Gain Flattening Filters produced by plasma ion assisted deposition

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Abstract: Plasma Ion Assisted Deposition (PIAD) with the Advanced Plasma Source (APS) results in Gain Flattening Filters with a depth of more than –10dB at a customer specified bandwidth from 1525 nm to 1565 nm. The temperature shift could be adjusted by using special substrates.

1. Introduction

Gain Flattening Filters (GFF) have the inverse characteristics of the gain from Erbium Doped Amplifier, thus balancing the gain across the band and providing a uniform signal [1]. The ability of producing shift-free coatings on large substrate areas by means of PIAD has been proven in many applications over the past ten years [2-4]. The low loss and stress values achieved, especially with silica and tantala films, allows besides the production of narrow band pass filters the with a remarkable total film thickness and number of layers also the production of GFF using the same equipment [4]. The requirements for gain flattening filters are different from DWDM applications. The Insertion Loss Error Function (ILEF) ist one of the most important parameters for GFF. The smaller the ILEF is the more difficult it is to produce the GFF. Other factors affecting the design and manufactoring of GFF include ist Bandwith, Depth, and Slope. The lagerer these parameters are the more difficult it is to design and manufacture a particular GFF filter [5]. The production of GFF cannot be achieved with common techniques used in the production of interference filters [6]. Only with the help of a direct monitoring system and its capability of error compensation, the production of GFF with large useful area is possible.

2. Experimental Setup

The experiments were done in an commercial available *APS 1104 DWDM* Boxcoater. The machine was equipped for the special requirements with respect to the production Gain Flattening Filters. A high speed single substrate drive was used for the coating runs. The optical measurement was done with a high resolution OMS 3000 monitoring system. Two sixfold quartz crystal sensors were used to control the deposition rates of the three high volume electron beam guns. The temperature of the substrate was measured and controlled during the whole process. The position of the evaporation sources, the substrate and the APS source were chosen to achieve an optimized uniformity in the substrate area. A special developed controlling of the APS source allowed a constant magnetic field, responsible for the plasma extraction, and an unchanged bias voltage, determining the ion energy, during whole process time of approx. 12 hours.

The measurements of the coated filters were done with an optical spectrum analyzer (OSA, Ando AQ6317B) and a single mode fiber optic setup with a measuring spot size of 400µm. The setup was aligned in order to measure at normal incidence. Measurements of the temperature shift were performed with a similar setup. Therefore the coated substrates were placed in a climate chamber and the temperature was varied over a period of 3h from 20°C to 80°C. The central wavelength shift was measured in steps of 10°C with an OSA (HP70950B) which was placed outside the chamber and connected via fiber to the measuring setup.

3. Results

Silicon dioxide and tantalum pentoxide were used as coating materials with deposition rates of 1.4nm/s for the SiO_2 and 1.1nm/s for the Ta_2O_5, resulting in a total coating time for GFF #1 coating run of 12 hours. The example shown in Fig. 1a and 1b has been produced using a coating system with standard DWDM equipment, including Leybold Optics‘ proprietary Advanced Plasma Source APS®, and OMS optical monitoring system. In this example, the desired low total thickness of the filter (here 31 µm) was realised with a 5-cavity system consisting of only 84 layers.

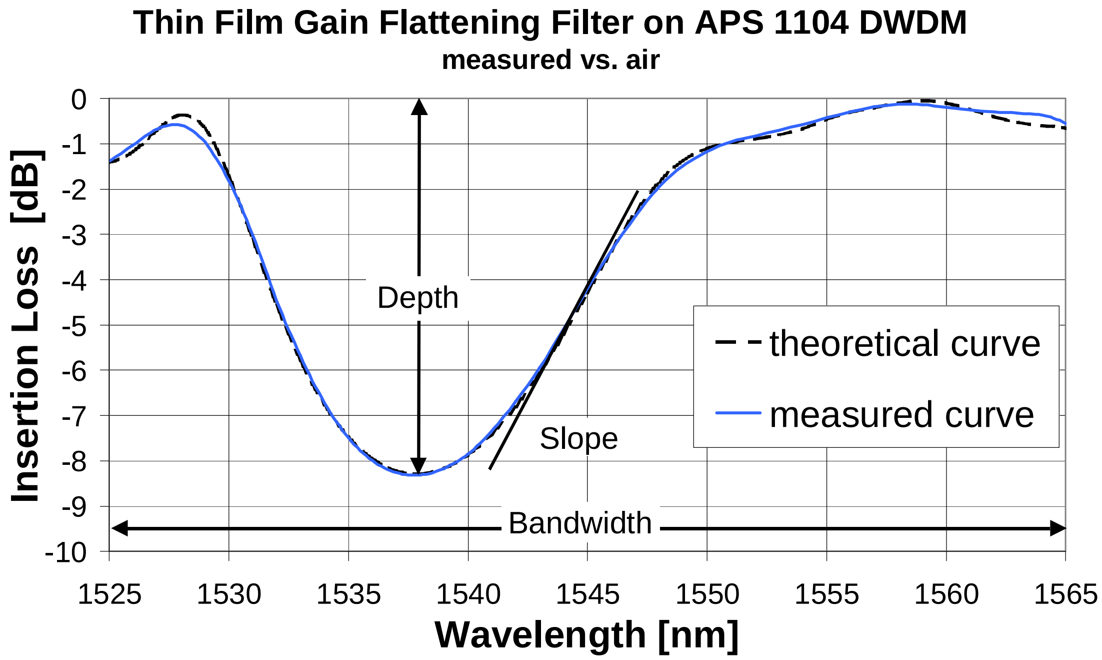

FIG 1a: GFF 5-cavity system (84 layers; thickness 31µm)

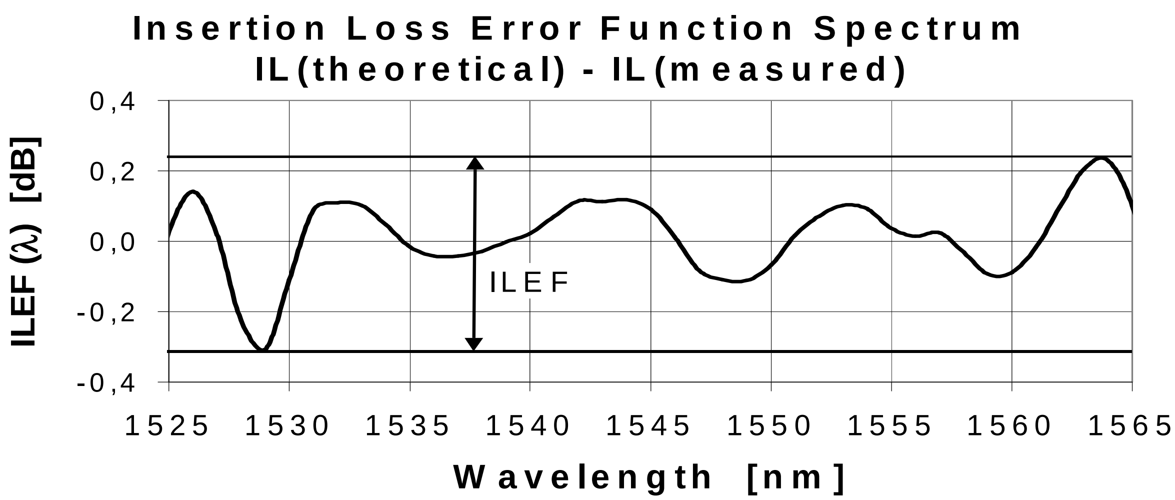

FIG. 1b: ILEF-function difference between theoretical and measured curve in dB

Using a more sophisticated setup with OMS 3000 Upgrade-Kit and a thermal stabilized optical measurement system advanced GFF systems can be manufactured. First trials on vaious systems show promising results (see FIG. 2).

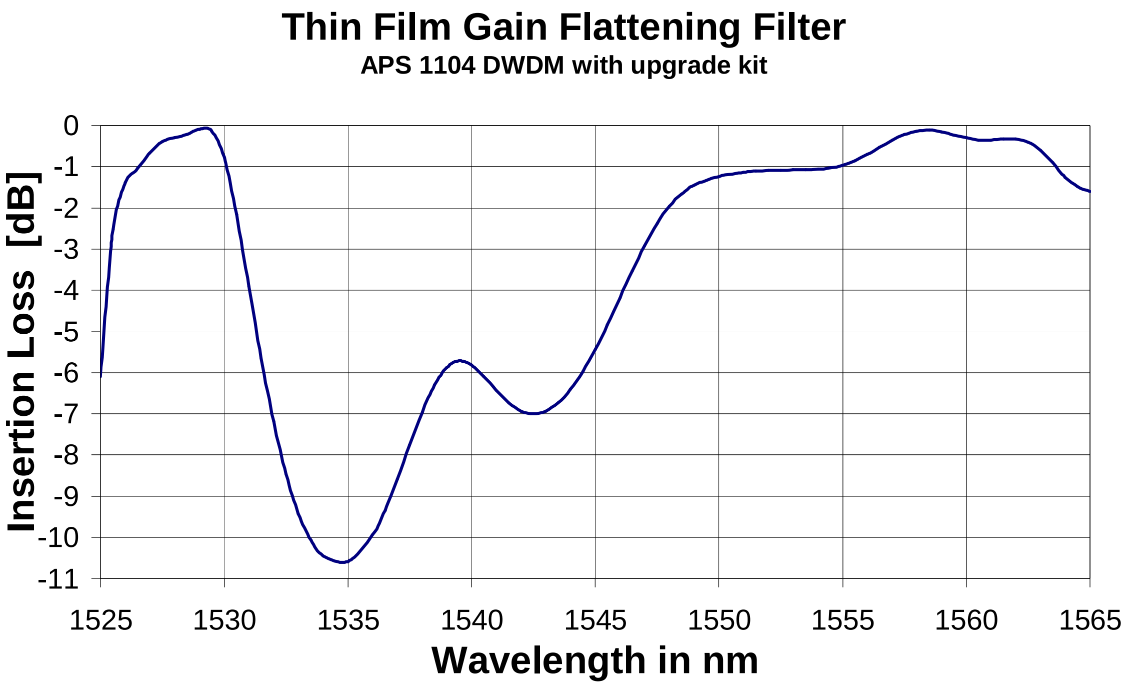

Fig. 2 Measured Spectra of a 2nd GFF design

4. Conclusions

Plasma ion assisted deposition with the APS in a special designed Boxcoater has the outstanding capability of producing GFF. The obtained uniformity in the area next to the monitoring spot allows the fast production of huge amounts of GFF filters. By choosing the right thermal expansion coefficient of the substrate it is possible to control the residual wavelength shift of the filter.

For further work it is necessary to monitor the spectrum of the measurured transmittance curve and apply a reengineerig software to compensate the the deviations of calculated monitoring curve to the actual values. This work will lead to a new dimension of process control.

5. References

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