Continuous Electron Beam Lithography Writing Modes for Optical Waveguide Nanofabrication

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Fabrication of long waveguides extending over several mm with highest degree of perfection has always been a challenge using electron beam lithography techniques. Conventional stitching in vector scanning electron beam lithography inherently results in discrete displacement errors (kinks) at the write field borders, which can significantly degrade photonic device performance[1]. Multipass strategies, also referred to as "shot shift" methods, can improve on the final result, however the stitching errors are "smeared out" rather than eliminated completely, and the development of such strategies adds more complexity to the overall nanofabrication process. Using a new and unique continuous writing mode called Fixed Beam Moving Stage (FBMS), we have been able to fabricate several mm long perfect and stitching error free arrayed and tapered waveguides.

In the example presented in Figure 1, an arrayed waveguide grating was created in FBMS mode over a length of several mm. The difference in length of the individual paths causes a well-defined phase shift between the signals. For this reason the precise control of the line width along each of the waveguides as well as their exact positioning with respect to each other is crucial for the performance of the final device.

The connection of waveguides to further functional parts often requires a tapering of the individual paths. A 2mm long and curved example thereof (Figure 2) was fabricated without stitching errors applying an innovative "trace-retrace-technique" for fabrication of the contours of the waveguide tapers in FBMS mode in combination with conventional stitching of the bulk section of the waveguide.

[1] M. Gnan, D. S. Macintyre, M. Sorel, R. M. De La Rue and S. Thoms, J. Vac. Sci. Tech. B 25 (6), 2007, p. 2034

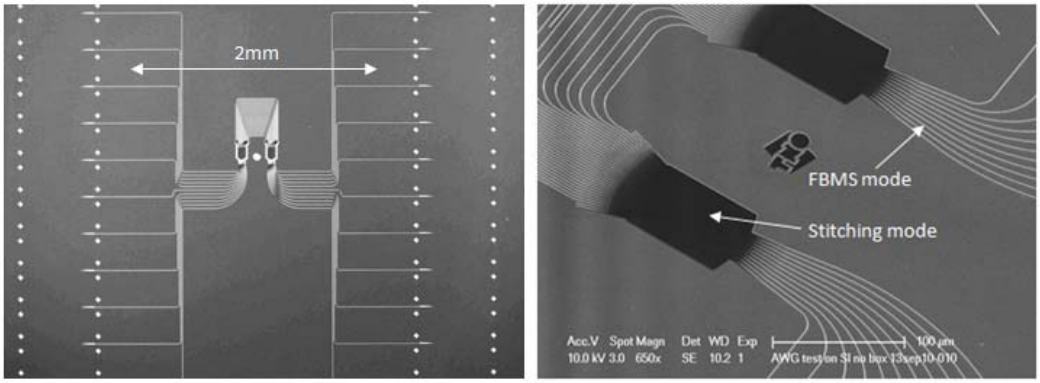

Figure 1: An arrayed waveguide grating (AWG) over several mm length: The shape and position of the lines have to be as perfect as possible in order to optimize signal transmission. The FBMS mode is combined with conventional stitching lithography in the same process step.

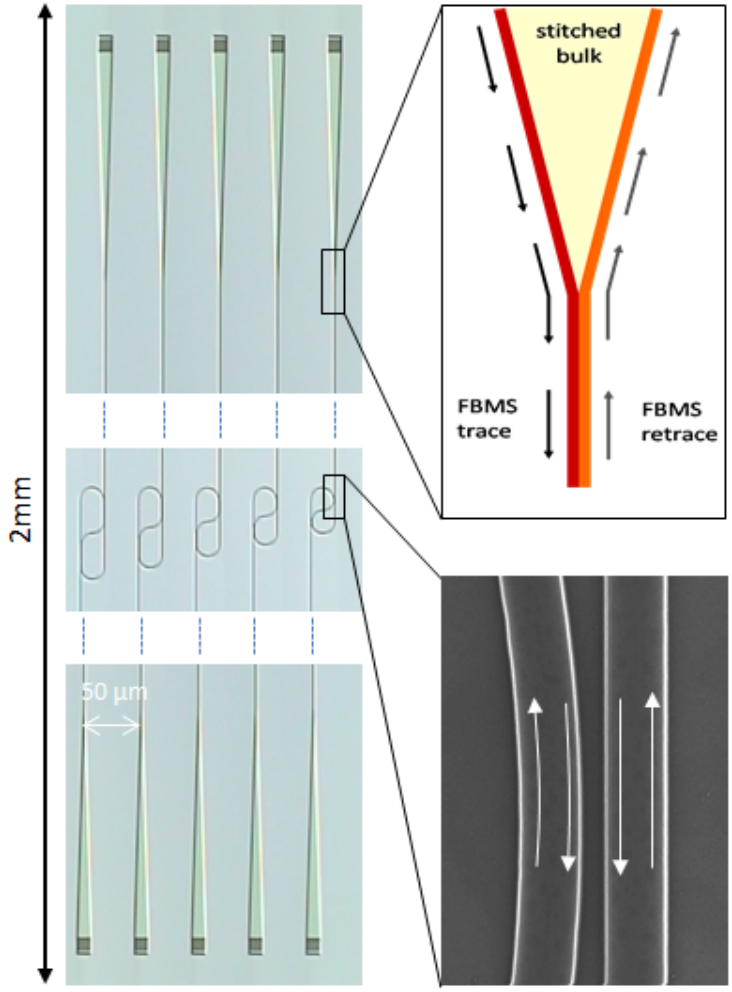

Figure 2: Optical micrograph of a 2 mm long waveguide with tapers: Boundaries (sleeves) of tapers are written in FBMS mode. Bulk is written in conventional stitching mode. The waveguides were patterned in trace-retrace-mode to optimize the transition from tapered area to constant line width.