Silicon Ridge Nanofabrication by Advanced Edge Lithography for Sub-10 nm NIL Applications

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Introduction

A new nanofabrication scheme is presented to form stamps useful in thermal nanoimprint lithography (T-NIL). The stamp is created in <110> single crystalline silicon using a full-wet etch-procedure including local oxidation of silicon (LOCOS) and employing an adapted edge lithography technique (detailed review of edge lithography can be found in reference [1]) on top of conventional photo-lithography. Ridges down to 10 nm in width have been produced. The silicon ridges have no inbuilt stress and are therefore less fragile than previously fabricated oxide ridges [2,3]. The ridge sample is used as a template in T-NIL and a full 100 mm wafer size imprint has been successfully carried out in both polymethylmethacrylate (PMMA) and mr-I 7010E polymer. Moreover, the imprinted pattern in PMMA is subsequently transferred into a device wafer.

Experimental

Si <110> wafer with 15 nm LPCVD SiN, (silicon rich nitride) and 80 nm TEOS annealed at 900°C for 1 hr in a N2 atmosphere tube.

Patterned by normal photolithography of 4 µm gratings. TEOS etching in 1%HF.

SiNx etching in 85% H3PO4 acid @180°C.

Si etching in OPD4262.

SiNx undercut etching in 85% H3PO4 acid @180°C.

TEOS removal in 1%HF. The substrate is dry oxidized at 950°C.

SiNx removal in 85% H3PO4 @180°C. Si etching in OPD4262.

SiO2 removed in 1%HF.

Si Nanoridges

Si nanoridge with a depth of 100 nm and width down to 10 nm. An ‘overview’ of Si nanoridges.

Nanoinprint

To facilitate demolding, before imprint, the wafer template is treated with 1H,1H,2H, 2H-perfluorodecyltri-chlorosilane from a gas phase under vacuum condition in a desiccator. The imprint process is performed onto a device wafer coated with an imprint polymer, both mr-I 7010E and PMMA, using an Obducat T-NIL machine.

Pattern Transfer

The grating pattern is transferred from PMMA into the silicon device wafer. The scallops are caused by the pulsed mode RIE procedure (SF6/C2F6) and can be reduced by proper tuning of the etch tool.

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References