Helium ion microscopy (HIM) for imaging fine line features patterned organic film with less damage

AIST [1], NISSAN CHEMICAL INDUSTRIES[2]

◦Shinichi Ogawa[1], Tomoya Ohashi[2], Shigeki Oyama[2], Yuki Usui[2]

E-mail: **ogawa.shinichi@aist.go.jp**

Acrylic organic films of 100 nm thick were spin coated on Si substrates, and then helium ion or electron beam was irradiated at a dose of $2X10^{15}$ at 30 kV and $1x10^{17}/cm^2$ at 0.7 kV of their adequate observation conditions, respectively. Morphological and structural changes after the beam irradiations were characterized by AFM, IR, Raman, and TOF-SIMS. Although the helium beam energy is higher, the combination of the lower helium ion current and the longer range of the ions means that the power density to the organic materials is nearly a factor of 10^3 lower with the 30 keV helium ion beam than it is with the 0.7 keV electron beam [1]. From this interpretation, one might therefore expect the materials to shrink less and be less damaged during HIM imaging than during SEM imaging. Question is “Is it true?”.

The AFM showed c.a. 35 nm decrease (shrink) in the film thickness by the electrons, while c.a. 30 nm by the helium ions case. It indicated the electrons might damage heavily than the helium ions. An IR showed larger signal intensity decrease with less peak broadening and OH system remained in a case of the electrons, while OH system was completely destroyed in a case of the helium ions as shown in Fig. 1. Raman showed more amorphous carbon in the helium ions irradiated film, which was probably formed by destruction of CH system. Those results mean that helium ions irradiations brought about less surface morphological transformation while it resulted in larger chemical damage in a deeper region of the film than the electron irradiations. This phenomenon is probably because heavier helium ions with higher energy came into deeper than electrons to the organic film cutting chains of the organic material with amorphous. TOF-SIMS showed the similar results for larger decrease of signal intensities of CH and CHO systems by the electron irradiation. Those results mean there were a lot of trade-off between irradiations of helium ions and electrons. Based on the above results with optimization, cross sections of filling of the organic materials into trenches were imaged by the HIM and SEM as shown in Fig.2. As described, helium ions damaged the organic materials heavier in depth direction than electrons, while it kept original surface morphology with less transformation or shrink, so imaging of the filled organic materials into trenches by the HIM presumably shows more realistic than the SEM imaging.

S. Ogawa would like to thank T. Kishioka from NISSAN CHEMICAL INDUSTRIES, LTD. for his fruitful discussions, and T. Iijima and Y. Morita for the usage of the HIM at AIST SCR Station.

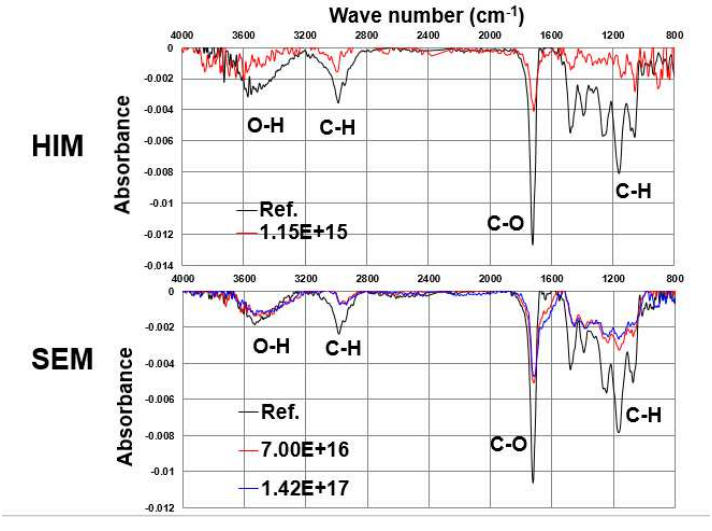
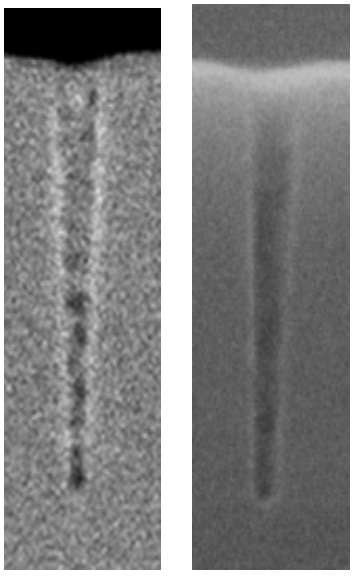


Fig.1 FTIR spectra from the helium ions (HIM) and electrons (SEM) irradiated acrylic organic films.



(a) (b)

Fig.2 Cross section images of filling of the organic materials into trenches by the (a) SEM and (b) HIM. Voids in (a) might be generated during the SEM observation.

Reference:

[1] S. Ogawa, W. Thompson, L. Stern, L. Scipioi, J. Notte, L. Farkas, L. Barriss: “Helium ion secondary electron mode microscopy for interconnect material imaging”, Jpn. J. Appl. Phys. 49 04DB12 (2010)