Electronic Structure Mapping on Patterned Carbon Nanotube by Scanning Photoelectron Microscopy

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The variety in the physical properties, such as the metallic or semiconducting behaviors, of the carbon nanotube (CNT) has attracted much attention recently. In the field of application, the high density of states at the tip is supposed to be useful for efficient field emission. In this work, we demonstrate how to control the topography of CNT by laser and explore the corresponding characters by scanning photoelectron microscopy (SPEM) at NSRRC 09A1 beam line.

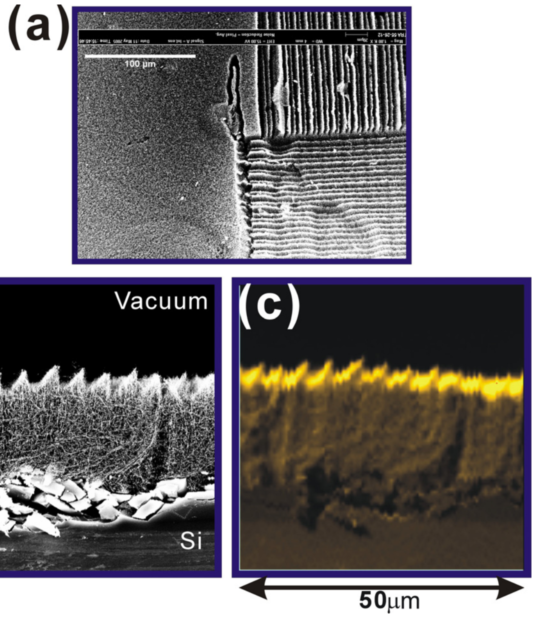

Figure 1. (a) is the original and modified area of CNTs taken by SEM. (b) and (c) are the cross-sectional modified CNTs part of SEM and SPEM image.

With the help of scanning electron microscopy (SEM), the detailed topography of modified CNT is connected to the electronic mapping obtained by SPEM in Fig. 1. Meanwhile, we can identify the different electronic structure, chemical shift and valence band below the Fermi level at various position created by laser.

In Fig. 2(a) and 2(b), the carbon 1s spectrum along the Y-axis line profile of SPEM image can be divided into three parts by laser influence. Furthermore, the binding energy of influence area at interface is higher than at sidewall. There exist a huge chemical shift ~ 1 eV larger than the related articles which own the slight chemical shift between the tip and sidewall of CNT.

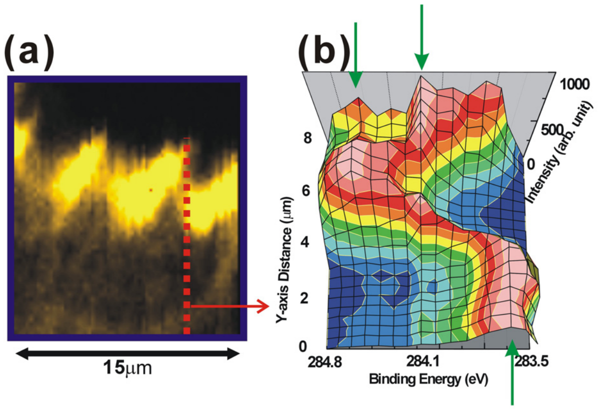

Figure 2. (a) is the cross-sectional SPEM image and (b) is the opposite line profile spectrum. The obvious chemical shift ~ 1 eV is observed between the modified area and sidewall area in (a).

Additional, the valence band of the varied position in Fig. 3 indicates the alterable carbon bonds with the acceptable laser amount. The magic phenomenon originates from the transition between σ and π bond since σ bond increases with the decreasing of π bond in Fig. 3(b).

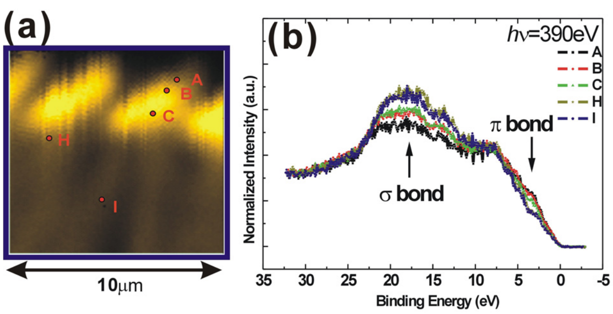

Figure 3: Based on (a) SPEM image, (b) valence bands measured at different point in the modified CNTs present the transition between σ and π bond.

The possible reasons might be the absorption gas effect or/and the reconstruction effect due to laser enhancement. Because the modified area is about 2 ~ 3 μm depth, the result of laser method could be bring the new generation of CNT application.