Department of Materials Science and Engineering
Norwegian University of Science and Technology

TMT4320 Nanomaterials, fall 2015

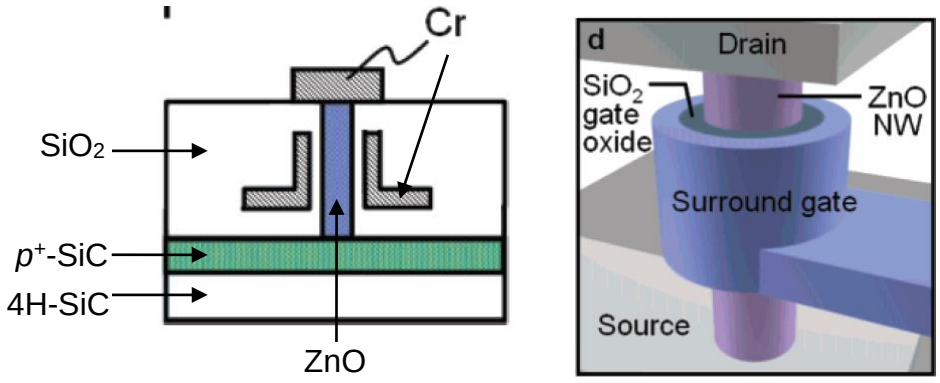
EXERCISE 12

Guidance: Wednesday 18th November, 18:15-20:00, H3
Due date: Friday 20th November, 14:00, boxes outside R7 or on It's learning

PROBLEM 1

To fabricate advanced nanostructures it is often necessary to combine several processing techniques in steps, to grow/deposit/etch successive layers and nanostructures.

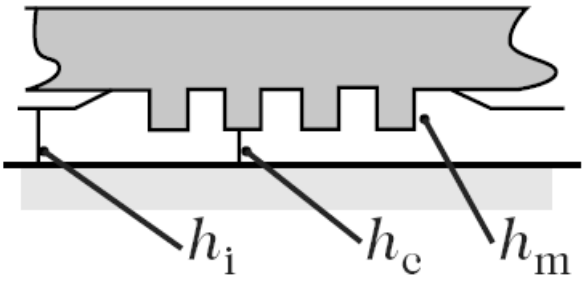
The figures below show a bottom-up integration of a semiconductor zinc oxide (ZnO) 1D nanowire to obtain a vertical surround-gate field-effect transistor (VSG-FET). The vertical device architecture has the potential for use in tera-level ultrahigh-density nanoscale memory and logic devices.



How would you proceed to fabricate such a one-nanowire structure if you start with a 4H-SiC substrate containing a p^+-SiC layer? Combine your knowledge of deposition techniques, lithography, etching, and 1D growth of ZnO, and suggest and draw a possible processing route with successive steps. In addition to the techniques described in the lectures you can use chemical mechanical polishing to accurately and uniformly polish the grown structures from the top.

PROBLEM 2

To obtain optimal imprint when using thermoplastic nanoimprint lithography the right relationship must be found between the depth h_m of the mould features, the initial thickness h_i of the polymer, and the residual thickness h_c of those features that have been cleared out (see figure below). The initial polymer thickness depends sensitively on the type of pattern to be imprinted.

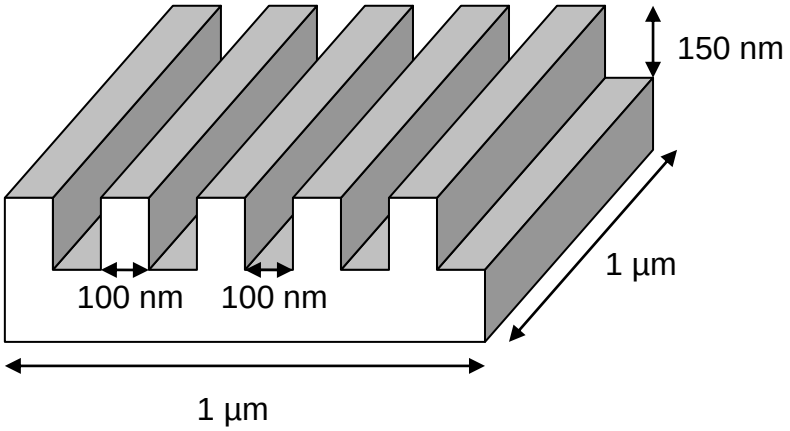


Neglecting the change in volume of the polymer, the conservation of matter in the case of periodic structures can be expressed by:

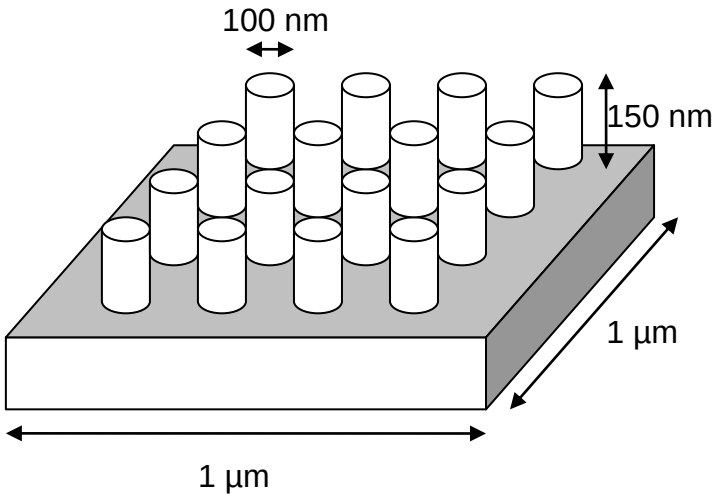
$$h_i = h_c + f \cdot h_m$$

Here the factor f is the ratio between the etched area of the mould and the total area of the mould, i.e., the etched proportion of the mould surface.

a) Calculate h_i if the stripe mould below is used and we want a residual thickness of the polymer film of 40 nm.



b) Calculate h_i if the whole mould below is used and we want a residual thickness of the polymer film of 40 nm. The cylinders have a perfectly circular cross-section.



PROBLEM 3

Below there are listed a number of abbreviations which are relevant to nanomaterials and nanotechnology and which we have used in this course. For each abbreviation, write out the full name.

CVD
RIE
FIB
VLS
AFM
EBL
SEM
fcc
SAM
PLD
MBE
TEM
hcp
CTAB
STM

PROBLEM 4

Explain briefly the following concepts, which have been covered in this course:

a) Reverse micelle

b) Stranski-Krastanov growth mode

c) Armchair carbon nanotube

d) Steric repulsion

e) Hydrothermal synthesis

f) Coordination number