Interferometric metrology of passive optical devices

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Introduction

To date, chromatic dispersion and time delay measurements have been mostly undertaken on optical fibers (broadband measurements) and mainly relied on the *RF phase shift method* [1]. Although moderate measurement accuracy can be achieved with this method, a trade-off between accuracy and wavelength resolution exists and imposes a severe limitation to narrowband device characterizations. On the hand, interferometric characterization of passive optical components can provide sub-picosecond time-delay and picometer wavelength resolution as well as increased dynamic range [2, 3, 4]. Its major limitation resides on the wavelength relative accuracy, stability and repeatability of the Tunable Laser Source - TLS (hereafter referred simply as TLS wavelength noise), which is used in conjunction with the fiber interferometric set-up. Continuously-swept TLS can allow much faster wavelength scans than stepped TLS. Commercially available swept lasers allow measurement results in seconds while stepped sources takes tens of minutes. This brought a newer revolution to this metrology science, since time and cost savings during characterization is extremely important for the device market.

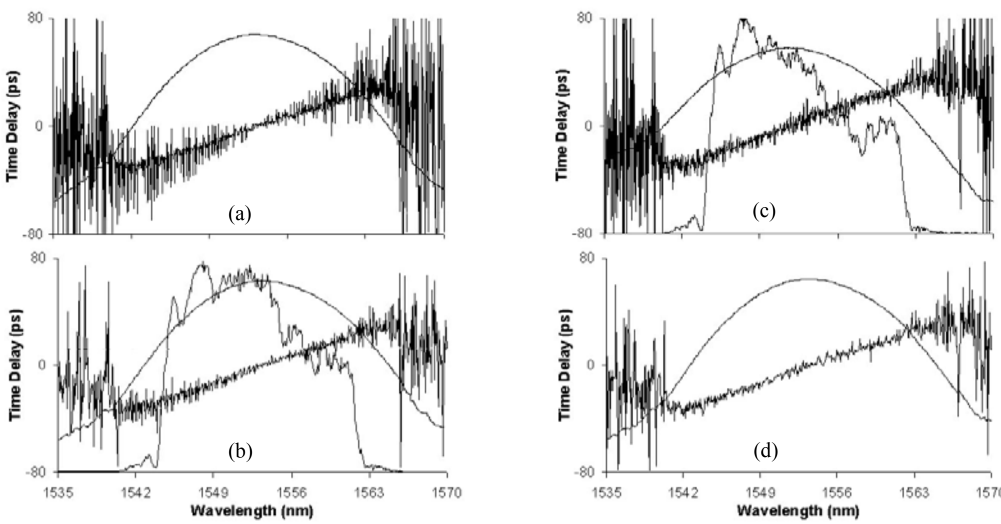

Fig. 1: Time delay, phase and reflectivity of a linearly chirped fiber grating measured using 2 different "stepped" tunable laser sources. (a) and (b): TLS-1; (c) and (d): TLS-2. In (a) and (c), $\Delta\lambda$= 0.020 nm and in (b) and (d), $\Delta\lambda$=0.050 nm.

Tunable Laser Influence in Interferometric Narrowband Measurements

We have recently developed an original interferometric approach, referred as Static Interferometric Technique (SIT) [5]. The excellent performance of this technique allowed us to evaluate some TLS commonly available in R&D laboratories. First, the features associated with the TLS wavelength noise could be quantitatively assessed. Second, the performance of different tunable laser sources could be compared. Fig. 1 shows the time delay, phase and reflectivity responses of a ~6 mm long linearly chirped fiber Bragg grating (FBG) measured using the SIT approach. Results obtained using two different "stepped" tunable laser sources from different manufacturers (TLS-1 and TLS-2), and two different $\Delta\lambda$, 0.020 nm and 0.050 nm, are presented. The wavelength noise combined with the interferometer path imbalance (ΔL) creates noise on top of the time delay data, which is clearly seen in figure 1. The amplitude of this noise is negligible at the central wavelength (~1555 nm) where the path imbalance is zero. However, on either side of this wavelength, the added noise increases due to gradual shift of the effective reflecting point in the chirped FBG. Fig. 1 also points out two other features. First, the TLS-2 provides considerably better results for both wavelength steps. Second, the noise amplitude in the phase measurements does not depend on the programmed wavelength step $\Delta\lambda$, but smaller $\Delta\lambda$ incurs in greater noise amplitude in the time delay results. The data of fig. 1 allow to quantify the wavelength noise of the tunable lasers: (a) from the edge wavelengths, we get $\Delta\lambda\varepsilon = \pm 0.021$ nm and $\Delta\lambda\varepsilon < \pm 0.006$ nm for the TLS-1 and TLS-2, respectively; (b) around the center wavelength, where $\Delta L \approx 0$, the phase noise is about ±1.6° for the TLS-1 and ±3.3° for the TLS-2. The phase and time delay measurement noises introduced by the TLS have a "quasi-white" distribution characteristic (*cf.* figure 1). This blur can be almost cleaned out by digitally filtering the measured data.

References

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