Journal of Robotics and Control (JRC)
Volume 1, Issue 4, July 2020
ISSN: 2715-5072, DOI: 10.18196/jrc.1426

Simulation of Vitiligo Therapy Equipment

Nur Hudha Wijaya[1], Adelia Agtesa[2], Gabriel De Brito Silva[3], V. Dhinakaran[4], Mian Usman[5]
[1, 2] Department of Electrical Engineering, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia
[3] School of Engineering and Applied Sciences, Nile University, Giza, Egypt
[4] Department of Mechanical Engineering, Chennai institute of technology, Chennai, India
[5] Department of Information Systems, University of Management and Technology, Lahore, Pakistan.
nurhudhawijaya@umy.ac.id, adelia.agtesa.2015@vokasi.umy.ac.id, gabriel.silva@eu4m.eu,
dhinakaranv@citchennai.net, usman.sattar@umt.edu.pk

***Abstract*— Vitiligo is a skin disorder caused by a lack of melanin pigment in the skin, which causes white patches on certain parts of the skin because this melanin pigment is not able to produce the skin color. Previously, one of the treatments for vitiligo was using a UVB lamp with a 311 nm wavelength that could not yet be adjusted to dim the lights as safety when conducting therapy. Therefore, the research aims to design a simulation of the vitiligo therapy device equipped with a timer LED lamp, a safety of lighting, and the data storage. The data are stored in the SD Card to make it easier for patients to control changes before and after therapy. The simulation of this therapeutic apparatus is controlled using the Arduino Uno system and regulates lightning protection using a PWM circuit and ultrasonic sensors. The highest error obtained is 2.4%. at 5 cm. The overall device system, namely timer, buzzer, hour meter, and data storage has been working well and the error value is still within tolerance which is below 5%. Thus, it is hoped that this vitiligo therapy simulation device is able to operate as a real therapeutic device.**

***Keywords*— vitiligo, ultrasonic sensor, depigmentasi, microcontroller**

I. INTRODUCTION

Skin disease is a skin disorder caused by fungus, germs, parasites, viruses, or infections. It can attack the whole or part of the human body. Scabies, ringworm, and tinea versicolor are some examples of skin disease. Vitiligo is a skin disease caused by genetic or hereditary factors. Vitiligo is a depigmentation disorder caused by the absence of melanocytes in the epidermis, mucous membrane, eyes and hair bulb. Its characteristics are white patches like milk, oval-shaped, and more visible in humans with dark skin. The incidence of vitiligo ranges from 1-2% of the world's population, where 30% of sufferers have a family history. In its initial development, 10-year-old vitiligo was 25%, 23 years old was 50%, and those 42 years were less than 10%. In this disease, the cause of loss of melanocytes in the epidermis is hereditary inherited dominant autosomal disease.

The effects of vitiligo disease are blotches on the skin and skin burning as a result of excessive exposure to sunlight in depigmented areas, which may even cause skin cancer. The depigmentation areas frequently found are facial skin, neck, scalp, and hands. The treatment for vitiligo, in general, is the use of vitiligo re-pigmentation. It was done by maximum exposure of the areas to sunlight for 15-30 minutes, then washed, and finally, sunscreen is applied. the side effects of the treatment are photoaging, phototoxic reactions, and prolonged use can cause burns.

Some previous researchers have conducted research using phototheraphy. The nanoscale metal-organic framework for cancer phototherapy was investigated by Lan. Phototherapy involves tissue irradiation with light and is generally implemented in the form of photodynamic therapy (PDT) and photothermal therapy (PTT) [1]. Nano materials for biosensing and phototherapy applications were investigated by Aliaksandra. There is great demand for the development of sophisticated health care solutions for early detection of diseases and effective treatment methods [2]. The development of neonatal incubators with phototherapy, biometric fingerprint readers, remote monitoring, and heart rate control adjusted for developing country hospitals was studied by Kapen. The proposed device consists of an acquisition module that senses temperature, humidity, fingerprint reader, baby's heartbeat, and phototherapy module which is used to treat newborn jaundice by lowering bilirubin levels in the baby's blood [3]. The design and implementation of an automatic phototherapy system was investigated by Pap. Clinical studies have shown that 311 Nm narrow-band UVB lamp effects reduce immune modulation symptoms, which can be a good alternative compared to steroid treatment [4]. The construction of nanomaterials by targeting the nature of phototherapy to inhibit resistant bacteria and biofilm infections was investigated by Wang. Phototherapy including photothermal therapy and photodynamic therapy has attracted widespread attention in treating infectious diseases as the development of drug-resistant bacteria and bacterial biofilms [5].

An Irradiation Method that Distributes Effective Irradiation Areas for Phototherapy Lights was investigated by Licla. Since the American Academy of Pediatrics (AAP) and the International Electrotechnical Commission (IEC) uphold the criteria of effective irradiation areas as part of design standards for neonatal phototherapy lamps [6]. Does increased enamel bond integrity increase with phototherapy? A systematic review was examined by Al-Hamdan. The aim of the current systematic review is to evaluate the efficacy of phototherapy (PT) on the strength of the bleached enamel bond [7]. Is phototherapy effective in the management of postoperative endodontic pain? A systematic review of randomized controlled clinical trials was investigated by

Alonaizan. In patients with post endodontic pain (population), what is the effect of phototherapy (intervention) compared with placebo (comparison) on post endodontic pain (outcome) by considering only randomized-RCT clinical trials (study design)? [8]. Very Low Power Phototherapy with NIR Laser Triggers and µCT Imaging for Breast Cancer in Vivo was investigated by Mohamed. In this study, we used bimetal sulfide, copper bismuth sulfide nanocrystals (CBS NCs) as a theranostic multifunction module for noninvasive X-ray contrast imaging and photodynamic therapy [9]. An implanted phototherapy device for treating diabetic retinopathy was investigated by Cook. This paper reports the first implanted phototherapy device to treat diabetic retinopathy by modulating stem cell metabolism through reduction of dark currents [10].

Efficacy of phototherapy in adhesive bonding from various dental positions to root dentin: A systematic review was investigated by AlFawaz. The aim of the current systematic review is to evaluate the efficacy of phototherapy in the adhesive bonding of various tooth posts to the dentin root [11]. Automatic and Portable Phototherapy Clothing (APPG) with Integrated Non-Invasive Bilirubin Detector examined by Shahroni. Hyperbilirubinemia or jaundice occurs in 60% of healthy infants and 80% of premature infants due to an increase in unconjugated bilirubin in red blood cells [12]. The Cyclometalated iridium (III) complex in therapy and phototherapy was studied by Zamora. The Octahedral Ir (III) complex containing cyclometala ligand shows great stability in biological media and is an excellent candidate for therapy and phototherapy for several major human diseases [13]. Folate and phototherapy: What we have to inform our patients is investigated by Zhang. Ultraviolet (UV) folate degradation has been studied in vitro and in vivo, but comprehensive reviews of subjects and recommendations for supplementing folate are still lacking, especially for women of childbearing age, where a decrease in folate causes newborns to become deformed in the neural tube [14]. Phototherapy and Combination Therapy for Vitiligo was investigated by Esmat. Vitiligo is a disease characterized by loss of melanocytes from the skin [15].

Effects of monochromatic infrared phototherapy on patients with diabetic peripheral neuropathy: a systematic review and meta-analysis of randomized controlled trials investigated by Robinson. Background Monochromatic infrared energy (MIRE) or phototherapy has been used to increase plantar sensitivity and pain in lower limbs of patients with diabetic sensorimotor peripheral neuropathy (DSPN), but the main results available are inconsistent [16]. The spectrophotometer design for neonatal phototherapy was investigated by Svobodova. This paper deals with the final assembly of spectrophotometric instruments and especially by creating control and calculation software [17]. Light blue led for the treatment of bilirubin in newborns: The prototype prototype was automatically investigated by Pineda-Lopez. Placing phototherapy equipment lights at appropriate distances from the neonate, and scheduling the treatment to be applied depending on the level of hyperbilirubinemia in patients, is a problem in large hospitals that do not have enough personnel who specialize in pediatrics, which causes that this equipment is used improperly true or not used [18]. The new design for phototherapy devices and skin color analysis were investigated by Nabizath. Phototherapy is also referred to as light therapy which is widely used to reduce high bilirubin levels in newborns suffering from jaundice [19]. Prediction of the occurrence of short-term side effects in the treatment of NB-UVB phototherapy using data mining was investigated by Mohamed. The prediction of short-term side effects in phototherapy treatment is important for dermatologists who provide phototherapy to adjust treatment and standardize clinical outcomes [20].

Therefore, it is necessary to simulate a vitiligo therapy device using LED lamps instead of UV-B narrowband ultraviolet B (NB UV-B/with a maximum wavelength of 311 nm), which prioritizes the safe distance and time of the therapy. The safest distance set in the device is 20 cm, the closest distance is 2 cm, and the time setting is 0 - 30 minutes (depending on the area of the skin affected by vitiligo). There is also data storage that stores the patient's data on the length of time of the therapy aims to facilitate the patients when they want to do further therapy because it should be done routinely and with different dosages.

II. BASIC THEORY

Vitiligo

Vitiligo is a common skin condition caused by pigmentation (color) missing on the skin. The skin color disappears in certain areas such as on the back of the hands, face, and underarms. This disease is not deadly and cannot be cured, but some skin color on the face and neck can return. Sometimes this disease is related to other diseases, such as thyroid. Vitiligo is a multifactorial polygenic disorder with complex pathogenesis. The exact etiology of this disease is unknown, but the virus may be one of the etiologies of vitiligo.

NB UV-B (narrowband ultraviolet B)

Ultraviolet [21]–[24] is divided into two main segments, namely UV-B and UV-A. UV-B has a wavelength between 290-320 nm. It can cause redness or erythema on human skin. UV-A has a wavelength between 320-400 nm, and the chance to cause redness or erythema is 1000 times smaller than UV-B. Ultraviolet has a negative and positive effect [25]–[30]. Phototherapy, or therapy using light, especially using ultraviolet waves, is being developed. One of the diseases that can be managed using ultraviolet light is vitiligo. The basis of the development of therapy in vitiligo is the effect of UV-B exposure which can trigger the transfer of skin pigment or melanocytes to the surface of the skin and also stimulate the production of additional melanocytes causing brownish-colored skin. The latest therapy developed using UV-B in vitiligo is Narrowband Ultraviolet B (NB-UVB). NB-UVB is a therapy using ultraviolet lamps with a maximum emission of 311 nm. At present, NB-UVB has been the first-choice therapy for this disease because it is safe and effective for young and adult patients.

III. METHOD

The method used consists of several stages, namely hardware design, software design, device testing, and data retrieval.

Hardware design

The block diagram illustrates the working system of the vitiligo therapy device as show in figure 1. The power supply functions to supply the series. It enters the step-up module to increase the voltage from 12 V to 40 V DC to turn on the LED lights. The PWM circuit adjusts the dim light of the therapeutic lights, controlled by the microcontroller. The timer in the device set is 0-30 minutes. The minimum system circuit controls the entire work of the device. An ultrasonic sensor HC-SR04 is used to measure the distance of an object set from 0-20 cm. If the object is at a distance of 0-20 cm, the lights will turn on. When the safe distance is detected, the lights will automatically turn off. The lamp will turn off and the buzzer will sound after the time-out setting is set. There is a data storage in the device to store the data of the patients.

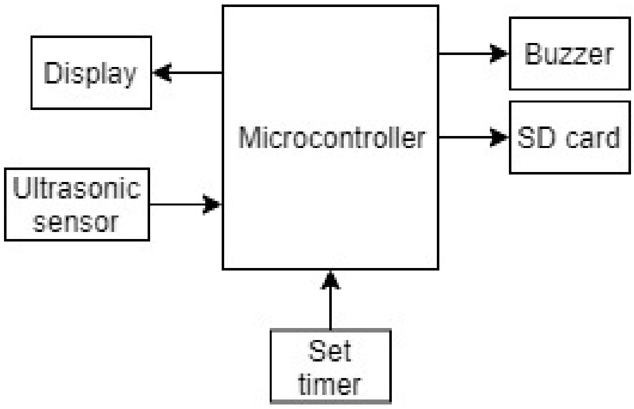

Fig. 1. System block diagram

Firmware design

The work process of the device starts by pressing the ON button as a start to perform the therapy as show in figure 2. An LCD initialization indicates that the device is ready to use, and the data will be displayed on the LCD. The timer setting is used to make a time selection of 10, 20, or 30 minutes. The therapy will start after selecting the timer. If the timer is not ON, the process will return to the timer selection. If the timer is ON, the LED light will turn on when the object is in front of the lamp. If the timer is ON, the hour meter will also be ON to determine the length of the light by counting down, namely, the timer value on the LCD will decrease one by one until the timer has run out. When the timer is out, the LED will turn off and the buzzer will sound indicating that the therapy process is over. To save your data, press the memory button, and the data will be stored on the SD card.

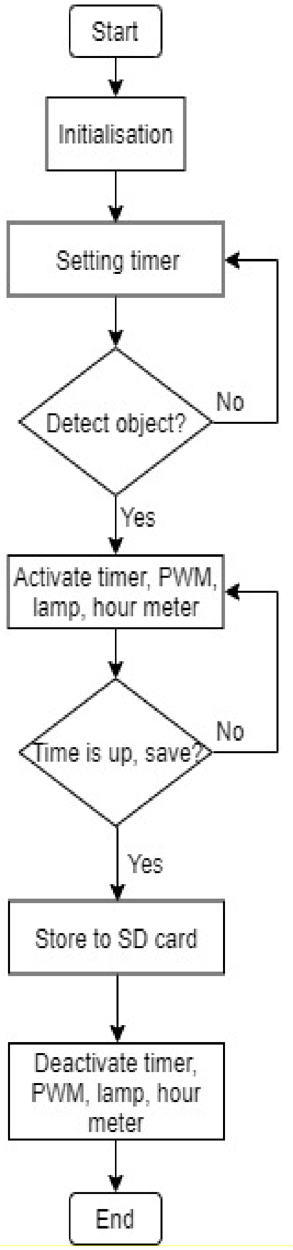

Fig. 2. System work flow diagram

Implementation

The minimum system circuit shown in figure 3 requires a 5V voltage. The voltage from the 12V power supply enters the IC regulator 7805 to generate a 5 V. There is a 100u capacitor as a filter in the input and output Ic regulator so that the DC voltage is perfect. Furthermore, the voltage of 5 V will go to AREFF and AVCC. In the circuit, there is a 12,000 MHz crystal as an additional external clock so that the processing of data is maximum, and a 22 pF capacitor as charging and blanking on the crystal oscillator chain.

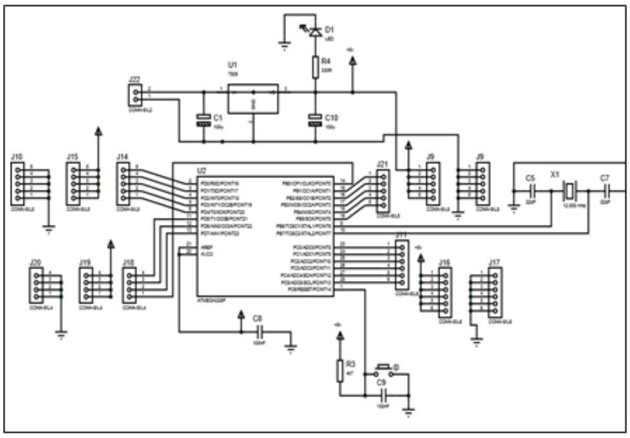

Fig. 3. Minimum system schematic diagram

IV. Result and Discussion

Time measurement test

The timer functions to set the duration of the therapy light when an object is in place and stops when there is no object in front of the lamp. The time selection in the simulation of the vitiligo therapy device is 0-30 minutes. Timer testing was done 20 times at 5, 10, 15, 20, 25, and 30 minutes using a stopwatch comparator.

TABLE I. Timer Comparison Test Result

Expected Time (minutes)	Standart average (minutes)	Tested average (minutes)	Error (%)	Standart deviation
5	**5**	**4.83**	**0.16**	**4.33**
10	**10**	**9.75**	**0.25**	**2.5**
15	**15**	**14.58**	**0.41**	**2.7**
20	**20**	**19.58**	**0.41**	**2.0**
25	**25**	**24.57**	**0.42**	**1.7**
30	**30**	**29.55**	**0.4**	**1.5**

Of the five experimental results, the measurement of time is still in the tolerance stage of 5%.

Distance measurement test

The proximity sensor is used to adjust the distance of the lamp with the object to be treated so that the therapeutic process becomes more effective and safer. The distance setting used is 0-20 cm. The test was carried out 5 times with a ruler comparison, besides, measurements of the lamp lux were carried out at 5 cm to know the dim or bright lights. The following are the results of the tests that have been carried out.

TABLE II. Distance Comparison Test Result

Expected distance (cm)	Standart distance (cm)	Tested distance (cm)	Error (%)	Standart deviation	Exp.
5	5	4.8	0.12	2.4	Dim
10	10	9.9	0.1	1.0	Dim
15	15	14.92	0.08	0.5	Bright
20	20	19.9	0.1	0.5	Bright

Out of the five experimental results, the time measure is 5%, within-the tolerance stage. The lamp Lux at 5 cm is 350 lux, which means in that distance, the lamp is in a dim state because the lux produced is only 1400. Whereas the lamp Lux at 20 cm is 4700, which means in that distance, the lamp is in a bright state because the lux produced is 5000.

V. Conclusion

The 5-minute time measurement has a 3.3% error, the 10-minute timer has an error of 2.5%, a 15-minute timer has an error of 2.7%, a 20-minute timer has an error of 2.0%, the 25-minute timer has an error of 1.7%, and the 30-minute timer has an error of 1.5%. Based on the results of these errors it can be concluded that the device is in a suitable condition because it is still within tolerance limits. The results of the measurement of a distance of 5 cm 5 times there is an error of 2.4%, at a distance of 10 cm has an error of 1.0%, at a distance of 15 cm has an error of 0.5%, and a distance of 20 cm 5 times there is an error of 0.5%. The measurement results are still in the tolerance stage which is under 5%. Kesimpulannya belum bagus. Itu hanya hasil dari pengukuran.

References

[1] G. Lan, K. Ni, and W. Lin, "Nanoscale metal–organic frameworks for phototherapy of cancer," Coord. Chem. Rev., vol. 379, pp. 65–81, Jan. 2019.

[2] R. Aliaksandra, "Nanomaterials for biosensing and phototherapy applications," in 2018 International Conference Laser Optics (ICLO), 2018, pp. 540–540.

[3] P. T. Kapen, Y. Mohamadou, F. Momo, D. K. Jauspin, N. Kanmagne, and D. D. Jordan, "Development of a neonatal incubator with phototherapy, biometric fingerprint reader, remote monitoring, and heart rate control adapted for developing countries hospitals," J. Neonatal Nurs., vol. 25, no. 6, pp. 298–303, Dec. 2019.

[4] P. Pap and S. T. Brassai, "Design and implementation of automated phototherapy system," in 2018 19th International Carpathian Control Conference (ICCC), 2018, pp. 271–276.

[5] Y. Wang et al., "Construction of nanomaterials with targeting phototherapy properties to inhibit resistant bacteria and biofilm infections," Chem. Eng. J., vol. 358, no. May 2018, pp. 74–90, Feb. 2019.

[6] P. M. Licla, E. Laura Bravo, G. Kemper, J. L. Villalobos, C. Del Carpio, and C. D. Aliaga, "A Method of Irradiance Distributing Over an Effective Irradiated Area for Phototherapy Lamps," in 2018 IEEE XXV International Conference on Electronics, Electrical Engineering and Computing (INTERCON), 2018, no. D, pp. 1–4.

[7] R. S. Al-Hamdan, "Does bond integrity of bleached enamel increases with phototherapy? A systematic review," Photodiagnosis Photodyn. Ther., vol. 25, no. January, pp. 401–405, Mar. 2019.

[8] F. A. Alonaizan and Y. F. AlFawaz, "Is phototherapy effective in the management of post-operative endodontic pain? A systematic review of randomized controlled clinical trials," Photodiagnosis Photodyn. Ther., vol. 26, no. February, pp. 53–58, Jun. 2019.

[9] M. S. Mohamed et al., "Ultra-Low Power NIR Laser-Triggered Phototherapy and µCT Imaging of Breast Cancer In Vivo," in 2018 IEEE 12th International Conference on Nano/Molecular Medicine and Engineering (NANOMED), 2018, vol. 2018-Decem, pp. 78–81.

[10] C. A. Cook, J. C. Martinez-Camarillo, M. S. Humayun, and Y.-C. Tai, "Implantable phototherapy device to treat diabetic retinopathy," in 2017 19th International Conference on Solid-State Sensors, Actuators and Microsystems (TRANSDUCERS), 2017, pp. 393–396.

[11] Y. F. AlFawaz and F. A. Alonaizan, "Efficacy of phototherapy in the adhesive bonding of different dental posts to root dentin: A

systematic review," Photodiagnosis Photodyn. Ther., vol. 27, no. April, pp. 111–116, Sep. 2019.

[12] N. Shahroni and M. M. Addi, "An Automatic and Portable Phototherapy Garment (APPG) with Integrated Non-Invasive Bilirubin Detector," in TENCON 2018 - 2018 IEEE Region 10 Conference, 2018, vol. 2018-Octob, no. October, pp. 1999–2004.

[13] A. Zamora, G. Vigueras, V. Rodríguez, M. D. Santana, and J. Ruiz, "Cyclometalated iridium(III) luminescent complexes in therapy and phototherapy," Coord. Chem. Rev., vol. 360, pp. 34–76, Apr. 2018.

[14] M. Zhang, G. Goyert, and H. W. Lim, "Folate and phototherapy: What should we inform our patients?," J. Am. Acad. Dermatol., vol. 77, no. 5, pp. 958–964, Nov. 2017.

[15] S. Esmat, R. A. Hegazy, S. Shalaby, S. Chu-Sung Hu, and C.-C. E. Lan, "Phototherapy and Combination Therapies for Vitiligo," Dermatol. Clin., vol. 35, no. 2, pp. 171–192, Apr. 2017.

[16] C. C. Robinson, P. D. S. Klahr, C. Stein, M. Falavigna, G. Sbruzzi, and R. D. M. Plentz, "Effects of monochromatic infrared phototherapy in patients with diabetic peripheral neuropathy: a systematic review and meta-analysis of randomized controlled trials," Brazilian J. Phys. Ther., vol. 21, no. 4, pp. 233–243, Jul. 2017.

[17] B. Svobodova, M. Penhaker, V. Kasik, M. Augustynek, and J. Kubicek, "Design of spectrophotometer for neonatal phototherapy," in 2017 IEEE 15th International Symposium on Applied Machine Intelligence and Informatics (SAMI), 2017, pp. 000417–000422.

[18] F. Pineda-Lopez et al., "Light blue led for bilirubin treatment in newborns: Automatic photherapy prototype," in 2017 IEEE XXIV International Conference on Electronics, Electrical Engineering and Computing (INTERCON), 2017, pp. 1–4.

[19] M. A. Nabizath, S. A. Soumya, V. Boomitha, C. Meena, and P. Sridharan, "New design for phototherapy device and skin colour analysis," in 2017 IEEE International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), 2017, no. August, pp. 253–257.

[20] S. Mohamed, B. Q. Huang, and M.-T. Kechadi, "Prediction of short term adverse events occurrence in NB-UVB phototherapy treatments using data mining," in 2017 2nd International Conference on Knowledge Engineering and Applications (ICKEA), 2017, vol. 2017-Janua, pp. 44–48.

[21] E. Ebert, H. Kruger, H. Ewald, M. Rabe, and N. A. Damaschke, "Comparison of two variants of a novel setup for real time high resolution UV-LED absorption spectroscopy," in 2015 9th International Conference on Sensing Technology (ICST), 2015, vol. 2016-March, pp. 430–433.

[22] E. Ebert, N. Damaschke, H. Krüger, H. Ewald, and M. Rabe, "New setup for a real time high resolution UV-LED absorption spectroscopy," in 2015 IEEE SENSORS, 2015, pp. 1–2.

[23] X. Zhang, Junbo Zhao, and Hua Yang, "The design of electronics ballast for long service life UV Lamps," in 2015 IEEE 2nd International Future Energy Electronics Conference (IFEEC), 2015, pp. 1–5.

[24] A. Bonanno et al., "A Low-Power 0.13-<inline-formula> <tex-math notation="LaTeX">μm </tex-math></inline-formula> CMOS IC for ZnO-Nanowire Assembly and Nanowire-Based UV Sensor Interface," IEEE Sens. J., vol. 15, no. 8, pp. 4203–4212, Aug. 2015.

[25] J. Kim, "UV-LED Lithography for Millimeter-Tall High-Aspect Ratio 3d Structures," in 2019 20th International Conference on Solid-State Sensors, Actuators and Microsystems & Eurosensors XXXIII (TRANSDUCERS & EUROSENSORS XXXIII), 2019, no. June, pp. 100–103.

[26] Y. Wang, X. Zhang, and D. Xu, "Electronic Ballast for 119W UV Lamp Controlled by Microprocessor," in 2009 IEEE Industry Applications Society Annual Meeting, 2009, pp. 1–5.

[27] Jungkwun Kim, M. G. Allen, and Yong-Kyu Yoon, "Automated dynamic mode multidirectional UV lithography for complex 3-D microstructures," in 2008 IEEE 21st International Conference on Micro Electro Mechanical Systems, 2008, pp. 399–402.

[28] Y. Wang, D. Xu, D. Guo, and X. Liu, "The New Soft Starting Methods for Electronics Ballasts of UV Lamps Based on Microcontroller," in 2006 1ST IEEE Conference on Industrial Electronics and Applications, 2006, pp. 1–6.

[29] J. M. Alonso, E. Lopez, J. Ribas, A. J. Calleja, M. Rico-Secades, and J. Losada, "Design and implementation of an electronic ballast for UV-based ozone generation using a low cost microcontroller," in IEEE 2002 28th Annual Conference of the Industrial Electronics Society. IECON 02, 2002, vol. 1, pp. 383–388.

[30] H. Kruger, M. Rabe, E. Ebert, P. Busch, N. A. Damaschke, and H. Ewald, "A flexible measurement system for absorption spectrometry using LED light sources and a high accuracy two-channel ADC for simultaneous sampling," in 2015 9th International Conference on Sensing Technology (ICST), 2015, vol. 2016-March, no. 2, pp. 652–655.