Towards Atomic and Close-to-atomic Scale Manufacturing

Background

Human beings are witnessing the third stage of manufacturing, i.e. Manufacturing III, after the Manufacturing stages I and II. Manufacturing I focused on craft-based manufacturing, as in the Stone, Bronze, and Iron Ages, in which manufacturing precision was at the millimeter scale; Manufacturing II currently looks at the precision-controllable manufacturing using machinery where the material removal, migration, and addition scales are reduced from millimeters to micrometers, and even nanometers; Manufacturing III aims at manufacturing processes directly focused on atoms, spanning the macro- through the micro- to the nanoscale where manufacturing is based on removal, migration, and addition at the atomic scale, namely, atomic and close-to-atomic scale manufacturing (ACSM).

Industrial demands

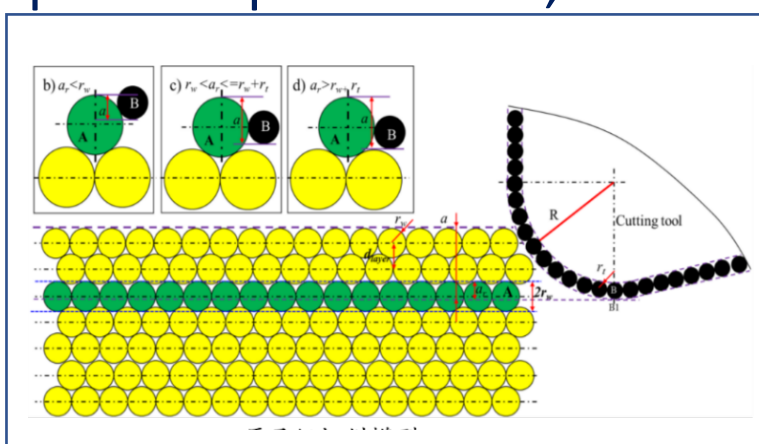
The renowned Moore's law is approaching its physical limit. Computer microprocessors, such as the recently announced A12 Bionic chip and Kirlin 980, use a 7nm manufacturing process with 6.9 billion transistors in a centimeter square chip. Such limits have been pushed to a 5nm and even a 3nm node, which represents a few tens of atoms. Hence, industrial demand involves a stable atomic scale manufacturing procedure to achieve a mass production of these devices.

New Method

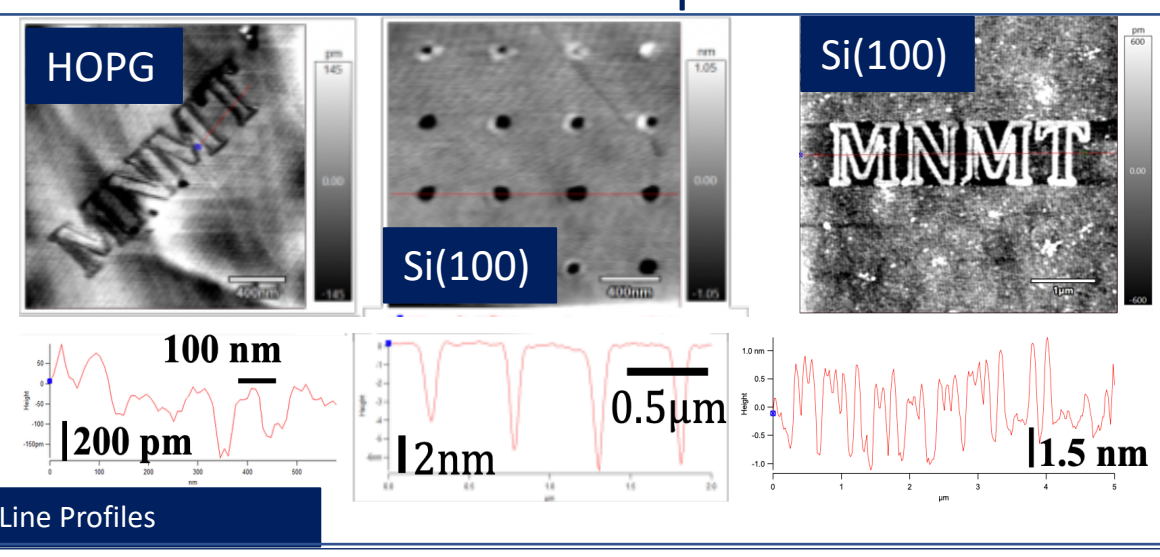
ACSM has a typical characteristic that the energy directly impacts on the atom to be removed, migrated, and added. ACSM as the next generation of manufacturing technology will be employed to build up atomic scale features for required function and performance with the capacity of mass production. Manufacturing with Atomic Cutting and Scanning Probe Microscopes have demonstrated capability for the operation of single atoms over silicon and HOPG.

Progress and results

Achieved depths of less than 0.34nm over HOPG and several nanometres over Si (100). Also, oxide deposit of ca. 1.5nm was obtained over silicon sample. It is also verified that atomic scale material removal is possible on HOPG and by finding optimum parameters, atomic layer removal from silicon samples can be attained.



Atomic scale cutting



Line Profiles

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