Examples of nanoimprint lithography activities at Glasgow University

Glasgow has many years of experience in embossing and nanoimprint lithography. Early interests started within the Department of Electronics and Electrical Engineering through collaborative research projects with biologists and notably those in cell engineering. Nanoimprint lithography is now used for device fabrication with applications in ultrafast systems, biology and optics. The combination of high resolution electron beam lithography and comprehensive dry etching and deposition facilities allows us to fabricate three dimensional stamping tools. These are either used directly to pattern a range of polymers or are electroformed to produce nickel shims which are subsequently used in nanoimprint lithography or mould injection. Important considerations are the properties of the material being patterned, mould release methods, pattern aspect ratio, pattern uniformity as well as the pressure and temperature applied during imprinting. We hope the following images give some idea of the breadth of experience we have in this field.
Cell guidance on a polymer structure formed by embossing using a patterned nickel shim

A primary rat cell on a poly(carbonate) injection moulded replica.

Imprintd gratings on self assembled polystyrene for applications in optics
The upper image is 10 nm lines imprinted into nickel using a diamond stamp. The lower, lines are imprinted into nickel using a silicon carbide stamp.

The fabrication of antireflective surfaces using electroformed stamping tools. Quartz 3D structures are formed by RIE to give the desired sloped profiles – left image. These are electroformed to produce a nickel stamping tool which is subsequently used to emboss the polymer. (right)
The fabrication of silicon stamping tools to produce T shaped gates by nanoimprint lithography. Left, a T shape with an Al head and a Cr foot are fabricated and used as an RIE mask with SF$_6$ and CHF$_3$ to form the head. The Al is removed and the Cr foot acts as a mask for a further etch to form the foot.

Silicon stamping tool for the fabrication of T shaped gates with 50 nm footwidth

Working pHEMTs with peak transconductance of 480 mS/mm and $f_t$ of 75 GHz fabricated using nanoimprint lithography
The following work was carried out to study the flow of resist during imprinting. Substrates were first patterned with overlapping gratings orientated in both x and y directions. These were planarised and the substrates used for imprint trials. Optical microscopy, scanning electron microscopy and atomic force microscopy techniques were used to study grating deformation and resist flow resulting from different imprint conditions. We believe this information is useful for assessing the quality of imprint lithography and for imprint process optimisation.
The above shows:-
SEM images showing resist flow in cross sections of an imprinted substrate; imprinting was carried out at 140 °C for 60 s. (a) an unimprinted substrate showing the undeformed embedded grid; (b) the edge of a 10 μm square after imprinting; (c) an optical micrograph of the square shown in (b); (d) SEM images of the cross section around the square shown in (c) and aligned so the correspondence can be seen. Note the enlarged vertical scale.