Compact, Ultrabroad-bandwidth, and High-resolution On-chip AWG Spectrometers

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Broadband and compact spectrometers are in high demand in various applications including spectroscopy, medical imaging, astronomy, agriculture, food industry, communication and many more [1]. Spectrometers realized in bulk optics are generally large, but realizing them in integrated optics, such as arrayed waveguide gratings (AWGs), is a compact alternative, which also has the benefit of being rugged [2]. However, combining large bandwidth with high resolution in AWG spectrometers results in large footprint. An approach that has been investigated as a solution to these limitations is the cascaded AWG, where a first stage divides the full bandwidth into wide passbands that are each consequently divided into smaller passbands in order to provide the required resolution. However, due to the Gaussian transfer function of the primary filters, these designs suffer from small passbands in the primary stage. As a result, many secondary AWGs are required and therefore the device footprint increases significantly.

Here, we present a compact, high-resolution, and ultrabroad-bandwidth on-chip spectrometer realized in silicon nitride (Si_3N_4) material platform. The spectrometer has a cascaded configuration with a 1×3 flat-passband AWG as the primary filter and three 1×70 AWGs as secondary filters. The primary AWG has 0.5-dB bandwidth greater than 50 nm over >190 nm spectral range, which is the first demonstration of such a broad passband flat-top AWG over a very large bandwidth to the best of our knowledge. The ultrabroad-bandwidth is achieved by using an innovative design that is based on a multiple-input multi-mode interference coupler placed at the entrance of the first free propagation region of the primary AWG.

To compare the size of our cascaded spectrometer with a conventional cascaded spectrometer, i.e. primary filter with Gaussian passband, we designed a cascaded design consisting of a 1×7 primary AWG with 30 nm resolution, and seven 1×30 secondary AWGs with 1 nm resolution. In this way, the FSR and resolution (of 1 nm) of both cascaded designs become the same.

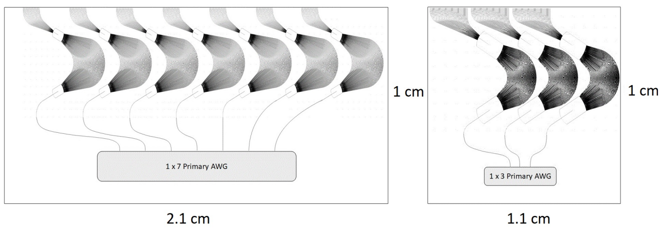

Fig. 1. Comparison of the size of both cascade AWGs

The overall device size of the ultrabroad-spectral-range flat-top cascaded spectrometer is half of that of the conventional one as is shown in Fig 1. The biggest advantages of the proposed spectrometer are the broad-spectral-range operation and the compact device size, which make it very attractive for many different applications. Among these are hand-held OCT, biosensing (smart food packaging), space based astronomy and many more.

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