Development of Urine Monitoring Sensor Module with Wireless Transmission Function

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***Abstract*— In modern society, there is an increasing focus on health monitoring, particularly in terms of urine detection for newborns and the elderly. While some researchers have developed local urine testing systems, a comprehensive urine monitoring system is still lacking. We have developed an ultrathin urine sensor electrode with a smart measurement and transmission system for health monitoring. The urine monitoring sensor system is extremely compact and features a user-friendly interface, ensuring a positive user experience. The measurement results demonstrate that the sensor, which utilizes multi-channel electrodes, has the potential to measure urination time and pattern. We believe that the practical application of urine sensors will benefit a wide range of individuals.**

Keywords- Urine monitoring; multi-channel electrodes; health condition; user interface; wireless transmission.

I. INTRODUCTION

With the increasingly serious challenges presented by an aging society, highly effective and low-cost health detection technology for both the elderly and newborns has become a significant research focus [1][2]. As researchers in the development of smart sensors, it is imperative to contribute efforts to address the aforementioned societal issues positively. We have developed a rapid manufacturing platform for fabricating the sensing electrodes, allowing the production of flexible, thin urine monitoring sensors on uneven surfaces through non-contact injection technology [3]. However, the complexity and high cost of this fabrication method restrict its large-scale application.

The sensor electrode manufacturing process described in this study adopts the direct printed electrode method, which is highly suitable for relatively flat surfaces and significantly reduces costs, thereby expanding its potential usability. In this study, we aim to discuss the extension applications of the given sensor in health monitoring fields. The composition of the sensor measurement and transmission system is introduced. Preliminary evaluations of the sensor system with multi-channel electrodes are also presented. Figure 1 shows the schematic view of our proposed urine sensor measurement system and its potential applications. The sensor system integrates the sensing and wireless transmission system (see Figure 1(a)) with an electrode array (see Figure 1(b)). Additionally, the authors have developed a User-friendly Interface (UI) application on the terminal tablet. The proposed UI (see Figure 1(c)) can display a line graph for each sensor electrode output value in the array, and a matrix diagram can also be presented for easy observation. The potential applications of the provided urine sensor are introduced, where the compact sensing system unit can be affixed to a nappy or a diaper, enabling real-time monitoring of the health conditions of children or elderly individuals. The ultra-small, low-power wireless sensor node can also be placed on a mat to measure the urine condition of pets. In Section 2, we will outline the characteristics of the sensor electrodes and system. Section 3 will present some preliminary measurement results. Lastly, in Section 4, the conclusion will be provided.

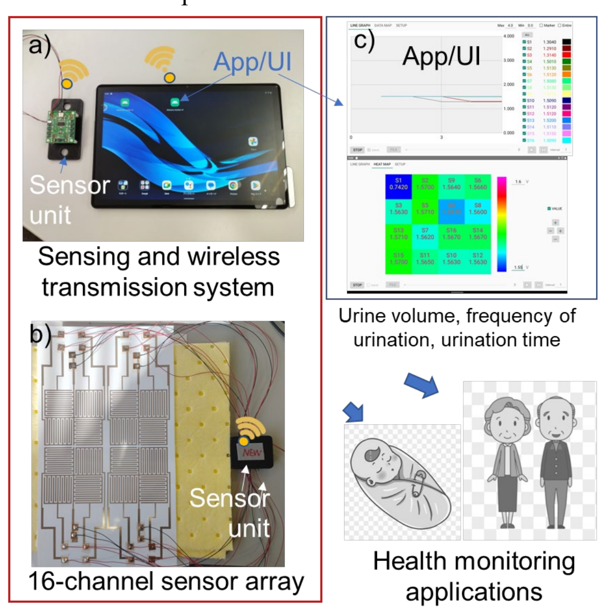

Figure 1. Wireless urine sensor system and its potential applications. (a and b) show the hardware of the sensor system, while (c) illustrates the software of the user interface.

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II. Sensor Fabrication and Specification

We developed a rapid manufacturing platform for creating urine sensor electrodes [3]. This platform facilitated the production of flexible, thin urine detection sensors on uneven surfaces. However, the fabrication complexity and high cost of this process limited its large-scale application. In this study, we adopted a direct printing method on the substrate, offering the benefits of low-cost and high-efficiency fabrication. Using an inkjet printer (PX-S160T, Epson Ltd.), the conductive solution was directly printed on photo paper to form the sensor electrodes with the desired pattern. Once the sensor electrodes and extension circuits were generated, a laminate film was coated to protect the electrode surfaces, ensuring a long lifetime and resistance to scratches and other damages. Furthermore, we designed and manufactured testing circuits and a measurement board specifically for the fabricated sensor electrodes. Resulting the given sensor can detect urine time and pattern for the measured objects.

III. Preliminary Measurement Results

A. Functional evaluation and measurement of the fabricated sensor electrode

The urine volume change diffusion experiment was conducted on the urine sensor with a 2×2 electrodes array. A certain amount of solution was dropped in the middle or at the edge of the electrodes array, and the sensor array accurately detected the spread diffusion of urine volume changes. To assess the operational quality of the sensor, long-term stability is a crucial factor. The authors evaluated the long-term stability of the fabricated sensor electrodes over several weeks, and the results indicated that the sensor could work continuously for 5 weeks, maintaining a stable output baseline and responsivity.

B. Evaluation of sensor system with 16-channel electrodes and wireless transmission functions

A preliminary measurement for the performance evaluation of the proposed urine sensor system was conducted in a controlled environment. The experiment took place in a draft chamber with a temperature of 25℃ and a relative humidity of 50%RH. The measurement system was placed in the chamber without any changes to the testing environment. Figure 2 shows the results of the evaluation of the sensor system with 16-channel electrodes and wireless transmission functions. As depicted in Figure 2(a), all channels consistently output voltage signals and maintain a stable baseline. Figure 2(b) shows the voltage output of the sensor electrodes under loading. In the first phase, 16 sensor electrodes were positioned under an absorbent mat, resulting in an output of approximately 1.30V. In the second phase, an equivalent solution was applied to the mat above each of the 16 electrodes. The results demonstrate that sensor electrodes from No. 1 to No. 16, respectively detect changes in solution volume, maintaining stable output voltage. The experiment verifies the detection performance and output stability of the fabricated sensor system.

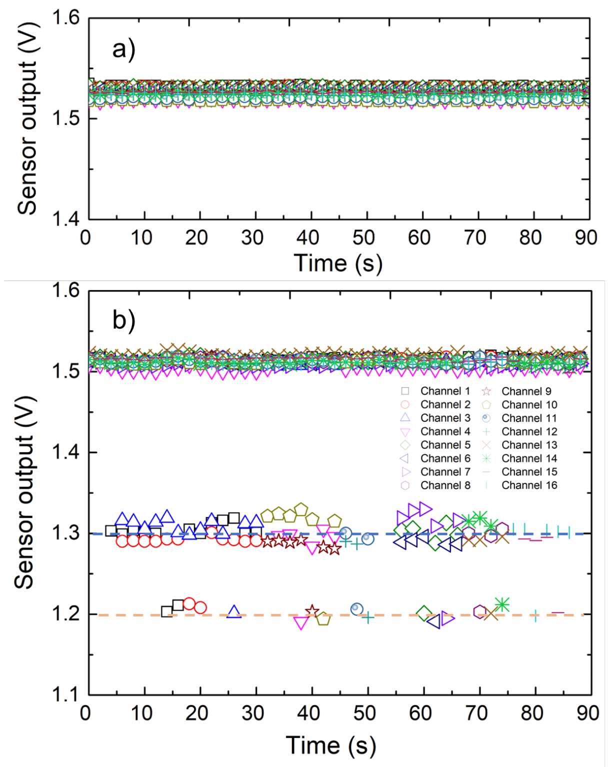

Figure 2. Sensor output of the measurement system with 16-channel electrodes and wireless transmission functions. (a) shows the output voltage with a stable baseline, while (b) shows the output of the sensor electrodes under loading.

IV. Discussion and Conclusion

We have developed an ultrathin urine sensor electrode with a smart measurement and transmission system for health monitoring. The urine monitoring sensor system is super compact in size, featuring a user-friendly interface to ensure a positive user experience. The measured results demonstrate that the urine sensor, equipped with multi-channel electrodes, can real-time monitoring the urination time and pattern properly.

Acknowledgment

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References

[1] E. Suganthi and L. Ashmiya, “Human Health Monitoring Using Wearable Sensor,” Sens. Rev., vol. 28, pp. 364-376, 2018.

[2] M. Cheng et al., “A Review of Flexible Force Sensors for Human Health Monitoring,” J. Adv. Res., vol. 26, pp. 53-68, 2020.

[3] L. Zhang, J. Lu, E. Takashi, and S. Matsumoto, “Rapid Manufacturing Approach of an Ultrathin Moisture Sensor for Health Monitoring,” Sensors, vol. 23, pp. e-1-12, 2023.