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Temperature-immune readout of an integrated optical wavelength meter based on microring resonators

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Wavelength meters are central for many applications such as in telecommunication systems [1] or laser monitoring [2]. The primary function of a wavelength meter is to provide an output signal that changes sensitively with the wavelength of the input light. Of central importance is the reproducibility of the output signal even in the presence of external perturbations, e.g., temperature changes causing thermal drift. Various different methods are usually applied to improve reproducibility, e.g., thermal stabilization or repeated calibration with an additional reference light source of well-known and stable wavelength.

We present an integrated optical wavelength meter that is immune to thermal drift, requiring no thermal stabilization or repeated calibration with additional light sources. Our experimental approach is depicted in Fig.1. The first central component is an optically integrated Si_3N_4 waveguide micro ring resonator (MRR) whose optical transmission spectrum can be changed via applying a heating voltage, V, as a control parameter. The second essential component is a neural network-based readout algorithm that is able to detect temperature changes and reduce their effect on the displayed output wavelength. The wavelength meter is calibrated and characterized with input from a tunable laser and a detector that measures the transmitted power. For the initial calibration the laser is tuned to a large number (e.g. 1000) of different but known wavelengths, for each wavelength a set of different values for the control parameter (e.g. 20 voltages) is sequentially applied, and for each wavelength-control parameter combination the output power signal is recorded.

Thereafter, for measuring a single unknown input wavelength, the transmitted power is measured for the same set of control parameters values. This provides a set of output powers per unknown wavelength. Minimizing the mean-square deviation as compared to the calibration[3] yields the measured (displayed) value for the unknown wavelength.

Three main results can be reported so far: first, when increasing the number of known input wavelengths and heating voltages in the initial calibration the measured wavelengths become increasingly more precise; second, we demonstrate for the first time the long-term reproducibility of such a wavelength meter (here up to one week); third, we observe that the displayed output wavelength does not change when deliberately changing the ambient temperature up to several degrees. The latter result shows that the readout provides temperature-immune operation of the wavelength meter, which makes a precise temperature stabilization or re-calibration after temperature change obsolete.

The current wavelength range of operation spans one free spectral range (FSR) of the MRR of 4 nm with a high spectral resolution of ~75 pm. An extension of the FSR is possible via exploiting waveguide birefringence of the MRR or using sequential resonators, e.g., in a Vernier fashion.

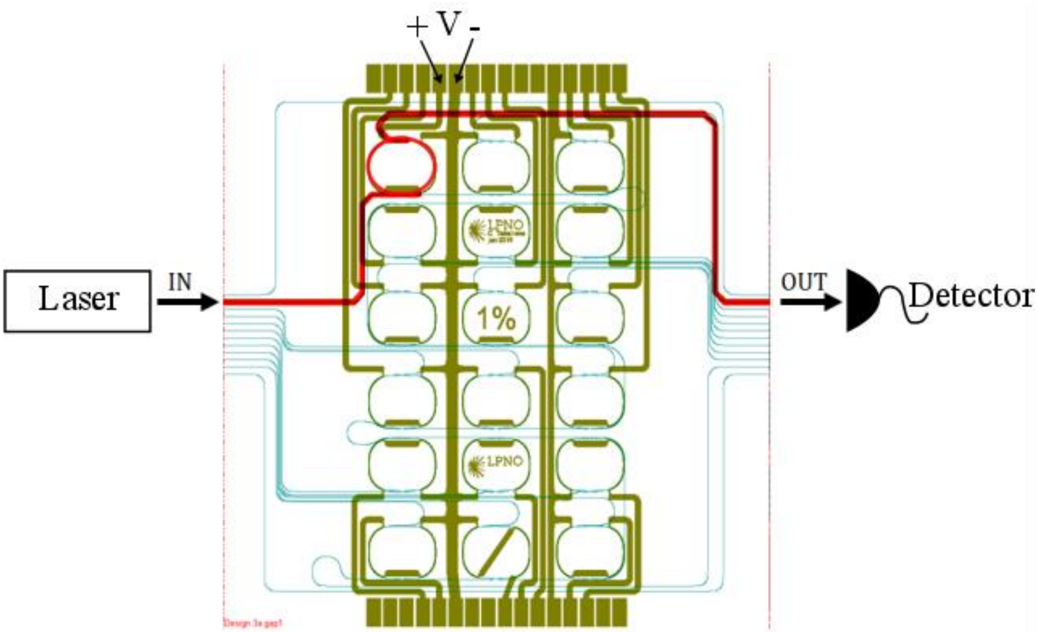

Fig. 1 Schematic setup for calibrating and characterizing the wavelength meter. Current measurements are carried out with resonators having moderate quality factors (Q~1000). The shown resonator circuit has been fabricated for higher Q-values (~ 1 million). The light path through on the resonators is shown in red (other waveguides shown in blue). Electric microwires (green) are used for resistive heating via a voltage, V, as control parameter.

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