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Suspended Silicon Membranes for high performing MEMS based Distributed Bragg Reflectors used in IR imaging applications

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Précis- Suspended silicon (Si) membranes have been successfully demonstrated for use in air-spaced Bragg reflectors (DBR's) for the near infrared (NIR: 0.7 – 1.5 μm), shortwave infrared (SWIR: 1.5 – 2.5 μm) and midwave infrared (MWIR: 3 – 5 μm) wavelength bands. Air-spaced DBRs have the advantage of using air as the low refractive index material in the quarter-wave DBR structure, providing maximum refractive index contrast for any given high-index material chosen. The higher the contrast between the high and low refractive index materials the higher the reflectivity and bandwidth of the DBR. We focus on the NIR, SWIR and MWIR regions because they offer valuable information for applications in image recognition and hyper-spectral imaging.

Experiment: In this paper we present suspended Si membranes, for use in the construction of MWIR, SWIR and NIR DBRs, fabricated using inductively coupled plasma chemical vapour deposition (ICPECVD) [1].Three suspended quarter-wavelength thick Si membranes were fabricated to operate as single-layer DBR reflector structures in the MWIR, SWIR and NIR spectral bands. The thickness of each layer was chosen to optimize reflectivity at the central wavelength in the chosen spectral band.
The suspended membranes were fabricated by surface micromachining and initially consisted of two materials: Si and Prolift. Silicon was used as the optical layer to provide the desired quarter-wave reflector characteristic. Prolift was used as a support for the silicon membrane around the periphery, and as a sacrificial layer to be removed beneath the silicon membrane. Prolift was spun on the wafer to the thickness required and hard baked at 210 °C. ICPECVD Si was deposited on the Prolift layer and stress release notches and etching holes were patterned by means of dry etching of the top Si layer [2]. The Si membranes were released by means of wet etching using developer AZ826 followed by critical point drying. Table 1 presents in detail the Prolift type and Si deposition temperature for each Si membrane. Figure 1. shows the optical profilometer measurements of the fabricated membranes (top images) and the cross section profile (bottom images) showing a membrane flatness of 20 nm over a 1000 μm × 1000 μm mirror area.

	Prolift used	Prolift thickness	Si Thickness	Si Deposition temperature	Wafer
MWIR Si Membrane	100-24	1200 nm	320 nm	190 C	Si
SWIR Si Membrane	100-16	560 nm	150 nm	175 C	Si
NIR Si Membrane	100-24	1200 nm	87 nm	175 C	BK7

Table 1. Layer thickness and deposition conditions for the Si membranes fabrication.

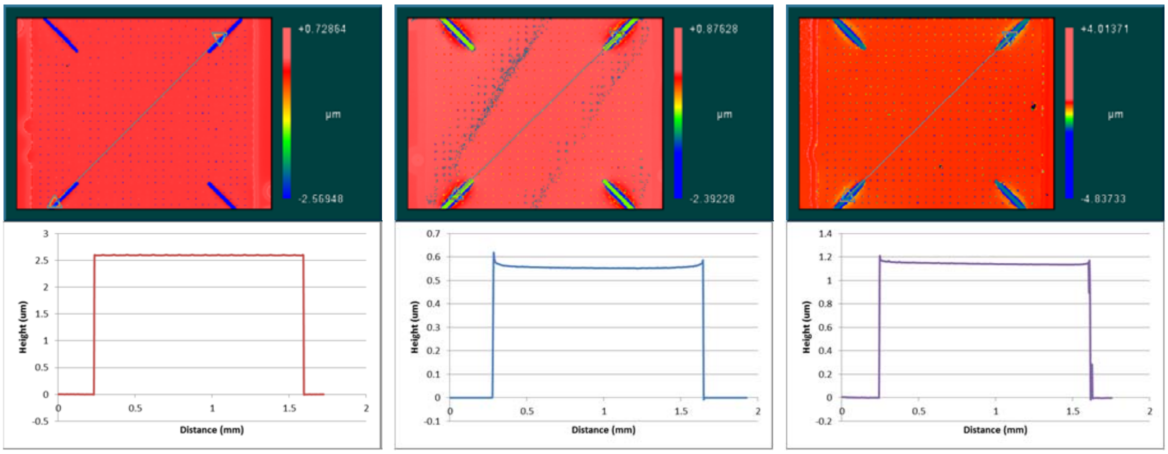

Figure 1. From left to right 300 nm thick Si membrane for a 1000 μm × 1000 μm MWIR DBR, 150 nm thick Si membrane for a 1000 μm × 1000 μm SWIR DBR and 87 nm thick Si membrane for a 1000 μm × 1000 μm NIR DBR.

Conclusion: Suspended ICPECVD Si membranes have been successfully fabricated on a Prolift structural layer with a flatness of less than 20 nm over a 1000 μm × 1000 μm mirror area. The suspended Si membranes were optimized to operate in the NIR, SWIR and MWIR regions with the aim to be implemented for high performance NIR, SWIR and MWIR DBRs.

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[1] D. K. Tripathi, M. Haifeng, K. K. M. B. D. Silva, J. W. Bumgarner, M. Martyniuk, J. M. Dell, and L. Faraone. "Large-Area MEMS-Based Distributed Bragg Reflectors for Short-Wave and Mid-Wave Infrared Hyperspectral Imaging Applications." *Microelectromechanical Systems, Journal of* 24, no. 6 (2015): 2136-144.
[2] M. Haifeng, K. K. M. B. D. Silva, M. Martyniuk, J. Antoszewski, J. Bumgarner, B. D. Nener, J. M. Dell, and L. Faraone. "MEMS-Based Tunable Fabry-Perot Filters for Adaptive Multispectral Thermal Imaging." *Microelectromechanical Systems, Journal of* 25, no. 1 (2016): 227-35.