Creation and transfer of gratings with spatially-varying periodicity

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Grating is one of the most important optical elements and is widely used in optical devices. Most gratings have fixed and constant periods, while tunable gratings and chirped gratings (gratings with spatially varying periods) are attracting increasing interests in recent years. For example, deformable gratings fabricated on PDMS-on-silicon have been used to obtain variable strains as well as periodicity [1]. Gratings with spatially varying periods also find novel applications as dispersive elements for compact spectrometers [2], spectrum splitting, etc.. However, large-area fabrication of spatially varying gratings, especially those featuring accurate chirp factors, is challenging. Interference lithography can generate gratings with nearly constant periods but cannot modulate the periodicity distribution. Electron beam lithography cannot precisely pattern gratings with slowly varying periods due to quantization errors in beam steering.

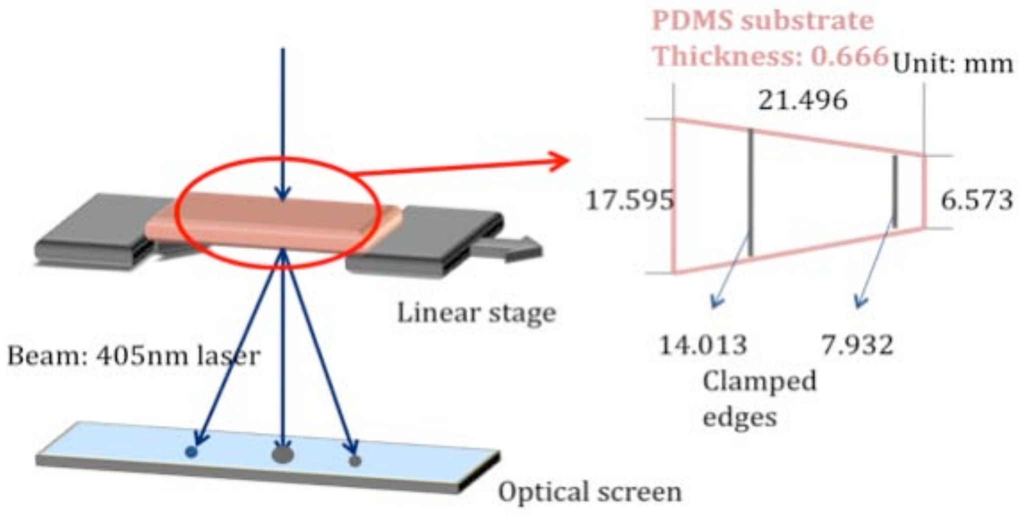
In this work, we develop a series of methods that can arbitrarily modulate the spatial distribution of periodicity in ordered patterns by deforming elastomeric substrates with specially designed shapes, and we further transfer the modified grating patterns on the deformed elastomeric substrates onto a rigid substrate for future use as a nanoimprint template. Fig. 1a illustrates the schematic of the experiment setup for generating chirped gratings by deforming the grating pattern on an elastomeric substrate. The PDMS elastomeric substrate that carries a 550-nm grating pattern is cut into a trapezoid profile with original dimensions shown in the schematic. Deforming this substrate by stretching it from two ends will generate nonuniform strain field in the substrate due to the trapezoid profile. A 405 nm laser indicator is used to measure the local period as calculated by the position of first order diffraction spots. Measured local period along the stretching axis is shown in Fig. 1b (black line). Also shown are an ANSYS simulation and an analytical calculation of the period distribution, which agree reasonably well with the experimental results.

The nearly-linearly varying grating period as seen from Fig. 1b shows that by tailoring the profile of an elastomeric grating substrate, chirps can be generated in the grating pattern by stretching the non-symmetric substrate. Applications based on these spatially varying periodic structures are being explored.

1. Truxal, S.C., N.-T. Huang, and K. Kurabayashi. *A nano grating tunable mems optical filter for high-speed on-chip multispectral fluorescent detection*. in *Engineering in Medicine and Biology Society, 2009. EMBC 2009. Annual International Conference of the IEEE*. 2009. IEEE.

2. Fortin, G. and N. McCarthy, *Chirped holographic grating used as the dispersive element in an optical spectrometer*. Applied optics, 2005. **44**(23): p. 4874-4883.

(a)



(b)

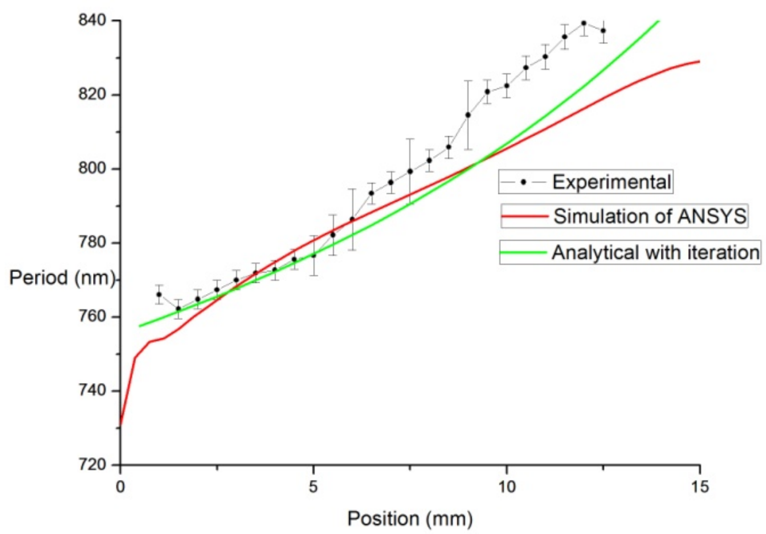


Fig. 1. a) Schematic of generating and measuring the chirped gratings by stretching an elastomeric substrate carrying the grating patterns and cut into an asymmetric profile; b) Measured local grating periodicity under stretching and comparison with ANSYS simulation and analytical calculation results.