UNIVERSITI TEKNOLOGI MARA

FABRICATION AND CHARACTERIZATION OF POROUS SILICON BY TWO-STEP ANODIZATION USING ALTERNATING CURRENT PHOTO-ASSISTED ELECTROCHEMICAL (ACPEC) ETCHING

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Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science
(Electrical Engineering)

College of Engineering

July 2022

ABSTRACT

There are several reliable etching techniques to produce a uniform porous silicon (Si) structure on the semiconductor. Wet etching technique that is commonly used such as metal-assisted electroless etching and direct current photoelectrochemical (DCPEC) etching techniques often produced a non-uniform porous structure. While alternating current photoelectrochemical (ACPEC) etching technique produced a high porosity distribution of porous Si but with shallow pores. Consequently, to further enhance the porous Si structures and properties, a new etching technique, which is a two-step alternating current photo-assisted electrochemical (two-step ACPEC) etching technique was introduced in this research work. In the first step, the Si sample was left immersed in the electrolyte for a few minutes. Then, in the second step, the ACPEC technique was applied. Therefore, this research aims to synthesize the porous structure of porous Si using the two-step ACPEC technique and characterize its structural properties under different etching parameters. The work of this research was divided into three objectives: the formation of porous Si using different etching techniques, crystal orientations, etching durations, and current densities. In the first objective, porous Si samples were etched using DCPEC, ACPEC, and two-step ACPEC etching techniques. The porous Si sample etched using two-step ACPEC etching had the highest pore density and porosity, higher surface roughness in root mean square (RMS), and improvement in the uniformity of pores compared to the other two techniques. This showed that the two-step ACPEC technique improved the structural properties of the porous Si compared to the other two techniques. Therefore, the two-step ACPEC etching technique was used to further study the properties of porous Si in the next objectives. For the second objective, two different crystal orientations of Si, namely Si n(100) and Si n(111), were used to synthesize porous Si using the two-step ACPEC technique. The pores formed on porous Si n(100) consist of a mix of crisscross-shaped and a few square-shaped pores while porous Si n(111) exhibited irregular-shaped pores. On top of that, porous Si n(100) exhibited higher pore density and surface roughness than porous Si n(111). This showed that different crystal orientations of Si affected the properties of porous structures. Then, the Si n(100) was used in the next objectives. In the third objective, porous Si was etched at different etching durations. Porous Si etched for 30 minutes exhibited the highest average pore diameter (429.69 nm), porosity (26.99%), surface roughness in RMS (44.50 nm), pore depth (42.94 nm), and pore density out of all the samples. The Raman spectra result showed an improvement in surface area to volume ratio for all of the porous Si samples compared to the as-grown Si. Hence, it could be inferred that different etching duration affected the formation of pores on porous Si structures and the optimized etching duration obtained from this work was 30 minutes. For the next etching parameter, porous Si samples were etched using the two-step ACPEC etching technique at different current densities. The results showed that as the current density increased, the estimated porosity, pore density, average pore depth and surface roughness value in RMS increased. However, when the current density exceeded above 20 mA/cm^2, the estimated porosity decreased significantly along with the average pore depth and surface roughness value in RMS. Therefore, it could be concluded that different current densities strongly affected the porous Si structures. Generally, the research outcomes from all these works show different morphologies can be obtained and altered by the potential of porous Si by varying different etching parameters which are eventually suitable for sensing devices.

ACKNOWLEDGEMENT

Foremost, I would like to express my gratefulness to Allah S.W.T for giving me this chance and strength to complete my Master. I would also like to express my deepest gratitude to my supervisor, Dr Rosfariza Radzali, and my co-supervisors, Dr Alhan Farhanah Abd Rahim, and Dr Puteri Sarah Mohamad Saad, for their full support, expert guidance, understanding, and encouragement throughout my research. Without their incredible patience and counsel, this thesis would not be completed. All the assistance from them is deeply appreciated.

I would also like to take this opportunity to thank all the team members, postgraduate students, laboratory staff from Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang, and NOR Universiti Sains Malaysia (USM).

My greatest appreciation to all my close friends who have been with me, encouraging me and providing me with ideas and suggestions throughout my Master's journey.

My thanks to all personnel that was involved in helping me complete this thesis of study be it directly or indirectly.

Finally, this thesis is dedicated to my parents and family for their unconditional love and support in completing my study. Alhamdulillah.

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