Understanding of Sulfonated Graphene and Nafion Hybrid Proton Exchange Membrane by Atomic Force Microscopy

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Proton exchange membrane (PEM), which is the heart of proton exchange membrane fuel cell (PEMFC) has several important roles such as imposing proton conduction, gas separation, and electrical insulation for anode and cathode. For PEM, the Nafion is most widely used because it has an excellent proton conductivity, mechanical, thermal, and chemical stability. However, it has a several limitation for application such as always requiring a high relative humidity environment and decreasing mechanical strength and conductivity close to the glass transition temperature of Nafion. Therefore, many inorganic material/Nafion hybridizations are tried for overcoming the intrinsic weakness of Nafion [1, 2].

One of the biggest issues for using inorganic material/Nafion is to enhance thermal and mechanical capability even in low humidity operation condition. One of good candidate of inorganic material/Nafion hybrid membrane is sulfonated graphene/Nafion. Because the sulfonated graphene (S-graphene) is the excellent H_2O absorber; so, it can work properly under the low relative humidity envornment.

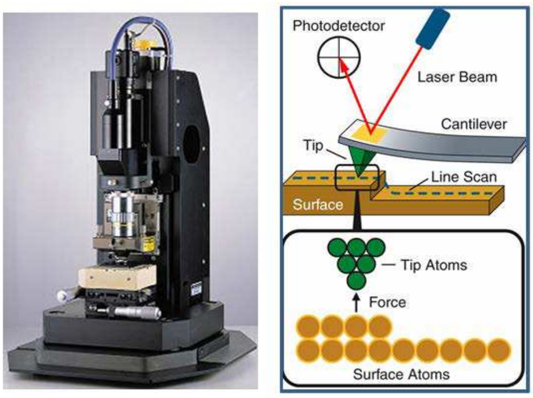

Figure 1. AFM module appearance and its operating principle in a schematic view

Experimental Approach

In the S-graphene/Nafion hybrid membrane the ionic channel distribution variation under morphological change is key for understanding hybrid membrane. For this study, atomic force microscopy (AFM) is crucial. The basic principle of AFM is well illustrated at figure 1. AFM can map the morphological structure as nano sized spacial resolution. PSIA NX-10 AFM is utilixed in this study. The imaging was done as contact mode and the DLC coated ultra-sharp silicon tip was used. The tip radius is around 20nm and spring constant of the tip is 40 N/m.

The topographies of two different membranes significantly show morphological evolution on the membrane before (figure 1(a)) and after (figure 1(b)) sulfonation of graphene mixed to Nafion. Figure 1(a) shows detailed structure of the pristine Nafion sample with many spikes distributed over the membrane, which ranges approximately from 1nm to 4nm height and from 100 nm to 200 nm width. S-graphene-Nafion composite membrane (figure 1(b)) shows entirely different surface structure compared with the pristine Nafion. It shows huge protrusions which has 80nm height at left and right side on the membrane. Also, it shows deep subsidence at the top center on the membrane.

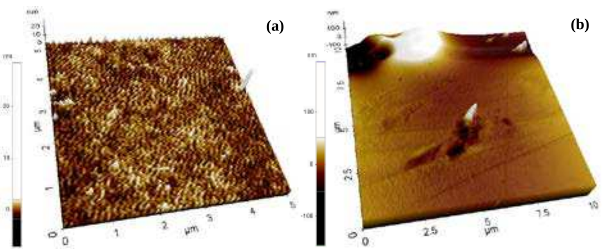

Figure 2. Morphological differences between (a) Nafion and (b) S-Graphene/Nafion membranes

References

1. N. Miyake, J. S. Wainright and R. F. Savinell, *J. Electrochem. Soc.*, 2001, **148**, A898.
2. S. P. Tung and B. J. Hwang, *Fuel Cells*, 2007, **7**, 32.