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Get Nano-information by Nano-pinhole in X-ray Holography

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It is well known that from the invention of Scanning-Tunneling-Microscopy (STM) by binning et al., the ero of nanotechnology is coming. Many members of Probe-Scanning-Microscopy family have obtained information of nanometer-resolution, the key of these successes lies in the usage of nano-probe as their detectors. In recent years, scientists contribute more and more interesting to the spectrum of x-ray, especially of the soft-x-ray (1-30nm). The move is driven particulary by the fact that biologists may hope to see a nearnative aqueous environment structural features.

If we focus x-ray energy by a fresnel lens onto a pinhole plane, then the diameter of the pinhole determines the lateral resolution of Non-Redundant holography (Stroke holography). So the difficulty in fabrication of fresnel lens now transfers to the problem of fabrication of a pinhole with nanometer radius. By the fabrication of a nano-pinhole we may hope to get nanometer-scale information in the x-ray region.

It is posible for us to get small pinhole, such as using taper hollow fiber as small hole, using e-beam of scanning electron microscope to fabricate this nano-pinhole, and shrinking the pinhole of thin film by electroplating, and so on. Here we put forward a new idea of nano-pinhole fabrication by STM system.

By appling voltage pulse between tip and substrate of STM system operated in constant current mode, leads to the transition of work station from tunneling to field emission. A factor of 10^2-10^3 increase in current between tip and substrate may occur in some typical experiments, and high-field strength (~1GV/m) may be achieved. Furthermore, the close proximity of tip and substrate adds some additional effects as exchange correlation and screening, which must be considered in the explanation of fabrication mechanism. Due to these characteristics high current with nanometer spatial resolution, high field between nanometer gap between tip and substrate, close proximity of tip and substrate of STM system, we conclude some methods and mechanisms in nano-fabrication as below:

NANOMETER-SCALE EXPLOSIVE THERMAL MELTING

A sudden burst of tunneling current (due to an instantaneous increase in bias voltage) from a STM operated in the constant-current mode. The high current density of injected electrons localized to a small region of substrate by the STM tip gives rise to an explosive event which may be reponsible for the electro-etching of substrate or thermal melting of substrate in nano-region.

FIELD-INDUCED ATOMIC EMISSION

If we position the tip of STM within nanometers of a substrate, high-field strength can be achieved with substantially lower voltage for the small gap between tip and substrate. Furthermore, the close proximity of tip and substrate causes overlap of atomic potencials, which can lead to a lowering of the energy barrier for field evaporation. By using tungsten as tip in gold substrate (the threshold for field evaporation is significantly lower in gold than in tungsten, 3.5V/A in FIM experiments for gold versus 5.7V/A for tungsten). One would expect some of gold removed from the substrate to be transferred to the tip.

STM ELECTRON BEAM EXPLOSURE

In classical electron beam fabrication the high-energy (~10KeV) electron beam causes an im-

portant scattering of the electrons in the resist layer as well as in the substrate, which leads to a lowing in resolution of fabrication beam. This proximity effect can be avoided when a low-energy (~10eV, but energetic enougy to cause bond scission in resist such as PMMA) electron beam leaving the STM tip is used for the explosure. After explosure and development a mask with a nano-pinhole is achived, then by reactive ion eching below substrate of anisotropical material, this leading to a bigger hole in substrate, and by metaling the hole from the back side of substrate, causing the shrinking of hole in substrate. In this way we would expect to fabricate a pinhole whose diameter is determined by that in mask.

All methods that can be used to obtain nano-information may also can be used as a method in nano-fabrication, for they are the two aspects of one problem. So we put forward the idea of nano-fabrication by STM system. Because nano-fabrication and imaging can be done in the same device, it is convenient for hole location and likely to solve the problem of nano-pinhole fabrication. By focusing x-ray energy onto this nano-pinhole to form point source in Non-Redundant holography we may envision to get nano-information in the x-ray region.

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