Scanning Probe Nanotechnology (SPN) Laboratory

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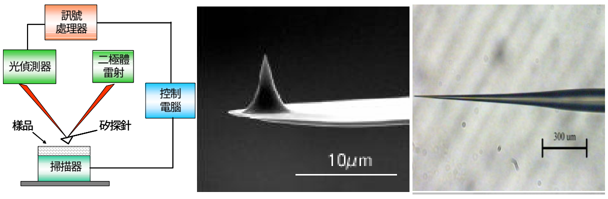
I. Nanocharacterization

Scanning Probe Microscopy (SPM)

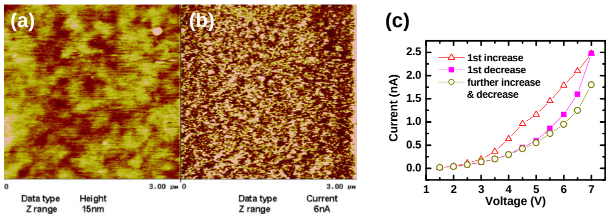
SPM is capable of measuring surface morphology with atomic resolution and able to characterize various surface properties such as mechanic, electric, magnetic, optical characteristics, etc., with nanoscale resolution. The major advantages of SPM include high resolution, instrumental compactness, and measurements in various environments. The main disadvantage is the lack of composition analysis.



(a) schematic diagram of SPM, (b) SEM image of an atomic force microscopy (AFM) probe, (c) optical image of a home-made scanning near-field optical microscopy (SNOM) fiber probe.

Optoelectronic Materials

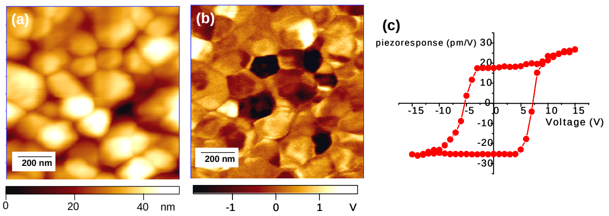
Conducting polymers have been the focus of extensive research activities recently. By applying a voltage between a metal-coated AFM tip and a polymer film, surface morphology and current images can be obtained simultaneously. In addition, charge transport behavior can also be deduced from local I-V curves.



(a) surface morphology and (b) local current image of an MEH-PPV film, and (c) local I-V curves.

Ferroelectric Materials

Ferroelectric thin films have gained much attention recently due to application in high density non-volatile memories. By applying an AC voltage between a metal-coated AFM tip and a film, surface morphology and remanent polarization images can be obtained simultaneously. In addition, nanoscale domains can be fabricated and local hysteresis curves can be measured by applying DC pulses.

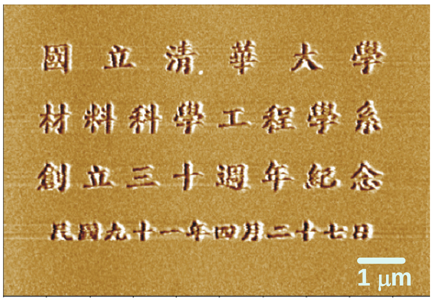


(a) surface morphology and (b) remanent polarization images of a BFO film, and (c) a local P-E curve.

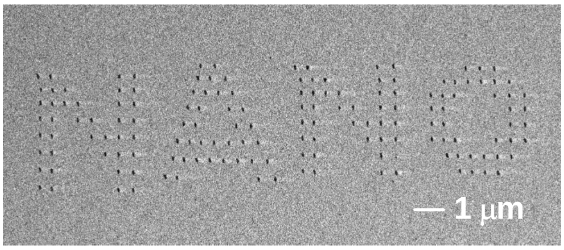
II. Nanolithography

Nanomachining

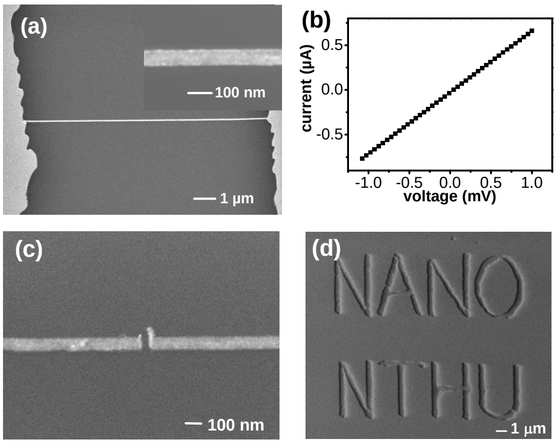
By using a large force between an AFM tip and a film, nanopatterns can be created on the film. By performing nanomachining on a PMMA film and subsequent lift-off process, fabrication of metal nanostructures can be realized with ease.



Chinese characters on a gold film with a smallest size of 0.5 × 0.5 μm^2. The smallest line width is 50 nm and the depth is 10 nm.



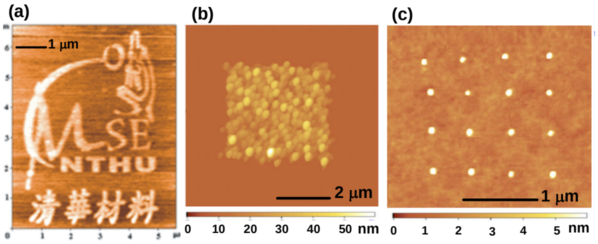
A gold nanodot pattern of the word "NANO".



(a) nanowire fabricated by AFM nanomachining and lift-off process, (b) I-V curve, (c) gold nanoelectrodes with a gap of 40 nm, (d) a gold nanopattern on sapphire.

Nano-oxidation

By applying a positive voltage bias to a substrate relative to an AFM tip, decomposition of water molecules under the tip occurs due to strong electric field. Decomposed ions facilitate local oxidation on the substrate and consequently the formation of oxide.

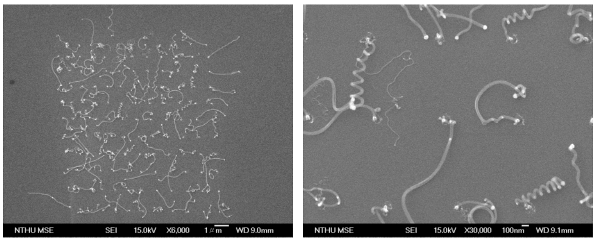


(a) a silicon oxide nanopattern, (b) a 4 × 4 μm^2 nickel oxide square, and (c) a nickel oxide nanodot array.

III. Nanomaterials

Silica Nanowires

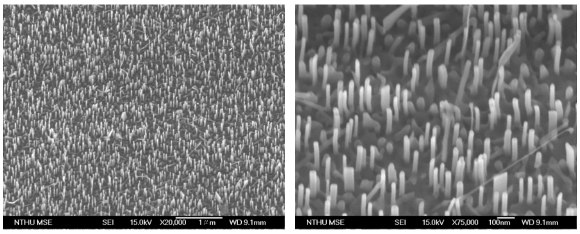
By using nickel as catalyst, silica nanowires can be created on silicon substrates by thermal annealing. Using nickel nanodots, selective growth of single silica nanowires can be accomplished.



Selective growth of single silica nanowires on nickel nanodots created by AFM nanomachining.

Zinc Oxide Nanowires

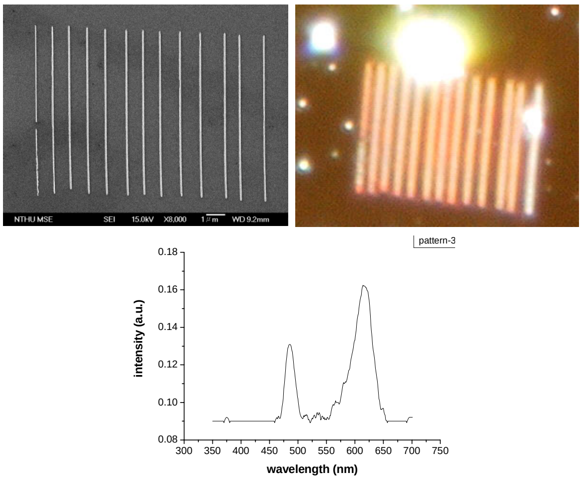
Zinc oxide nanowires can be grown on sapphire substrates by using gold as catalyst in a furnace that generates zinc vapor and flows it down to the substrate.



SEM images of ZnO nanowires on sapphire substrate

Metal Nanowires

Nanostructures of gold, silver, etc. have the effect of localized surface plasma resonance (LSPR) that can be used for biolabeling, biosensor and related biological detection.



SEM image of a gold nanowire array, LSPR image under an optical microscope, and the spectrum.