Tunable Infrared Filter based on a Fabry-Perot-Interferometer

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Introduction

Much effort has been involved in developing micromachined optical filters on base of Fabry-Perot-interferometers (FPI) in recent years. Most of them is dedicated to wavelength division multiplexing for optical communication or to gas analysis in near or mid infrared [1 - 3]. Dielectric mirrors are applied for reflectors in almost every case because of their low absorption compared to metal reflection layers. Most important properties of a FPI filter are the full width half maximum bandwidth (FWHM), the peak transmission and the tunable spectral range which are influenced by the reflectivity and the phase change of the mirrors and limited by the curvature and tilt of the mirrors and the non uniformity of the cavity.

Design and fabrication

The approach discussed here minimizes mirror curvature by using 300 µm thick Si mirror carriers for the fixed and the movable mirror of the FPI. Specially arranged silicon bending beams act as a parallel spring suspension of the movable mirror and lead to an almost perfect parallelism of the mirrors (see SEM view in Fig. 1).

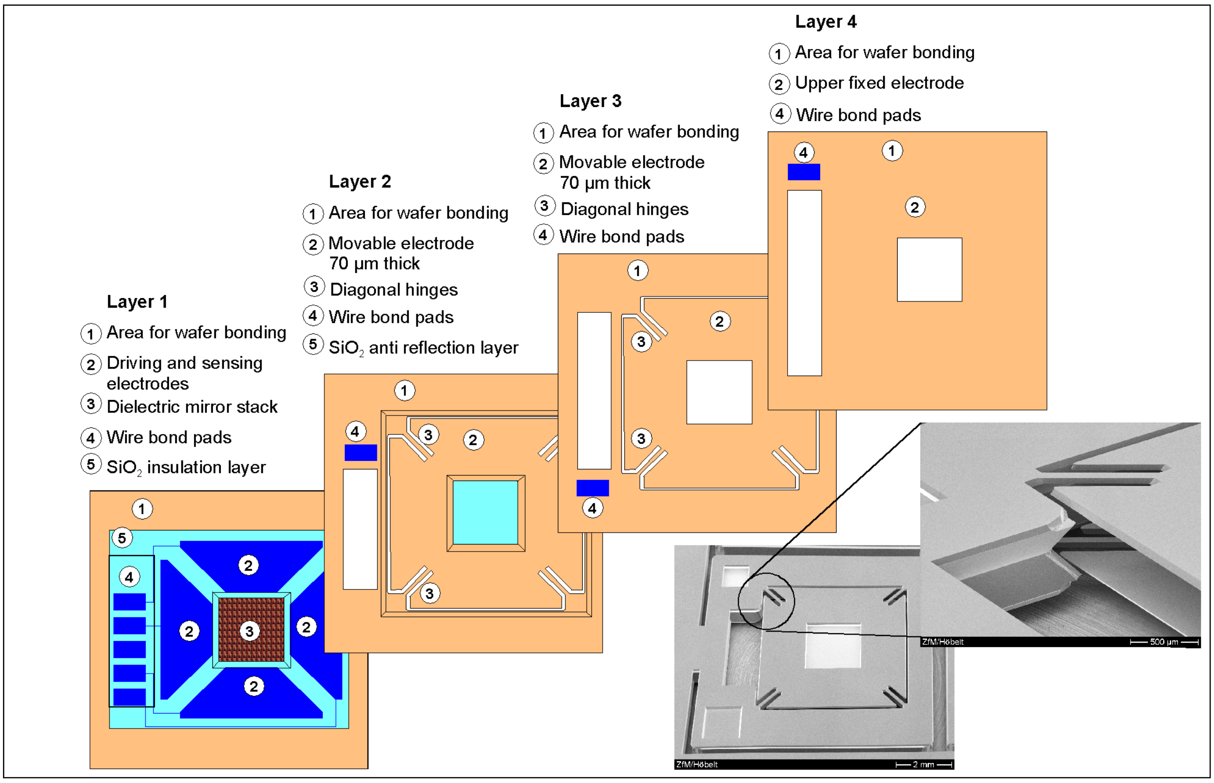

Fig. 1. *Top view onto the layers of the FPI and SEM view of the parallel spring suspension*

The device consists of a carrier for the fixed mirror and electrodes (layer 1), the movable mirror carrier and suspension (layer 2 and layer 3) and the upper electrode (layer 4, Fig. 1). Mirrors of dielectric layer stacks enclose the cavity in first order configuration. The cavity size is electrically tuned and the cavity size capacitively detected by a closed loop control. The optical active area with a size of 2.2 x 2.2 mm² is placed in the middle of the driving and detection electrodes, of the suspension with diagonal bending beams and of the rim. The fabrication technology is based on bulk micromachining which offers the opportunity to fabricate the mirrors on very flat and mechanically stiff material. A cross sectional drawing and a SEM view can be seen in Fig. 2. The IR radiation penetrates the silicon mirror carrier of layer 2 and is directed to the cavity. Layer 2 and layer 3 are elastically suspended so that the cavity size can be changed by the applied voltages. The radiation leaves the device trough layer 1. Anti reflection layers reduce reflection loss due to the in-continuity of refractive index of air and silicon.

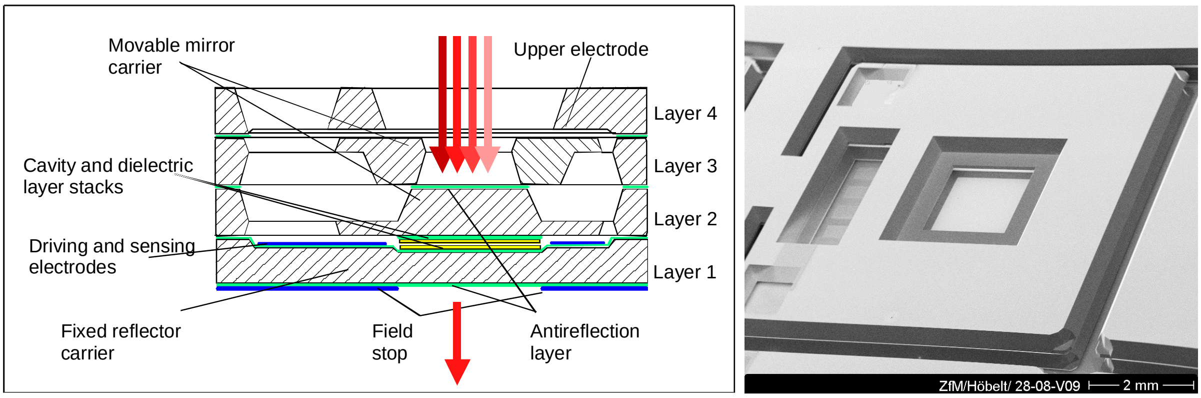

Fig. 2. *Cross sectional drawing of the FPI and SEM view*

Results

The over all optical transmission of the first prototypes and the dependency of central wavelength on the driving voltage have been measured by an Fourier Transform Infrared Spectrometer at different driving voltages applied to the fixed electrodes in order to deflect the movable mirror towards the fixed one during this measurement (Fig. 3). The center wavelength can be tuned between 3 ... 4 µm by applying 25 V at maximum. The FWHM bandwidth is approximately 50 nm and the peak transmission between 45% and 55%. It is necessary to apply an optical low pass filter with a cut off wavelength of 2.8 µm to block transmission of higher order wavelength. We expect lower FWHM bandwidth and higher transmission at center wavelength applying three quarter wavelength stacks.

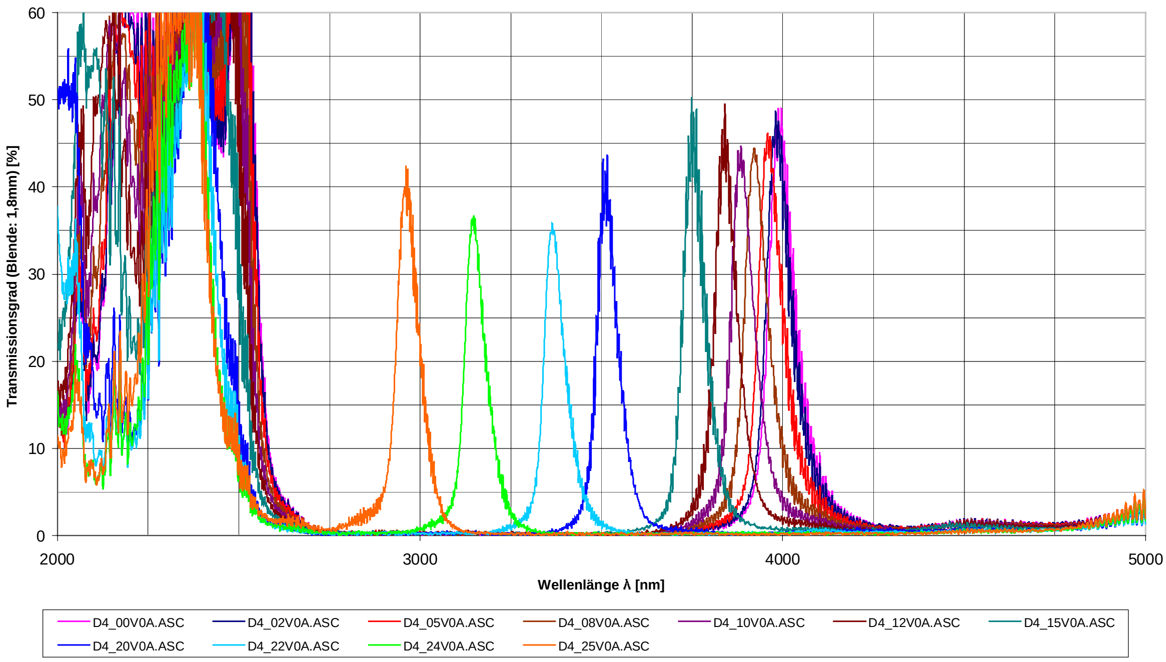

Fig. 3. *Transmission of the FPI at different driving voltages*

References

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