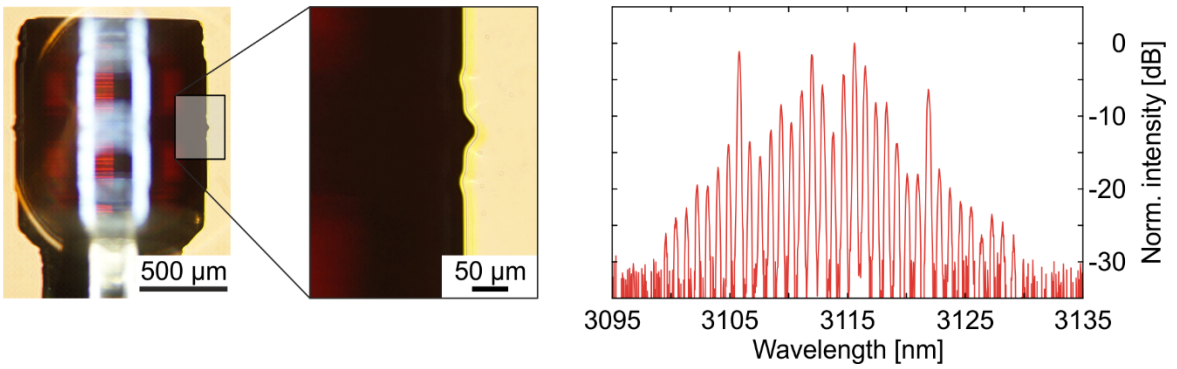
Mid-infrared $\chi^{(2)}$ microcombs based on parametric down-conversion

Kerr frequency comb generation in microresonators, based on the $\chi^{(3)}$ nonlinearity, is nowadays a well developed and understood system. While the realizations are mainly around telecom wavelengths, it is however necessary for some applications to generate combs at shorter or longer wavelengths, as for astrocombs or spectroscopy, which still remains a challenge. For this purpose, an alternative comb generation scheme based on the $\chi^{(2)}$ nonlinearity, might be a viable alternative to reach these spectral ranges. The generation is given by a series of three-wave-mixing processes which start, for example, with near degenerate parametric down-conversion. This leads to the generation of equidistant sidebands around the pump frequency and half the pump frequency, i.e. two frequency combs separated by an octave [1]. In this work, we use this approach to generate a mid-infrared microresonator comb around 3.1 µm by pumping a $CdSiP_2$ microresonator (see Fig. below) with a continuous-wave 1.55 µm laser. The combs are 30 nm wide, and different repetition rates, corresponding to multiples of the resonator's free spectral range, are obtained. This scheme is compatible with integrated telecom laser sources and therefore has the potential, to realize a completely on-chip mid-IR comb source. Further engineering of the dispersion would provide a clear pathway to extend the combs widths and numerical simulations indicate that solitons could be generated.

References

[1] N. Amiune, D. N. Puzyrev, V. V. Pankratov, D. V. Skryabin, K. Buse, I. Breunig, Opt. Express 29, 25 (2021) 41378

Figures



Left: Photograph of a millimeter-sized whispering gallery resonator made of $CdSiP_2$ with a zoom into the light-guiding cross section. **Right:** Output spectrum generated by pumping the $CdSiP_2$-based resonator with a few mW power at 1.56 µm pump wavelength.