Advanced Ion Microscopy Focus Topic
Room: Central Hall - Session HI-ThP

Advances in Ion Microscopy Poster Session

HI-ThP1 Sub-10 nm Width High Aspect Ratio Trench Patterning of Gold Film using Helium Ion Microscope, ***Etsuo Maeda***, The University of Tokyo, Japan, *T. Iijima*, National Institute of Advanced Industrial Science and Technology (AIST), Japan, *R. Kometani*, The University of Tokyo, Japan, *S. Migita*, *S. Ogawa*, National Institute of Advanced Industrial Science and Technology (AIST), Japan

The helium ion microscope (HIM) realized the sub-nm level imaging with helium (He) ion beam from single tungsten atom on the top of the trimer. There are numbers of study focusing on nanostructure imaging, for example carbon nanotubes, graphene films, and self-assembled monofilms [1-3]. Through these previous studies, the advantages of HIM for imaging with high resolution and high contrast have been proved.

In our work, an HIM (Carl Zeiss ORION PLUS at AIST SCR station) was applied for sub-10 nm He ion beam etching to realize nano-gap trenches of high aspect ratio for the high sensitive surface enhanced Raman scattering (SERS) devices consisted by gold (Au) structures. To reveal the penetration depth of the He ions into the Au film with 30 kV acceleration voltage, two-body collision calculation was performed [4]. As the results of the calculation, the expected penetration depth was decided as 200 nm. Following the penetration depth results, Au films were prepared (70, 160, and 700-nm-thick) on 500-nm-thick silicon dioxide (SiO_2) layer. After a focused He ion beam irradiation (10^{20} ions/cm^2, acceleration voltage: 30kV, beam current: 2.5 pA), a cross section shape was evaluated with Z-contrast transmission electron microscopic (TEM) images.

In case of thin films (70 and 160-nm-thick), funnel shapes from beam profile were observed. The dimension of the funnel shape was ~40 nm as width and ~35 nm as depth. The narrowest gap size was 5.5 nm for 70-nm-thick Au film and 1.4 nm for 160-nm-thick Au film. The lowest estimated aspect ratio of the nano-gap trench was 24.0 with 160-nm-tchik Au film. Moreover, observed Au atom penetration depth of 160-nm-thick Au film was 20% lager than that of 70-nm-thick Au film. With 70-nm-thick Au film, the fabricated narrow gap was destroyed by recoiled He ions from an interface between the Au film and SiO_2 layer.

Unlike the thin Au films, a thick Au film (700-nm-thick) showed blistered shape in the middle of the film as expected. The fissures in the thick Au film could be related to the blistering phenomena as seen in the Si substrate. He ions which could not path through thick Au film might be gasified in the thick Au film. For the purpose of realizing the nano-gap trenches for SERS devices, we need more structural and morphological characterization to suppress these blistering phenomena.

[1] C. Zhao et al., Nanoscale, 7, 18239-18249, 2015.

[2] Y. Naitou et al., Appl. Phys. Lett., 106, 033103, 2016.

[3] A. Beyer et al., Beilstein J. Nanotechnol., 6, 1712-1720, 2015.

[4] J. F. Ziegler et al., Nucl. Inst. Methods Phys. Res. B, 268, 1818, 2010.

HI-ThP2 Optimized *ex situ* Lift Out of FIB Prepared Specimens, ***Lucille Giannuzzi***, EXpressLO LLC

Focused ion beam (FIB) microscopes may be used to prepare site specific lift out specimens for subsequent characterization by transmission electron microscopy, surface science, or other analytical techniques [1-3]. *ex situ* lift out (EXLO) exploits the physics of adhesion forces for picking up a specimen with a solid probe tip and placing or manipulating it to a suitable carrier [1-3]. In this presentation, techniques for fast, easy, and successful lift out and manipulation reproducibility rates are described. Once the specimen is lifted out to the probe, the probe can be rotated to position the specimen either on top of, or under the probe, depending on the type of carrier to be used. In addition, since the specimen is not rigidly fixed to the probe, the specimen orientation can be rotated about the probe using the carrier itself, for precise positioning in just a couple of minutes. Precise orientation of the specimen with respect to the probe provides the greatest success rates, reliability, and throughput of the manipulation process. These and other methods will be fully described and presented.

References:

[1] L.A. Giannuzzi et al., Mat. Res. Soc. Symp. Proc. Vol. 480 (1997), MRS, 19-27.

[2] L.A. Giannuzzi and F.A. Stevie (eds.) Introduction to Focused Ion Beams, (2005) Springer.

[3] L.A. Giannuzzi et al., *Microsc. Microanal.*, 21, 1034–1048, (2015).

Authors Index

Bold page numbers indicate the presenter