Impedance Analysis of Conducting-Bridge Random Access Memory

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The elucidation of switching mechanism is crucial to optimize the performance of conducting-bridge random access memory (CB-RAM). Recently, it was reported that water strongly affected the resistive switching characteristics [1,2]. On the other hand, the impedance method is effective in obtaining parameters related to ion migration, and is applied to, for instance, the investigation of Li transfer in Li ion batteries [3]. In this paper, we applied the impedance method to a Cu/HfO$_2$/Pt structure. The effect of water supply on parameters related to ion migration was investigated. The effect of water to Cu/HfO$_2$/Pt on $I$-$V$ characteristics was measured by dropping a small amount of ultrapure water on the surface of a HfO$_2$/Pt structure with a dropper and contacting the HfO$_2$ surface with the Cu-probe through the dropped water. Figure 1 shows $I$-$V$ characteristics measured with and without water supply. Both the initial resistance and the forming voltage decreased by water supply, and their further decrease with time after water supply were confirmed. Figure 2 displays the Nyquist plots of the impedance spectra of pristine Cu/HfO$_2$/Pt before and after water supply. The transition from the 45-degree lines to the semicircles with increasing frequency suggests that both ion migration and charge transfer at the electrode/HfO$_2$ interface are dominant at low frequency, whereas charge transfer is dominant at high frequency. The crossover $\omega$ decreased with time after water supply. This result means that ion migration is enhanced by absorption of water into the HfO$_2$ layer. [1] Tsuruoka et al., Adv. Funct. Mater. 22, 70 (2012). [2] Hasegawa et al., ECS Trans., in press [3] Itagaki et al., J. Power Sources 148, 78 (2005).

\begin{figure}[h]
\centering
\includegraphics[width=0.4\textwidth]{fig1.png}
\caption{$I$-$V$ characteristics of forming processes w/ and w/o water supply.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.4\textwidth]{fig2.png}
\caption{Time dependence of impedance spectra of a pristine Cu/HfO$_2$/Pt after water supply.}
\end{figure}