Novel Poly-L-Lactides micromachining by X-ray lithography

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Poly-L-Lactides(PLLA) is a biodegradable polymer material which is sensitive to X-ray as a resist and free of stress crack formation. PLLA polymer has very good proprieties of substantial degradability and changes in solubility under irradiation compared with that of most of other different kinds of polymers. To my knowledge, there are few papers to report the PLLA micromachining by ion beam irradiation [1] or by molding process [2].

A new technique to generate the micro structures with the very smooth sidewall is demonstrated. The function of synchrotron radiation on PLLA is breaking the PLLA polymer main chain and generating intermediates which can be degraded further and finally dissolved by the solvent interaction. Sufficient changes in the PLLA solubility occur under x-rays radiation on bulk PLLA material by breaking the polymer backbone, and at the same time, avoiding the cross linking of the PLLA.

PLLA is a new resist material for x-ray lithography and can be developed in alkaline developers after x-ray exposure. The mask patterns are designed as tips with a line width of 100μm. Desired microstructures have also been fabricated using this novel X-ray lithography technique. The PLLA structure sidewall obtained by this process is very smooth compared with that of other micromachining methods. The exposure experiment is carried out in beamline 13 of AURORA in Ritsumeikan University. The exposure dosage is about 0.02Ahour. Fig1 shows the result after developed in NaOH(1N) developer for 1 hour at room temperature. The rough bottom and the smooth sidewall are observed due to different etching rate by consuming PLLA to generate lactic acid salts (Fig.2). The depth of the PLLA is about 140μm. In addition, the RMS value of the sidewall roughness was within 200nm. Fig.3 shows the fabricated PLLA micro structures after exposure by the synchrotron irradiation and developed by the GG developer.

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Fig.4 illustrates the enlarged image of sidewall of the Fig.3.The stress crack formation occurs after the development at room temperature by using the GG developer. As a conclusion, the method of using PLLA material, synchrotron radiation, and the alkaline developer to fabricate micro structures is effective and has a promising future in bioscience field.

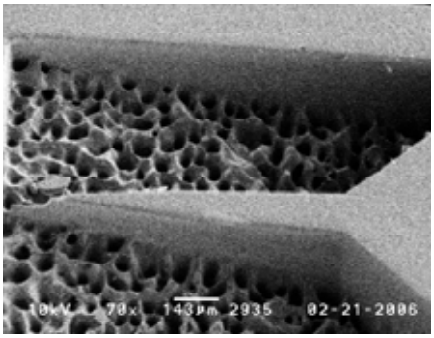

Fig.1PLLA micro structure with alkaline developer

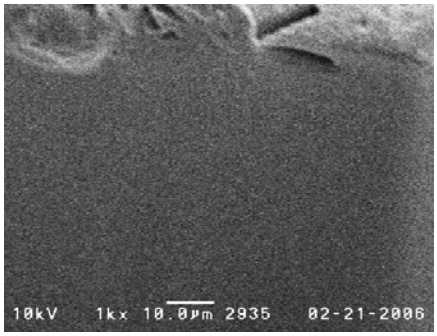

Fig.2 The enlarged sidewall of the Fig.1

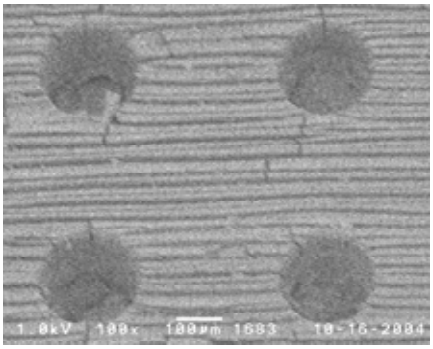

Fig.3 PLLA micro structures with GG developer

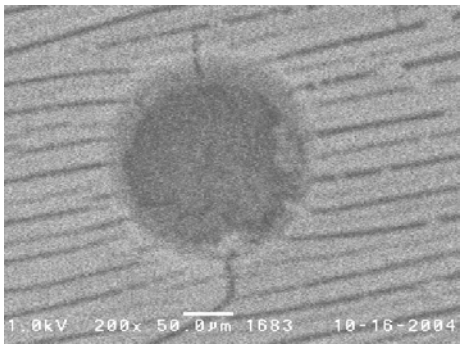

Fig.4 The enlarged sidewall of the Fig.3

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References

[1] A.Yamamoto et al, “Microfabrication of a biodegradable polymer by ion beam irradiation for a new co-culture system of cells” Euro. Cel. Mater. Vol. 6. Suppl. 1, pp.77, 2003.

[2] C.Konig et al, “Autosterilization of biodegradable implants by injection molding process” J.Biomed. Mater.Res.Vol.38(2),pp.115-119,1997.