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Low-Loss Tunable All-in-Fiber Filter for Raman Spectroscopy

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Abstract: We show a novel in-line Rayleigh-rejection filter for Raman spectroscopy, based on a solid-core Photonic Crystal Fiber (PCF) filled with a high-index material. The device is low-loss and thermally tunable, and allows for a strong attenuation of the Rayleigh line at 532 nm and the transmission of the Raman lines in a broad wavenumber range.

OCIS codes: 060.5295, 300.6450.

All-in-fiber Raman probes rely on the replacement of bulk-optics components with fiber components. The realization of a fiber-based notch filter for the rejection of the Rayleigh-scattered light is crucial. So far, fiber Bragg gratings have mainly been used [1]. The tunability of such gratings, ~ 20 nm at telecom wavelengths [2], is not enough for Raman systems working at visible wavelengths where fluorescence correction is achieved by using a tunable laser [3].

Here we show a low-loss, highly tunable filter, based on a large mode area fiber (LMA-5, NKT Photonics A/S) filled with a high-index material (Immersion Liquid 5040, Cargille Laboratories). The resulting device exhibits spectral bandgaps and is suitable for integration in a 532nm Raman system as an in-line filter. To our knowledge, this is the first realization of a Rayleigh-rejection filter by exploiting the photonic bandgap effect in a filled solid-core PCF. At room temperature (RT), the FWHM bandwidth is ~ 143 nm, and the insertion loss is 0.3 dB. The thermal tunability from RT to 70°C is 32 nm, as shown in Fig. 1. At 70°C, the extinction ratio at 532 nm is 20.5 dB.

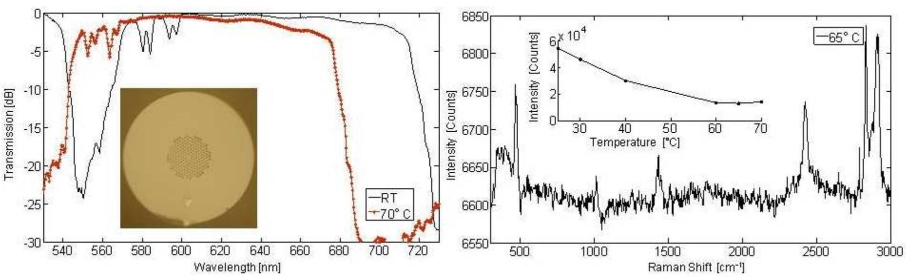

Fig.1 (Left) Transmission spectra of the device at RT (22°C) and at 70°C, both normalized to the spectrum of the unfilled fiber; (Right) Raman spectrum of cyclohexane transmitted through the filled fiber, at 65°C. Inset: attenuation of the Rayleigh line due to the tuning of the filter.

In Fig. 1 we show the Raman spectrum of cyclohexane measured in a 90° configuration by using a 532 nm excitation laser, in conjunction with the fabricated filtering device. The strongest lines (2938, 2923 and 2852 cm^{-1}) are clearly identifiable. As shown in the inset, the application of this device to a 532 nm Raman system provides a strong attenuation of the Rayleigh-scattered light.

We have successfully demonstrated a low-loss all-in-fiber Rayleigh-rejection filter, suitable for spectroscopy of weak Raman scatterers. The broad FWHM bandwidth allows for the transmission of a 3549 cm^{-1} wavenumber range.

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