A neonatal thermometer with PDMS bandage substrate for comfortable, biocompatible adhesion for prolonged use*

Prateek Jha[1], Bharadwaj Amrutur[1,2], Sanjiv Sambandan[3], Prem Mony[4]

***Abstract*— Continuous monitoring of body temperature of a premature infant can help detect hypothermia, which is a leading cause of mortality and morbidity in developing countries. A significant design challenge is to develop an attachment mechanism for the monitoring device that is safe, biocompatible and rugged for prolonged and continuous use in a home setting for at least two weeks. This brief presents initial results from our approach of using a PDMS based substrate for a wireless thermometer device.**

***Index Terms*—PDMS bandage, neonatal monitoring, hypothermia detection**

I. INTRODUCTION

Hypothermia has been shown to be among the leading indicators for neonatal mortality and morbidity, in low birth weight babies, in the developing nations [1]. A hypothermia event (where the body temperature falls by 1C or more below 37C) can happen anytime during the critical period of the first month of a baby's life and hence it is essential to continuously monitor the temperature during this period and take necessary action. A contactless solution based on IR imaging is a candidate approach, though not very practical for long term monitoring over the duration of weeks. Hence a contact based solution, which is wearable, seems to be the most practical. In a hospital NICU, such contact based temperature probes are routinely used and held in place on the baby's abdomen via medical grade bandages (Fig. 1). Such bandages are too expensive and not very skin friendly for prolonged use in a home setting. Embedding the temperature probe in to clothing is another possibility [2], though this has issues of cost and usability, as infants need too many clothing changes in a day. Another option is a belt-based attachment of the device around the baby's abdomen. However this could impede free movement of the abdomen during breathing, if improperly tied. In this brief, we describe our attachment solution that can stay on the skin for long durations, doesn't cause any kind of irritation to the skin or the body, and is safe and comfortable for the infant.

Fig. 1: Attachment via a medical tape

II. PDMS BASED BANDAGE

A custom made, contact based wireless thermometer device was developed earlier to continuously monitor the infant's temperature Fig. 2 [3]. To attach this to the infant skin, we have developed a PDMS based bandage structure that can house the device, so that both mechanical adhesion as well as thermal contact is provided. This bandage is a bi-layer substrate, with the bottom layer providing adhesion and the top layer providing the mechanical stability, durability and flexibility. Various ratios of (PDMS: cross-linker) were studied. A ratio of 20:1 was identified for the substrate layer and a ratio of 55:1 was identified for the adhesive layer (Fig. 3). A hole in the bandage allowed the temperature probe's metallic surface to make contact to the skin, thus ensuring good thermal equilibrium with the skin. The PDMS based bandage showed good adherence to the human skin. Adult volunteers reported no discomfort even after repeated attachment and detachments. The adhesion levels go down after repeated use – however it is restored after cleaning with water. The device with the bandage was tested in the NICU against the hospital's temperature probe and the results over a one-hour period are reported in Fig 5. The output of the device stabilizes after an initial settling down time of about 20 minutes with an average of 0.21 degrees of difference in temperature.

Fig. 2: Wearable wireless, temperature monitoring probe

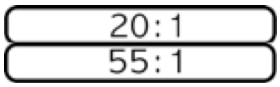

Fig 3: Bi-Layer structure for the PDMS bandage

Fig. 4: Bandage substrate showing the probe's bottom cover affixed to the bandage.

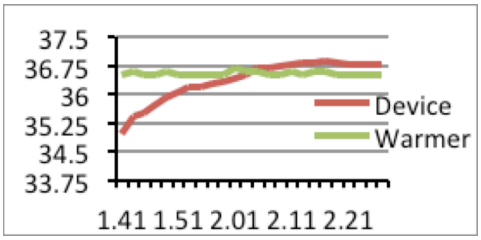

Fig. 5: Comparison of measurement results from the bandage based device and the NICU warmer probe.

III. CONCLUSION

The PDMS based bandage is a promising approach to create a mechanical platform for interfacing wearable to skin. Further work is needed to make it more robust. Another promising thread is to integrate the electronics directly on the substrate.

IV. ACKNOWLEDGMENT

We thank Sumi Anu of St. Johns Research Institute, for conducting hospital experiments and Alok Rawat, Hitesh Rao of IISc with the device design.

[1] Kumar V. et. al., The Lancet 372(9644)2008. [2] Chen, W. et. al., BodyNets 2010. [3] Rao H., et. al., Biodevices 2014. [4] Zhixin Wang, et. al., Int. J. Appl. Polym. Sci. 2014, 131, 41050.

*Research supported by Robert Bosch Centre for Cyber-Physical Systems, at the Indian Institute of Science, Bangalore. [1]Department of Electrical Communications Engineering, IISc.[2]Robert Bosch Centre for Cyber-Physical Systems, IISc. [3]Department of Instrumentation and Applied Physics, IISc [4]St. Johns Research Institute, Bangalore. Corresponding author: e-mail: prateek.jha89@gmail.com