UNIVERSITI TEKNOLOGI MARA

ENHANCEMENT OF TA_2O_5 NANOSTRUCTURES PROPERTIES VIA ELECTROCHEMICAL ANODIZATION SYNTHESIS METHOD AND SURFACE MODIFICATION WITH GOLD NANOPARTICLES FOR HUMIDITY SENSING APPLICATION

NUR LILI SURAYA
BINTI NGADIMAN

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ABSTRACT

Nanostructured metal oxide have been widely employed in electronic devices as sensing layer. One of the most crucial issue in nanostructure fabrication is to optimize the synthesis method in order to produce high sensitivity and reliable sensor. Due to this issue, a synthesis method with high potential to produce metal oxide nanostructures on tantalum foil substrate, namely anodization, is highlighted in this study and surface modification using doped gold nanoparticles is also implemented to improve the characteristics of the nanostructured sensing layer. A set of parameter has been optimized to synthesis Tantalum Pentoxide (Ta_2O_5) via anodization synthesis method. Anodization is one of the simplest synthesis methods for fabricating generous nanostructures metal oxide. The purpose of this study is to optimize the anodization time and voltage of Ta_2O_5, employ the optimized Ta_2O_5 as humidity sensor and improve the functionality through doping method. The significant growth of anodized Ta_2O_5 nanotubes has increased the number of pore structures and offered more water absorption active sites for humidity sensing detection. Physical and chemical properties of anodized Ta_2O_5 nanotubes were justified using FESEM, XRD, EDX, AFM and UV-VIS analysis. Synthesizing nanostructures through anodization method producing Ta_2O_5 nanotubes with pore diameter ranging between 10 to 50 nm. From XRD analysis, cubic crystalline structure was obtained through annealing at 500 °C for 2 hours, thus improved its crystalline structure and generated a favourable medium of interaction. Then, further surface modification of Ta_2O_5 has been conducted by doping with gold nanoparticles. All fabricated sensors were tested for humidity detection in the range of 40%–90% humidity level to evaluate their response time, repeatability, hysteresis and sensitivity. This study has elucidated the relationship of anodizing time at optimum anodization voltage during nanostructure construction towards the variation of current output in humidity sensing due to the availability of oxygen vacancies and active sites as an effort to improve humidity sensing. Longer anodization times produced nanostructures with improved adsorption of H^+ ions and linear sensitivity. The Ta_2O_5 nanotubes-based humidity sensor possessed good response time as well as consistent stability and repeatability in long exposure of the test environments. The anodized 60 min sensor operates at 10 V bias voltage shows the most promising performance of humidity sensor with 32.7 nA/%RH of sensitivity, This is due to the presence of high density of pore distribution on the sensors's surface. Hence, anodization is a reliable method to create nanostructures of Ta_2O_5 and enhance the physical and chemical properties to improve H^+ molecules adsorption on the Ta_2O_5 surface. Different concentration of gold nanoparticles (0.12 mM to 0.63 mM) were doped into the Ta_2O_5 nanotubes to act as a catalyst and enhance the functionality of the humidity sensor. According to the characterization results, 0.25 mM gold nanoparticles causes the Ta_2O_5 nanotubes based humidity sensor to produce the best performance. This is expected to occur because the optimum distribution of gold nanoparticles present on the Ta_2O_5 surface enhances the chemisorption and physisorption process which shorters the response and recovery time of the humidity sensor operation.

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