Microfabrication of thick through silicon for use as X-ray lithography masks

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The need for low-cost micro fabrication technologies in modern life-sciences is increasing. For example, the PMMA microstructures act as ultrahigh Q factors optical cavities, which modify the spontaneous emission rates and alter the spatial distributions of the input and output radiation [1, 2]. We fabricated thick (525μm) silicon patterns by ICP dry etching, and realized a new X-ray lithography mask (Fig.1). The X-ray mask with 525 μ m-thick silicon absorbers could expose about 200μm-thick PMMA structures. In the etching process of silicon wafer, the circle structure of about 0.3mm in diameter, from which pattern edge roughness is less than 100nm. From the results of the pattern edge roughness and the side etch width, the pattern fabrication accuracy of sub-micron was achieved. Furthermore, the obtained mask achieved a low pattern distortion due to the silicon proprieties. The proposed technique to generate very fine flat sidewall surface is demonstrated by applying it for fabrication of micro structures.

The (100) Si chip with through pattern shown in Fig.1 is used as a LIGA mask. The X-ray photoresist is PMMA therefore it is easy to pattern in PMMA resist only by development after X-ray exposure. The mask pattern is design as the circle and line having a line width of 100μm and the diameter of a circle are 300μm. The dosage is about 0.01Ahour. After being developed in GG developer for 1 hour, the result observed by SEM is shown in Fig2. The PMMA patterns are circle and line in shape and the thickness is 100μm. In addition, the RMS value of the surface roughness was within 100nm.

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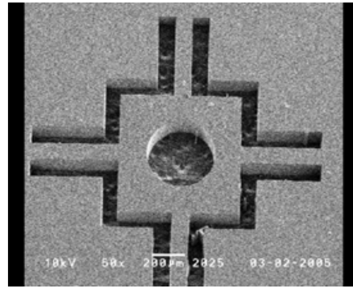

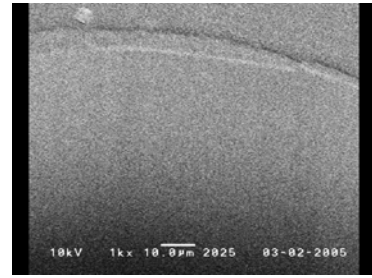

Fig.1 Si x-rays mask Fig.2 Fabricated PMMA structure Fig.3 The sidewall of the Fig.1

PMMA micro structure using Si as x-ray lithography mask are fabricated. The fabrication of X-ray masks is a critical and challenging process in LIGA technique. As inductively coupled plasma (ICP) deep etching appears to be the most suitable source for deep silicon etching, we fabricated a new type X-ray mask using this technique. The etching parameters is as following: In etch step, the etch gas is SF_6 and the flow rate 130 sccm and the etch time 9 seconds. In deposition step, the protection gas is C_4F_8, and the flow rate 85 sccm, the deposition time is 7 seconds. The ICP-RIE coil power is 600W, platen power 15W, and chamber pressure is 20 mTorr, thereforce, the etching rate: 2.5 μm/min.

In comparison with other types of X-ray masks, the mask we fabricated has the advantages of its low cost and its simple fabrication process. Desired microstructures have also been fabricated using this new type X-ray mask in LIGA technique. The polymer sidewall has been smooth enough to use as a mirror.

Acknowledgement

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References

[1] B.E. Little, S.T. Chu, H.A. Haus, J. Foresi, and J.P. Laine, "Microring Resonator Channel Dropping Filters," Journal of the Lightwave Technology, Vol.15,no.9, pp.998-1001,1997.

[2] R. D. Meade, A. Devenyi, J. D. Joannopoulos, O. L. Alerhand, D. A Smith, and K. Kash, "Novel application of photonic band gap materials: Low-loss bends and high Q cavities," J. Appl. Phys. Vol.75, no.6, pp.4753-4756, 1994.