YUPQA PARDASIMON TERMOELEMENTLARNING PARAMETRLARINI COMSOL MULTIPHYSICS DASTURI YORDAMIDA ANIQLASH

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Annotatsiya. Ushbu maqolada xozirgi kunda keng qo‘llanilayotgan yupqa pardasimon termoelementlarni samaradorligini oshirishga qaratilgan. Bi_2Te_3-P va PbTe-N moddalarini termoelektirik material sifatida foydalanib, undagi issiqlik o‘tkazuvchanlik, Zeebek koyfisenti, Elektr o‘tkazuvchanlik hamda qotishma uzunligini haroratga bog’liqligini comsol Multiphysics dasturi yordamida aniqlandi.

Comsol Multiphysics dasturi yordamida termoelektirik xodisasi modelllashtirish orqali termoelektirik jarayonida hosil bo‘ladigan o‘zgarishlarni harorat bilan bog’liq bo‘lgan qiymatlarini olish va natijalarni taxlil qilish asosida Zeebek koyfitsentini haroratga bog’liqligi, issiqlik o‘tkazuvchanlikni haroratga bog’liqligi hamda birikma uzunligining haroratga bog’liqlik grafiklari olingan.

Kalit so‘zlar. Yupqa pardasimon termoelementlar, Bi_2Te_3-P, PbTe-N, Comsol Multiphysics dasturi, Zeebek koyfisenti, Elektr o‘tkazuvchanlik, uzunlikning haroratga bog’liqligi.

Аннотация. В этой статье основное внимание уделяется повышению эффективности тонкопленочных термоэлементов, которые в настоящее время широко используются. Используя вещества Bi2Te3-P и pbte-N в качестве термоэлектрического материала, зависимость теплопроводности, коэффициента Зеебека, электропроводности и длины сплава от температуры в нем была определена с помощью программы comsol Multiphysics. Путем моделирования термоэлектрического явления с помощью программы Comsol Multiphysics на основе полученных температурных значений изменений, возникающих в термоэлектрическом процессе, и анализа результатов получены графики зависимости коэффициента Зеебека от температуры, зависимости теплопроводности от температуры и зависимости длины соединения от температуры.

Ключевые слова. Тонкопленочные термоэлементы, Bi2Te3-P, pbte-N, программа Comsol Multiphysics, коэффициент зибека, электропроводность, зависимость длины от температуры**.**

Annotation. This article aims to increase the effectiveness of thin-veined thermoelements, which are widely used today. Using Bi2Te3-P and PbTe-n as thermoelectricity materials, the thermal conductivity in it, Zeebek coyfisent,

ISSN 3030-3907

electrical conductivity as well as the dependence of alloy length on temperature was determined using the comsol Multiphysics program. Using the Comsol Multiphysics program, temperature dependence of the zeebek coyficent, temperature dependence of thermal conductivity as well as temperature dependence graphs of compound length were obtained based on temperature-related values of changes produced in thermoelectricity by modeling thermoelectricity.

Keywords. Thin-veined thermoelements, Bi2Te3-P, PbTe-n, Comsol Multiphysics program, Zeebek coyfisent, electrical conductivity, temperature dependence of length.

Kirish

Bi_2Sb_3 material qotishmalari issiqlikni elektr energiyasiga aylantirishda yoki aksincha elektr energiyasini sovutish maqsadida qo‘llaniladi.

Mazkur material nisbatan past haroratlarda (300–400 K) samarali hisoblanadi.

Bu uni sovutish qurilmalari yoki mikroenergiya ishlab chiqaruvchi uskunalar uchun mosligini anglatadi. Elektron o‘tkazuvchanligi yuqori, ammo issiqlik o‘tkazuvchanligi past, bu termoelektrik materiallar uchun ayni muddaodir [1].

Bundan tashqari Bi_2Sb_3 qotishmasi yuqori termoelektrik samaradorlikka ega. Samaradorlik koeffisiyenti (ZT) odatda 1∼1.21 atrofida bo‘ladi [2, 3].

Bi_2Sb_3 energiya ishlab chiqaruvchi qurilmalarda, masalan, issiqlikni qayta elektr energiyasiga aylantiruvchi termogeneratorlarda qo‘llaniladi [4].

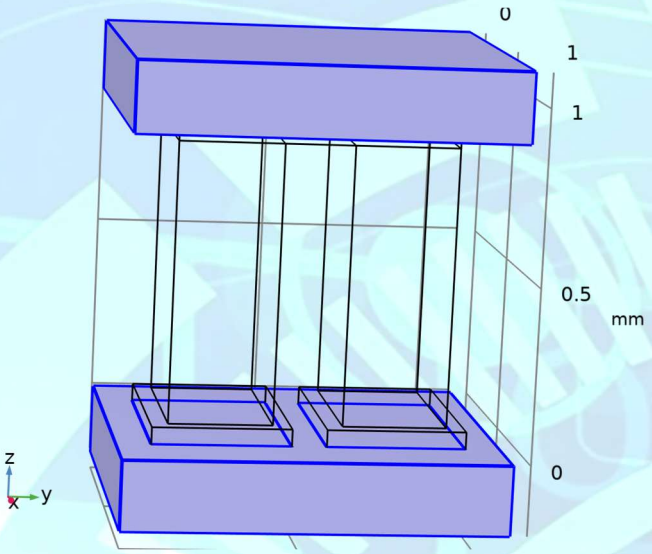
Bu material Peltye elementlarida sovutish funksiyasini ham bajaradi.

Nano o‘lchamli materiallar bilan qo‘shib qo‘llanganda, uning samaradorligi va xususiyatlari yanada yaxshilanadi. Bi_2Sb_3 — bu yuqori samarali termoelektrik material bo‘lib, u past haroratlarda ishlaydigan generatorlar va sovutish tizimlarida keng qo‘llaniladi [5]. Uning ximik tarkibi va kristall tuzilishi materialning yuqori funksionalligini ta’minlaydi [6-7].

Usullar va eksperimentlar. Termoelektirik modda modulini comsol Multiphysics dasturi yordamida 3D ko‘rinishini chizmalar orqali tasvirlaymiz. Termoelektirik modda modulini yuqori va pastgi qoplamalari uchun alumin materiali tanlandi, alumin o‘zidan issiqlikni yaxshi o‘tkazuvchi modda hisoblanadi hamda keng tarqalgan iqtisodiy jixatdan arzonligi ayni muddaodir [8]. Qoplamaning korinishi 1- rasimda keltirilgan va aluminining parametri 1-jadvalda berilgan.Termoelektirik modda modulini comsol Multiphysics dasturi yordamida 3D ko‘rinishini chizmalar orqali tasvirlangan [9-11].

Ushbu eksperimentni o‘tkazishda p-tip uchun - Bi2Te3 va n-tip uchun – PbTe material qorishmalari va uning shakli to‘rtburchak shakilda tanlanib olingan.

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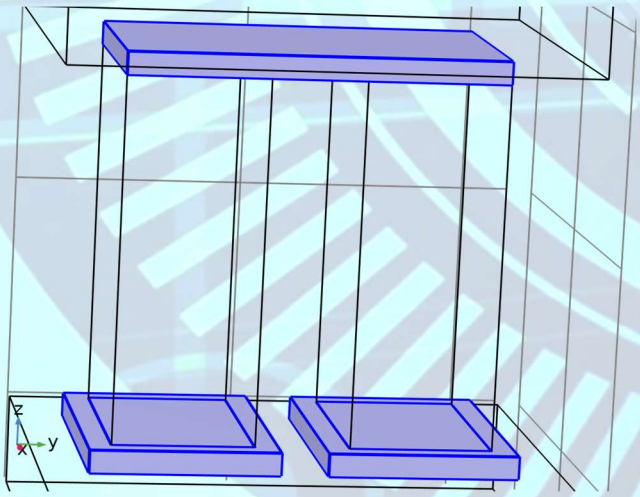
1-rasim. Termoelektirik modda qoplamalari

Termoelektirik modda modulini qoplamalarini qismini alumindan qilingan, alumin o‘zidan issiqlikni yaxshi o‘tkazuvchi modda hamda keng tarqalgan iqtisodiy jixatdan arzon [12]. Qoplamaning ko‘rinishi 1- rasimda keltirilgan va aluminning parametri 1-jadvalda berilgan.

1-jadval.

Material parameters.

Name	Value	Unit	Property group
Heat capacity at constant pressure	900	J/(kg·K)	Basic
Density	3900	kg/m³	Basic
Thermal conductivity	27	W/(m·K)	Basic



2-rasim. Termoelektirik modda modulining kantaklari

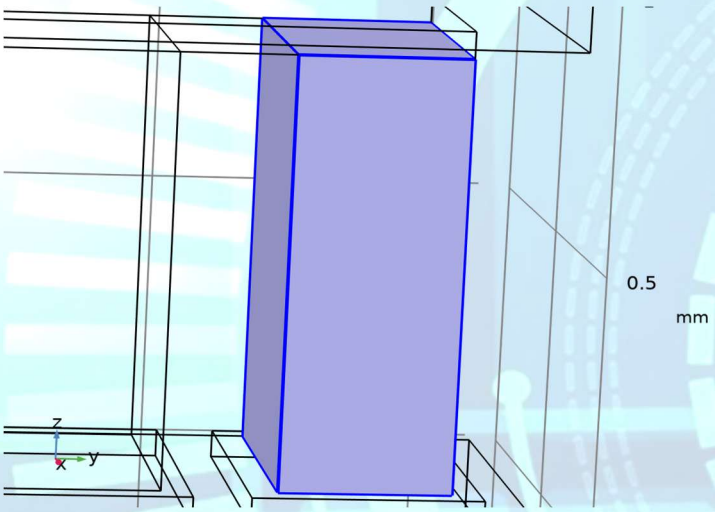
ISSN 3030-3907

Termoelektirik modda modulning P va N tiplarini ulash uchun misdan foydalanildi uning ko‘rinishi quydagi 2-rasimda keltirilgan, misning parametrlari esa 2-jadvalda keltirilgan.

2-jadval.

Material parameters

Name	Value	Unit	Property group
Electrical conductivity	5.998E7	S/m	Basic
Heat capacity at constant pressure	385	J/(kg·K)	Basic
Relative permittivity	1	1	Basic
Density	8960	kg/m³	Basic
Thermal conductivity	400	W/(m·K)	Basic



3-rasim. Termoelektirik moddaning p- tipi (Bi2Te3)

Termoelektirik moddaning p turini Bi2Te3 qotishmadan foydalanildi. Uning Comsol dasturidagi ko‘rinishi quyidagi rasmda keltirilgan, moddaning parameterlari 3- jadvalda berilgan.

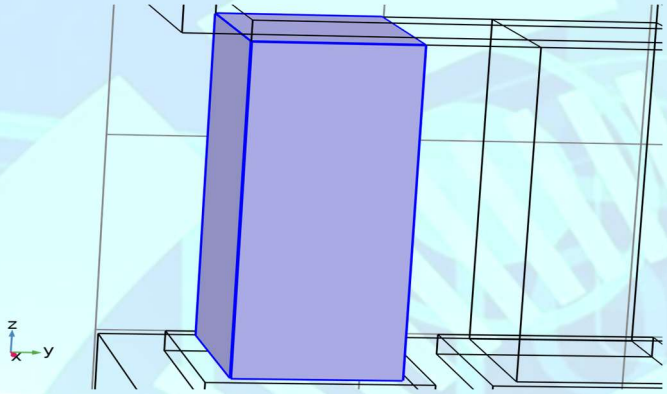
3- jadval.

Bi2Te3 materieal parameters

Description	Value	Unit
Heat capacity at constant pressure	160	J/(kg·K)
Density	7860	kg/m³
Seebeck coefficient	S(T)	V/K
Electrical conductivity	sigma(T)	S/m
Thermal conductivity	k(T)	W/(m·K)
Relative permittivity	1	1

ISSN 3030-3907

Termoelektirik moddaning N tipiga PbTe dan foydalanildi uning ko‘rinishi 4-rasimda keltirilgan, madda parameterlari 4-jadvalda keltirilgan.



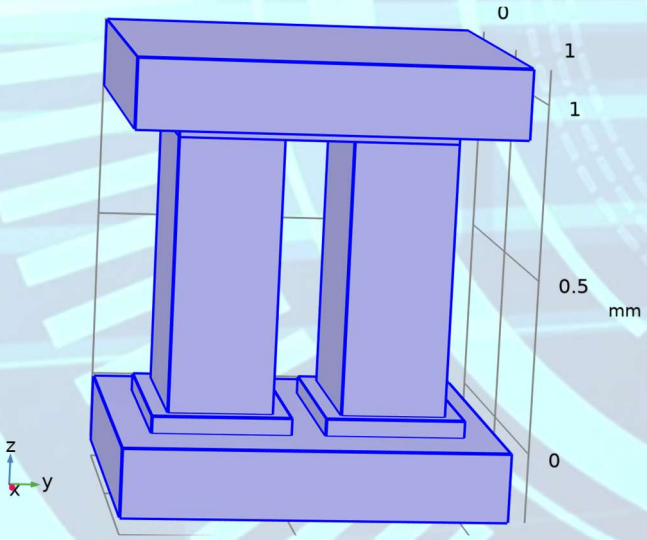
4-rasim. Termoelektirik moddaning N- tipi (PbTe)

4-jadval.

PbTe materieal parameters

Description	Value	Unit
Density	8160	kg/m³
Heat capacity at constant pressure	151	J/(kg·K)
Relative permittivity	1	1
Seebeck coefficient	-1.87E-4	V/K
Thermal conductivity	1.46	W/(m·K)
Electrical conductivity	60976	S/m

Termoelktirik modda modulining umumimy korinishi 5- rasimda keltirilgan.



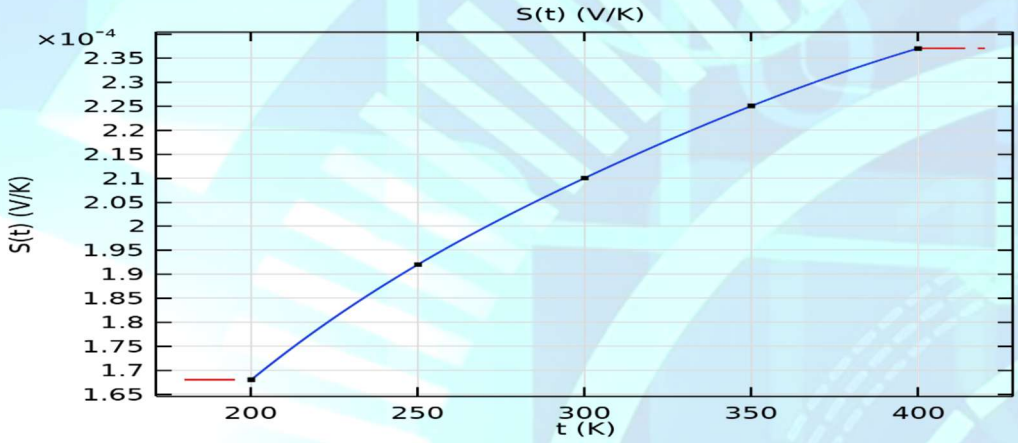
5-rasim. Termoelektirik modda modulining umumiy ko‘rinishi.

Seebeck effekti, ikki xil temperatura sharoitida joylashgan o‘tkazgich yoki yarim o‘tkazgichning elektr toki ishlab chiqarish qobiliyatidir [13]. Bu effekt, harorat farqi sababli material ichida hosil bo‘lgan harorat gradienti natijasida yuzaga keladi. Agar ikki xil metall yoki yarim o‘tkazgich o‘rtasida harorat farqi mavjud bo‘lsa, bu materiallarda erkin elektron tashuvchilarining harakati natijasida

ISSN 3030-3907

elektr yurutuvchi kuch (EYK) paydo bo‘ladi [14]. Seebeck effekti, termal energiyani elektr energiyasiga aylantirish tizimlarida, xususan termoelektrik generatorlarda ishlatiladi. Bu tizimlar, issiqlikni to‘g'ridan-to‘g'ri elektr energiyasiga aylantirib, energiya samaradorligini oshiradi [15].

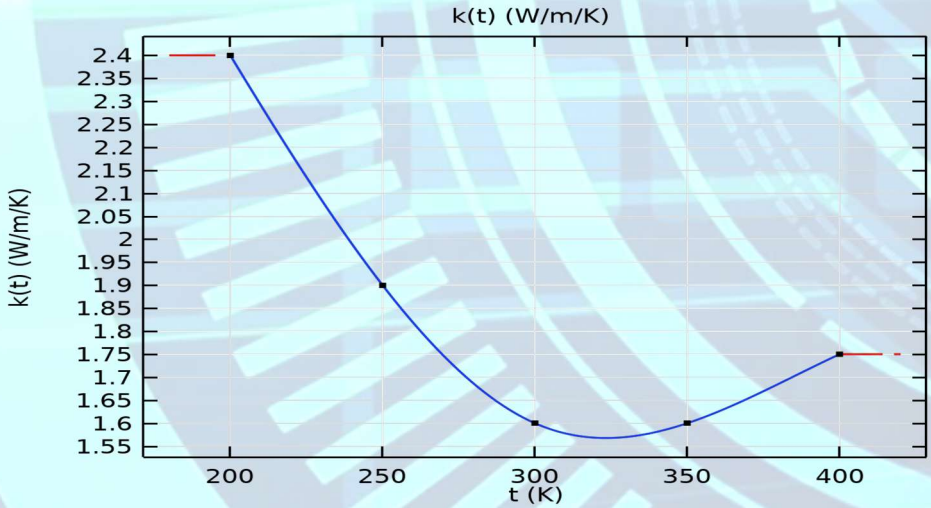
Maqolada Seebeck koyfisenti, issiqlik o‘tkazuvhanligi hamda elektr o‘tkazuvhanligini temperaturaga bog’liqligini o‘rganilgan va grafiklari ketirilgan. Seebeck koyfisenti



6-rasim. Seebeck koyfisentini temperaturaga bog’liqligi ketirilgan.

Seebeck koyfisenti temperature ortishi bilan nochiziqli o‘zgarishini ko‘rishimiz mumkun bu qimat malum tempera turaga yetganidan keyin, Seebek koyfitsentini o‘zgarish deyarli nolga teng qiymatga erishadi bu qiymatdan keyin Seebek koyfitsenti maksimal qiymatiga erishadi.

Termal conductivity



7-rasim. Termal conductivity ni temperaturaga bog’liqligi.

Termal conductivity yarimo‘tkazgichlarda temperaturaga bog'liq bo‘ladi, chunki yarimo‘tkazgichlarning elektron va struktura xususiyatlari temperatura bilan o‘zgaradi.

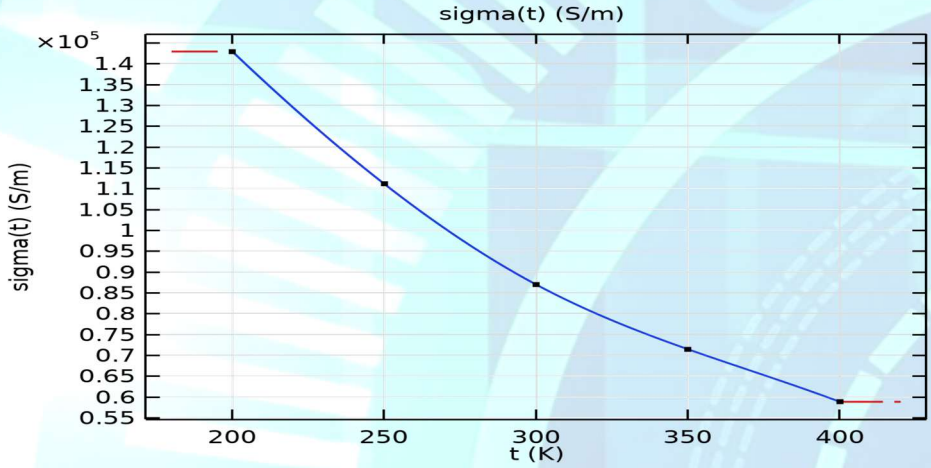
ISSN 3030-3907

Tugunlar va defektlar: Yuqori haroratda yarimo‘tkazgichlarda tugunlar va defektlar soni ko‘payishi mumkin, bu esa elektronlarning harakatiga to‘siq qo‘yadi va issiqlik o‘tkazuvchanligini kamaytirishi mumkin.

Elektronlar harakati: Harorat oshganda, elektronlar tezligini oshiradi, bu esa ularning harakatini osonlashtiradi va issiqlik o‘tkazuvchanligini oshiradi.

7- rasimdan hulosa qilishimiz mumkunki 325 K xaroratgacha moddaning issiqlik o‘tkazuvchanligi kamayap undan keyin yana oshib borishini kuzatish mumkun.

Elektr o‘tkazuvchanlik



8-rasim. Elektr o‘tkazuvchanlikni temperaturaga bo‘liqligi.

Defektlar va tugunlar Harorat oshganda, material ichidagi tugunlar va defektlar ko‘payishi mumkin. Bu defektlar elektronlarning harakatiga to‘siq qo‘yishi mumkin, natijada o‘tkazuvchanlikni pasaytirishi mumkin.

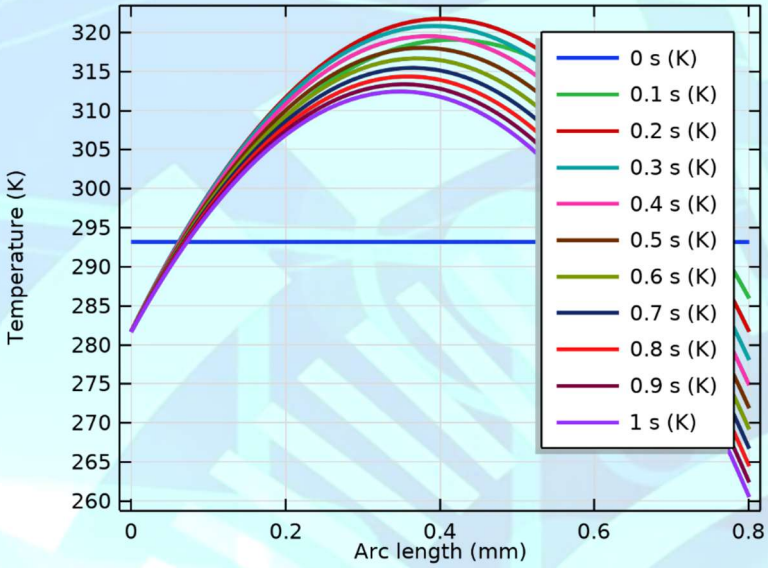
Termoelektirik moddalarda temperature farqi yuzaga kelganda moddalrda elektr toki xosil bo‘ladi.Termoelektirik moddaga berilgan issiqlikni quydagi formulalar orqali xisoblanadi. Issiqlik o‘tkazuvchanlik quydagi formula orqali xisoblangan.

$$\rho C_p \frac{\partial T}{\partial t} + \rho C_p \mu * \bar{V}T + \bar{V} * q = Q + Q_{ted}$$

$$q = -k \nabla T$$

bu yerda C_p-o‘zgarmas bosimdagi issiqlik sig’imi, p - moddaning zichligi, q - issiqlik miqdori.

ISSN 3030-3907



Xulosa

Termoelektirik moddalarda temperaturaning farqi yuqori bolgan sari ularda xosil bo‘layotgan elektr toki va kuchlanishi ortib boradi, Seebek koeffisenti past temperada yuqori qiymatiga erishiladigan modda olinsa temperatura farqi past bo‘lishiga qaramasdan yuqori potensiallar farqini yuzaga keltirish mumkin. Hamda termoelktirik moddani elektr qarshiligi gradiyenti kamayishiga erishish mumkin.

FOYDALANILGAN ADABIYOTLAR RO’YHATI

1. S. Sai Krishna, M. Muralikrishna and R. Gowrishankar. Understanding Thermoelectric Behavior of Materials Using Comsol. Journal of Applied Physical Science International, Volume 9 [Issue 3], Page 79-89, 2017.

2. A.M. Kasimakhunova., M.O. Atajonov, (2023) Research on Technologies for Manufacturing Film Thermoelements (Bi_2Te_3) and (Sb_2Te_3) in Modern Thermoelectric Technologies. NTZ “IZVESTIA” of the National Academy of Sciences of the Kyrgyz Republic. ISSN 0002 – 3221. pp. 211-220.

3. https://www.solarreviews.com/blog/do-you-wire-solar-panels-series-or-parallel

4. Doron Shmilovitz. On the Definition of Total Harmonic Distortionand Its Effect on Measurement Interpretation. IEEE Transactions on Power Delivery, (2005) vol. 20. № 1. DOI:10.1109/TPWRD.2004.839744(410)

5. https://www.acnelectrical.com.au/2024/04/17/mastering-off-grid-solar-installation-techniques/

6. https://labprojectsbd.com/2020/04/22/mppt-solar-charge-controller-with-synchronous-buck-converter-with-smps-mobile-charger/

7. Dioari Ulrich Combari., Emmanuel Wendsongre Ramde, at all. Performance Investigation of a Silicon Photovoltaic Module under the Influence of a Magnetic Field. (2018) https://doi.org/10.1155/2018/6096901

ISSN 3030-3907

8. Muhiddin Atajonov., Qudrat Mamarasulov., at all. (2024, November). Research of solar panel model based on photovoltaic module. In AIP Conference Proceedings (Vol. 3244, No. 1). https://doi.org/10.1063/5.0241785
9. K. Arul Raj and Narmatha Dayalan. Simulink Based Modelling and Simulation of Solar Power Generation with Grid Interconnection System Using Matlab for Home Appliances. International Journal of Electrical and Computer System Design, (2024) Vol. 05, pp.43-47.
10. https://blog.ecoflow.com/us/what-is-mppt-solar-charge-controller/
11. Yuyu Dai. Impact of Shading Area on PV System. (2020) DOI: 10.1088/1755-1315/440/3/032073
12. Muhiddin Atajonov. Development of technology for the development of highly efficient combinations of solar and thermoelectric generators. (2024) AIP Conf. Proc. 3045, 020011, https://doi.org/10.1063/5.0197733.
13. Muhiddin Atajonov., Qudrat Mamarasulov., Odiljon Zaripov. (2024, November). Study of solar photoelectric plant in MatLab (Simulink) package. In AIP Conference Proceedings (Vol. 3244, No. 1). AIP Publishing. https://doi.org/10.1063/5.0241783
14. Atajonov Muhiddin Odiljonovich (2024). MODELING OF AN AUTONOMOUS PHOTOELECTRIC MODULE. Descendants of Al-Farghani, (4), 285-288. doi: 10.5281/zenodo.14555439
15. A.M. Kasimakhunova., M.P. Abdullaeva., M.O. Atajonov. (2023) Prospects for the Development of Combined Alternative Energy Converters. NTZ "IZVESTIA" of the National Academy of Sciences of the Kyrgyz Republic. ISSN 0002 – 3221. pp. 339-348.

ISSN 3030-3907