Characterisation of Nanoimprinted Line Profile Using Subwavelength Optical Diffraction

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Abstract

Sub-wavelength diffraction has been applied to imprinted polymer lines which have different average widths and side-wall angles, resulting in a significant change in the measured relative diffraction efficiencies. Diffraction has also been applied to structures which have been heated to a temperature at which the polymer relaxes and partially reflows, creating rounded line profiles. Comparison of the measured signal before and after reflowing shows a large difference in relative intensities. Dimensions used in optical simulations are in good agreement with atomic force microscopy measurements.

1 Introduction

Nanoimprint lithography (NIL) is an alternative high resolution, low cost, lithography method for fabricating structures with features as small as ten nanometres, by using a rigid stamp to pattern thin polymer films [1]. It is targeted in the ITRS roadmap as a potential next generation lithography for the 22 nm node. Its adoption as a widely used fabrication technique depends upon the use of suitable, reliable and cost-effective metrology techniques, capable of characterizing three dimensional shape features [2]. Sub-wavelength diffraction metrology is a new technique which has been used to characterise structures with critical dimensions as small as 50 nm, to distinguish defects produced during the nanoimprint process [3].

2 Method

The subwavelength diffraction technique analyses a diffraction pattern from specially designed grating test structures, and based on comparison of the measured diffraction intensities with simulation results, information can be obtained about the critical dimension, height and defects in the structures (Figure 1).

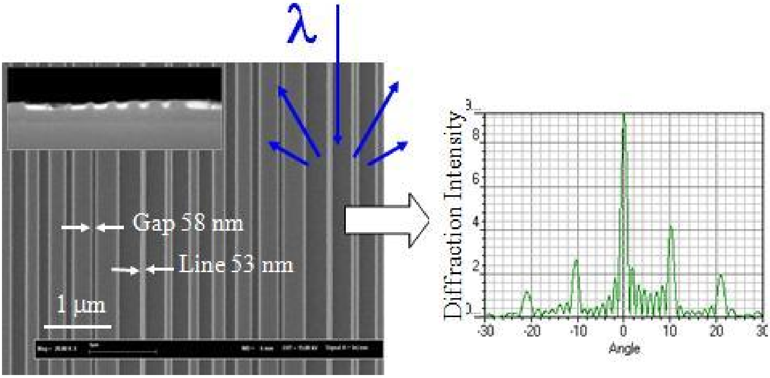


Figure 1. Nanoimprinted test grating structures and asymmetric diffraction pattern.

The diffracted light from the structures is modelled using the rigorous coupled wave analysis. Dimensions used in the simulations are based on atomic force microscopy measurements, performed using a high-aspect ratio tip. Parameters were then varied to achieve an optimum fit to measured data (Figure 2), including line widths, height and underlying polymer residual thickness. Final simulated dimensions, used to match with the measured optical signal, and AFM dimension values are in close agreement. An example is shown for the middle line of sample 2 below, in Table x, in which they differ by 8 nm.

Table 1. Comparison of AFM measurements and dimensions used in optical simulation for best fit to measured data (Figure 2).

Dimensions in nm		Height	Top Width	Mid Width	Bottom W	Residual
Sample 2	AFM	154	164	321	369	50*
	Simulation	154	160	313	361	50

*Based on initial resist thickness and calculation using conservation of volume.

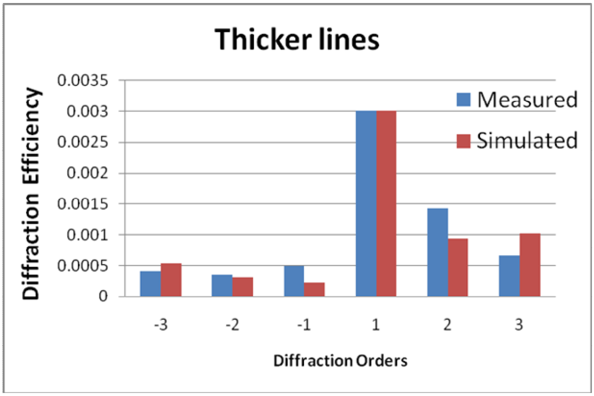


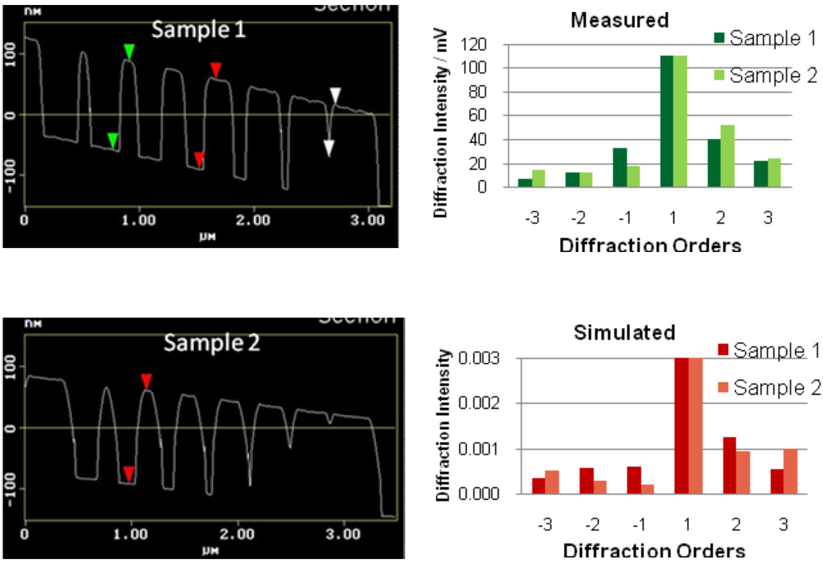
Figure 2. Comparison showing good agreement between simulated and measured diffraction efficiencies.

3 Results

Sub-wavelength diffraction has been used to compare two different imprints from the same silicon stamp which have different average widths and side-wall angles (Figure 3(a)). This results in a significant change in the measured relative diffraction efficiencies (Figure 3(b)), so that the ratio of +1st order/-1st order intensities is greater for Sample 2 in both the measured and simulated results.

Table 2: Relative diffraction efficiency values for both samples

+1st/-1st	Sample 1	Sample 2
Measured	3.3	6.1
Simulated	4.8	13.3



(a) **(b)**

Figure 3. (a) AFM cross-sections of imprinted graings with different line profiles. (b)Measured and simulated diffraction intensities for samples 1 and 2, showing the greater relative intensities for the +1st/-1st order ratio for sample 2 in both measured and simulated results.

Acknowledgements

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