Simultaneous Electrochemical Formation of Valve Metal Oxide / Conducting Polymer Bilayered Films

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A thin layers of semiconductor junctions based on an inorganic metal oxides and a organic conducting polymers are studied and applied in most importantly in the field of electrolytic capacitors with low ESR and high frequency characterisctics (Fig.1). We have already demonstrated a novel electrochemical method which enables to form the following three layers of thin semiconductor junctions instantly and simultaneously [1), 2)]. The three layers refer to valve metals (Al, Ta, Nb, Hf, W) as under layer, metal oxides (Al_2O_3, Ta_2O_5, Nb_2O_5, HfO_2, WO_3) in middle, and a polypyrrole film at a top layer. Such layers were found to be formed simply by electro-oxidizing the respective metals in aqueous solution (Fig. 2) only in the presence of sulfonate-based surfactants as electrolytes.

In this presentation we will focus on Nb. We have investigated the growth of oxide (Nb_2O_5) on a Nb substrate and that of a polypyrrole layer on a Nb_2O_5 in aqueous solution containing sodium dodecylbenzenesulfonate. Their semiconductor property was also studied as a function of the thickness or the charges consumed during electrolysis. During the course of electrolysis, there observed three distinctly different slopes in anodization curves: at each regime the band structures of the bilayered film are proposed (Fig.3).

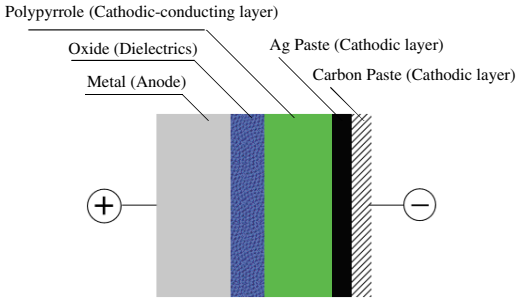

Figure 1 A Structure of solid electrolytic capacitor using the simultaneously formed oxide / polypyrrole film.

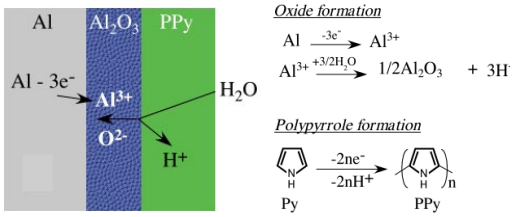

Figure 2 Simultaneous electrochemical formation of bilayered aluminum oxide / polypyrrole film.

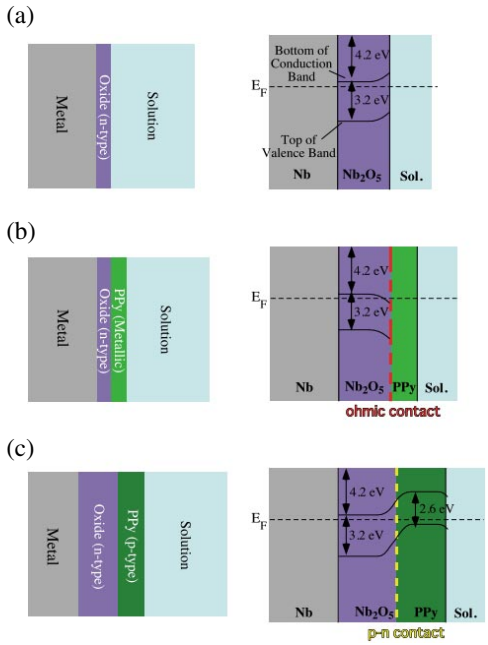

Figure 3 A mechanism for simultaneous electrochemical formation of bilayered Nb_2O_5 / polypyrrole films in various growth step. (a) Step I (0~8 mC cm^{-2}), (b) Step II (8~70 mC cm^{-2}), (c) Step III (>70 mC cm^{-2}).

Reference

1). K. Naoi, Y. Oura, A. Toshizawa, M. Takeda, and M. Ue, *Electrochemical and Solid-State Letters*, **1**, 34 (1998).

2). K. Naoi, A. Shimada, and K. Machida, *Electrochemistry*, **6**, 278 (2001).