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 characteristics (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 (Al₂O₃, Ta₂O₅, Nb₂O₅, HfO₂, WO₃) 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 (Nb₂O₅) on a Nb substrate and that of a polypyrrole layer on a Nb₂O₅ 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).

Reference


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 Nb₂O₅ / 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).