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Proofreading

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Cover design

Andreas Vogel

Additional design

Stephan Friedman

Editorial office

Premier Publishing Praha 8

Karlín, Lyčkovo nám. 508/7, PSČ 18600

Email:

pub@ppublishing.org

Homepage:

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Section 1. Economics and Management

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INNOVATIVE WAYS OF SELLING SERVICES

*Ziyaeva Mukhtasar Mansurdjanovna*¹

¹ Tashkent state university of economics

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Abstract

This article explores innovative approaches to selling services in today's dynamic business environment. With technological advancements, changing consumer behaviors, and evolving market dynamics, traditional sales strategies are becoming outdated. Businesses must embrace digital transformation, prioritize customer-centricity, explore innovative pricing models, and build strategic partnerships to stay competitive. By leveraging these strategies, companies can drive growth and maximize the potential of their service offerings.

Keywords: *Service sales, innovation, digital transformation, customer-centricity, pricing models, strategic partnerships*

Introduction

In today's rapidly evolving business landscape, the sale of services is undergoing a transformation driven by technological advancements, changing consumer behaviors, and shifting market dynamics. As traditional sales strategies become outdated and ineffective, businesses are compelled to explore innovative ways to market and sell their services effectively.

This article aims to delve into some of the most innovative approaches to selling services, offering insights and strategies that businesses can leverage to stay competitive in an increasingly crowded marketplace. From harnessing the power of digital platforms to adopting customer-centric sales methodologies, the following explo-

ration will shed light on the cutting-edge techniques driving success in service sales today.

As the business landscape continues to evolve, the ability to innovate and adapt is essential for success in service sales. By embracing digital transformation, prioritizing customer-centricity, exploring innovative pricing models, and building strategic partnerships, businesses can stay ahead of the curve and drive growth in an increasingly competitive market. Through continuous experimentation, learning, and refinement, companies can unlock new opportunities and maximize the potential of their service offerings.

Analysis and results

Online Platforms

The online platform has replaced traditional advertising methods such as billboards or print ads due to the advancement of technology. From millions of social media users to countless internet surfers shopping online, it is clear that company's target audiences are already present online. Although it may seem obvious that every company should be utilizing these methods of advertising, there are still companies who are only using the traditional methods due to a lack of knowledge about online advertising, a lack of confidence or for some, they are simply satisfied with their current sales figures. Before considering online platform though, a company needs to ensure that they are capable of executing orders or services for customers who are based worldwide if worldwide sales are the intention. According to Hui-Lien Tung from the National Chiao Tung University in Taiwan, setting up offices or stores abroad may not be a cost-effective way for the company to make international sales. By doing so, the company may incur fixed costs that can't be recovered if the venture fails, or bargaining power of customers may force the company to lower prices. As Tung suggests, a cost-effective alternative for making international sales is to use the internet. This is due to the internet being a tool that helps international sales, it not only breaks the barriers of national boundaries but also allows the customer to compare prices or reviews for a product in a quicker and convenient manner. An inquiry that many companies have discussed is what type of approach should be used on the internet to gather more customers and how? Social media marketing and e-commerce websites are the two most effective methods of portraying products or services to potential customers.

Social Media Marketing

The growth of social media platforms like Facebook and Instagram has provided companies an opportunity to gain new clients and retain old customers in a less obtrusive manner compared to traditional marketing techniques. Companies can engage and inform their customers by providing rich content such as infographics or videos. In an article, "The 6 Benefits of Social Media Marketing," Jayson DeMers highlights key advantages

including increasing website traffic, building conversations, raising brand awareness, enhanced brand loyalty, cost effectiveness, and gaining marketplace insight. The insight gained from social media can expose trends, new competitive information, and awareness of what customers want, all of which can affect your business in many positive ways. For example, we have discovered the popular use of chat apps such as Snapchat amongst our target market is an area we can exploit as a new alternate customer contact channel. The availability of automated Snapchat marketing tools on web-based platforms and also useful hybrid apps which use cloud API on PC such as Snaplytics are indicative of the potential success we could gain pursuing this. Creating an official company page and curation of content can sow the seeds for a community of fans and repeat customers. In a recent competition held on our Twitter page, encouraging people to follow our Twitter and retweet the "pinned" tweet for a chance to win an Amazon Echo Dot, we gained several new followers and the retweet results had significant reach seen in the data below.

With so many current and potential customers in support of a "good" or "very good" company e-reputation, generation of free or paid company content and search or sponsored advertisements on social media could result in too much success to measure for any SME with little concern of the patience and overall cost. This form of e-marketing is rarely intrusive and detailed demographic targeting can ensure no time is wasted from the wrong viewers. For example, in utilizing Facebook Ad Marketing tools, we can selectively show our ads only to those in the UK within a certain age group, who have liked specific pages or have interests relating to our services.

Taking note social media has the ability to both build and ruin a brand image, it is important to always deliver a consistent brand image with tone and visual factors, prompt responses to inquiries, and dealing with any customer disputes or complaints in a dignified manner. Any forgotten replies to a customer can be found in hidden notifications during the activity log, so it is imperative to have efficient and disciplined social media management. A smart means of reducing damage to an image from an issue is compen-

sation to a victimized user, and social media can sometimes be the best place to alter opinion with a public display.

E-commerce Websites

Due to the recent e-commerce boom, having a website is seen as a legitimate way to do business. An e-commerce site can be defined as a website that allows a consumer to shop for goods and services online, and these can be implemented in various ways to sell products. One way they can do this is through setting up a storefront on an auction site like eBay or purchasing a webstore solution provider like Shopify. Regarding service businesses, only the latter may be relevant due to eBay having a specific culture associated with it and people may not take the service as seriously. However, both of these methods present the issue of there being no traffic as it is the equivalent to setting up shop in the middle of the desert. Multiple ads may have to be placed to guide people to the webstore and this can end being quite costly. Another issue is that the business has to compete with many similar businesses in the same manner of setting up a store. This is akin to having a niche in a shopping mall where a customer may visit any of the stores if it means getting what they want. The alternative that was specified in the introduction is creating a unique market for service. Doing a service at this type of website is essentially like the early days of the internet where a business could be the first of its kind and thus have minimal competition. The key difference now is that there are billions of people on the internet and many of them want services of some kind but the method of finding customers is the same, creating so much potential traffic to a site. This may seem like a novel idea, take what's available and do it via internet at a website specifically for it, but there is very little that is completely new. An example of this is a personal advertisement to do some web scripting at low cost where he had in mind a specific task. During a discussion it was pointed out that the task could instead be done through creating a mod on a private server for a certain game which would likely be far more fun and an equally beneficial task. This was an epiphany as there is much that can be done in place of something else, services are just a means to an end and often that end can be more efficiently achieved

in a different form. A private server administrator may want some functional web content but not want to spend money hiring a web developer and a web developer may enjoy doing some pro-bono work and get some virtual items as a token of appreciation. The service industry transcends many interests and walks of life, there is potential to do any given service in a game of some kind. Previously the web scripting ad could have been lost in a sea of other similar offers but by taking it to the game in question it has unique market, specifically people who play that game. The seller then knows clients for this project can be found on the game and task can be done with in-game items as payment, an opportunity that could not have been realized if it was not mentioned that it was a chat with a different context.

AI-powered Chatbots

Chatbots have enhanced the way businesses provide customer service and support. When a customer enters a store, there is usually a representative to assist them with anything they need. However, in a traditional online service, the customer often views products independently without any help or guidance. Chatbots offer a virtual assistant designed to provide help and support to customers 24/7. 51% of consumers say that a business needs to be available 24/7. Today's consumer does not want to wait until the next day for help. If the service is online, the chatbot simulates a salesperson chasing the customer, offering assistance and information about products. This is a critical part of selling services, as the first step to buying a product is understanding what it is and if it will suit the customer. Any consumer would prefer to ask questions about a product and get answers immediately, rather than waiting a whole day to be able to ask a representative.

Chatbots are AI-powered software designed to interact with customers by simulating human-like conversations. With almost 1 billion monthly active users on Facebook Messenger, many businesses have developed chatbots on this platform which are easily accessible to customers. Other than setting up on a messenger platform, chatbots can be integrated into a business's website or mobile app. These chatbots are capable of providing instant replies to customer queries.

They never sleep and can provide support to customers from all over the world. Since they are machine-powered, chatbots are capable of doing the work of multiple customer support agents for only a fraction of the cost. High-end chatbots use machine learning and are capable of analyzing complex customer queries and providing accurate responses. With the advancements in natural language processing, chatbots are becoming indistinguishable from real human agents.

Traditionally, providing 24/7 support has always been a costly undertaking. Businesses have to hire staff in different parts of the world to cover the different time zones. This meant having 3 shifts a day per region to cover the 24-hour period. With ever-increasing wages and job competition, hiring support staff is becoming increasingly expensive. Running a call center is said to cost 2–4 times the amount of the salaried staff because of the infrastructure, recruitment, and training costs. This has led to businesses looking into cost-effective ways of providing 24/7 support without burning a hole in the pocket.

Availability of customer support: in this case, 24/7 service has always been what sets one company's service apart from someone else's. In this increasingly competitive world, where businesses have to compete globally irrespective of the size, 24/7 support adds the

extra edge to the customer service and can be the deciding factor for a potential customer to sign up. There have been numerous studies and surveys which suggest the positive impact of providing 24/7 support. Forrester research found that 45% of US consumers will abandon an online transaction if their questions or concerns are not addressed quickly, and 51% of US online consumers say that they would place an order if they could have a quick question answered first. These stats just go on to show that there is a direct correlation between providing 24/7 support and converting potential prospects into actual customers.

Conclusion

In conclusion, the landscape of service sales is undergoing a profound transformation, driven by technological advancements and shifting consumer expectations. To thrive in this dynamic environment, businesses must embrace innovation in their sales approaches. By leveraging digital transformation, prioritizing customer-centricity, exploring innovative pricing models, and building strategic partnerships, companies can unlock new opportunities for growth and success. Through continuous adaptation and experimentation, businesses can stay ahead of the curve and remain competitive in an ever-evolving marketplace.

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Contact: mehrivoxidova@gmail.com

Section 2. Journalism

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MEDIA “SINS” IN COVERING RELIGIOUS CONFLICTS

*Giorgi Abazadze*¹

¹ Akaki Tsereteli State university, Georgia

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Abstract

The pursuit of neutrality in journalism is crucial to maintaining the credibility and integrity of the media. Maintaining a neutral position helps to fairly represent all sides of the story, allowing the audience to formulate their own informed opinions without media bias. However, the presence of assessment tones – where journalists express personal judgments or subjective assessments in their coverage – can undermine this objectivity. Such tones can not only color the information presented, but also lead to polarization of viewers’ opinions, which is especially harmful in a politically sensitive environment. Random bias in covering events in the media can come from various sources, including institutional influences.

Coverage of conflicts, including religious conflicts, is a risk and a threat to journalists. However, in many cases journalists disseminate only useful information and propaganda from one side, which also leads to professional and moral pressure. Journalists often represent one of the conflicting parties, which adds to their moral and professional dilemmas.

Keywords: *sins of the media; coverage of religious conflict; Difficulties in maintaining neutrality; propaganda; Journalists in the “crossfire”*

Coverage of religious conflicts is a risk and a threat to journalists. However, in many cases they disseminate only useful information and propaganda from one side, which also leads to professional and moral pressure (Boudana, 2015). Journalists willfully or involuntarily become part of the conflict. (Zandberg & Neiger, 2005). The professional role of journalists requires maintaining neutrality, but at the same time they represent a particular religious community, so this factor complicates impartiality in covering

religious conflict. (Nygren, 2018). It should be said that journalists are “in cross-fire” because they try to balance professional autonomy with political leadership and public pressure.

In times of religious conflicts, journalists cannot be mistaken for subjectivity. This is the most difficult process, because in religious conflicts, media representatives have both internal and hidden as well as overt pressures, external or internal and hidden and overt pressures that force them to use

self-censorship. This pressure prevents them from reporting certain events or they report without harming themselves and others (Jungblut & Hoxha, 2017). Pressure prevents journalists from fulfilling their professional duties. It should be noted that when violence ends, even in post-conflict situations, self-censorship or censorship does not immediately disappear for journalists.

The media often “sin” when covering religious conflicts; Not very rarely does the term “extremist” refer to Muslims and for the most part remain silent on Christian extremists.

Moreover, we often find in the media articles about “good Christian” and “bad Muslim.” In the case of Muslims, stories are told by naming terrorists’ religion or ethnicity, and in the case of Christians, without naming them. For example, the Norwegian mass murderer Anders Breivik does not characterize the media as a Christian terrorist, although he considers himself a Christian. In most articles, Breivik is referred to as a “mass murderer” (Aljazeera, 2023), not a Christian terrorist. Consequently, the media has formed a public opinion that terrorists are predominantly Muslims.

Several articles have been published in world media in which Breivik is characterized as a Christian terrorist (Strømme, 2017). To refute this, the American scholar Stephen Protero wrote that Christians denounced Breivik; The scientist interpreted his action as a political act, not a religious one. However, it has been forgotten that terrorism is often used to achieve political goals.

As proof of the “sins” of the media, we can cite another example – the 1995 Srebrenica massacre (Smith, 2023). The event is widely described in the media as “the killing of 8.000 ‘Muslim’ men and boys by ‘Serbs’”; Serbian political and military leaders accused of war crimes are not referred to by the media as Christian terrorists. It is impossible to bypass the religious coverage of the Israeli-Palestinian war in our work.

The Israeli-Palestinian conflict is caused by several factors: religious, ethnic, national and historical. However, in our work we will focus only on religious factors. It is interesting to what extent religion affects the identity, politics and attitudes of the actors involved in this conflict.

First, several religious factors related to Islam and Judaism are important – “extreme religious Zionists” in Israel are very strict when it comes to any concessions with the Arabs. Also, Islamist groups in Palestine and the Islamic world as a whole support the need to liberate “holy” territories and places for religious reasons, and preach violence and hatred against the Jewish nation and Israel. At the same time, tensions are exacerbated by religion-based stories about the hidden religious agenda of the other side that extends to the extremist media.

It should be noted that the situation was very tense by the widespread rumor that there was a “Jewish plan” – the destruction of the Al-Aqsa mosque and the construction of a Jewish temple on its waste.

It is interesting to find an article published in 2021 where a journalist quotes the words of one of the Jews: “I have no such intention, because God will do this.” “God will extinguish the Al-Aqsa mosque and build a third temple on earth instead.” “Everything, including al-Aqsa, belongs to the Jews, because God created the world only for His holy people, the Jews” (World, Middle East, 2021). No less provocative and irritating are other articles on this issue; Among them is an article published in April 2023 (Muslim-Mirror, 2023) discussing the insult of the “Al-Aqsa Mosque” and the plan to demolish it. The journalist is clearly on the side, he does not simply tell the story, but exacerbates facts with words such as “merciless”, “cruel”, etc. – “Israeli police destroyed doors and windows to enter al-Aqsa and mercilessly attacked the pilgrim. He then reminds the reader that: “The Al-Aqsa Mosque is an Islamic place where, for decades, according to long-term international agreements, unwanted visits, prayers and rituals by non-Muslims are prohibited.” However, the Palestinians “Al- The Aqsa Mosque is only allowed for a while, which is why they fear that the foundation will lay for the division of the mosque between Muslims and Jews, just as the Ibrahim mosque was split in Hebron in the 1990s. However, Israel’s control of East Jerusalem, including the Old City, violates several principles of international law that stipulates that the occupying state does not have sovereign-

ty over the territory it occupies and cannot afford any permanence there. Make changes. Israeli soldiers broke batons, and rifles during Ramadan in the prayer hall of the Al-Aqsa Mosque, causing outrage around the world. The author concludes the article with the words: “Faced with Jewish barbarism, Palestinians remain the most oppressed and brave fighters in human history” (Muslim-Mirror, 2023). With these words, the author seems to be calling for a fight against the Palestinians. It can be said that such provocative conversations in the media really reach their goal, because Palestine and Israel are in a state of war today; One of the main motives of the conflict is religious.

According to Hamas, an “al-Aqsa storm” has begun – an attack on Israel to protect a holy place; They targeted hundreds of soldiers and civilians. Interestingly, only Muslims have the right to pray in the building under the agreement of the status quo that was originally reached more than a century ago (Raine, Lau, Poole, & Meyer, 2023). In the Muslim world, many fear that the right to be the only pilgrim was violated and the mosque itself was in danger.

The deterioration of the socio-economic situation in the Arab and Islamic world contributes to the growth of religious radicalism; All of this leads a large proportion of young people to bigotry and religion-inspired politics. Of course, religious beliefs often hold a sacred and central place in the lives of individuals; Shapes their identity, values and purpose. However, when freedom of expression concerns religious sensitivities, conflicts may arise. Conflict often arises when expressions, willful or unintentional, question or offend deep religious beliefs.

The 2015 Charlie Hebdo incident is a stark example of tensions between freedom of expression and religious sensitivities. The publication of a caricature of the Prophet Muhammad in a satirical journal sparked outrage in the Muslim world, leading to tragic consequences. The incident highlighted the need for societies that share respect for religious beliefs and the protection of the right to freedom of expression (Liparteliani, 2023).

Achieving a delicate balance between freedom of expression and religious sensitivities requires a nuanced approach. Governments,

civil society, and religious institutions play an important role in promoting an environment where both rights coexist harmoniously.

Incidents in Copenhagen and Stockholm, where far-right groups and individuals demonstrably burned the Holy Book of Islam – the Quran, have sparked a global debate over the delicate balance between freedom of expression and religious sensitivities (Liparteliani, 2023). An Iraqi Christian refugee living in Sweden in Stockholm burned a copy of the Quran outside the central mosque. This fact led to such a noise that it became necessary to evacuate the embassy staff after protesters stormed the building.

Two far-right activists in Copenhagen destroyed a copy of the Quran in front of the Iraqi embassy. After these incidents, Denmark and Sweden began to discuss the prohibition of religious protests accompanied by the burning of the Qur’an or any other religious text;

The Danish Foreign Ministry said – Although the protection of freedom of expression is crucial, such protests are beneficial to extremists and pose a threat to overall security and prosperity (Liparteliani, 2023).

Around these incidents, a debate began about the balance between freedom of speech and respect for religious minorities. Both countries are looking for legal means to intervene in some circumstances; Among them – in protests with the embassies. However, it was emphasized that any amendment should be made within the framework of freedom of expression protected by the Constitution.

The debate has sparked strong reactions throughout the Islamic world – diplomatic protests, condemnation of decisions, etc.;

There are conflicting opinions around granting permission for demonstrations of a religious nature.

Freedom of expression is the cornerstone of democratic societies that allow people to express their opinions and views without fear of censorship or retaliation. In Western democracies, this right is reinforced as a fundamental principle that promotes open discourse, critical thinking, and the progress of society. However, insulting religious sentiments in the name of freedom leads to tension and the essence of multicultural coexistence is questioned.

The burning of religious texts, especially of such a sacred book as the Qurania, is obviously a highly provocative act, and it is highly likely to have dire consequences.

The incident in Copenhagen and Stockholm was followed by major protests and demonstrations in Islamic countries. They believed that allowing the fact of burning the Quran in itself implies implicit support for the event by the authorities and contributes to the strengthening of Islamophobia.

The geopolitical consequences of the Qur'an's burning demonstrations were deep, which appeared in Turkey's response – President Erdogan made the decision not to discuss the issue of Sweden's membership in NATO because of the encouragement of Islamophobia; Therefore, religious conflicts can have dire consequences on international relations. These incidents have shown us that religious conflicts affect the diplomatic alliance and global cooperation.

Although freedom of expression is a fundamental right, it is accompanied by a responsibility to balance individual freedoms among different communities. When issuing permits for offensive demonstrations of religious symbols, the expected results should be taken into account on a national and international scale. The government should assess both the right to expression and the potential damage that may result from it. The hardest consequences of provocative demonstrations should be taken into account.

Officials in Sweden and Denmark view the burning demonstrations of the Qur'an as legitimate, arguing that freedom of expression allowed protesters to do so.

This fundamental democratic principle allows people to express their views, even if they are controversial or offensive to some.

The Scandinavian perspective emphasizes the importance of protecting this right and that the stocks do not necessarily reflect the position of the government. However, the challenge lies in reconciling the legal right to express opinions with the potential consequences that may arise as a result of provocative actions (Liparteliani, 2023). Swedish Prime Minister Ulf Krystersson admits that the decision made by Stockholm police to allow the Qur'an burning rally is legal; However, it is advisable to understand the potential

risks of these types of demonstrations in the future.

The Prime Minister's statement shows that there are numerous applications for such promotions, indicating a growing trend that could put the country in serious danger. Despite expressing concern, Cristerson does not have specific strategies set to prevent these threats, and there has been no revision of the strategy for issuing permits for such actions (Liparteliani, 2023).

EU High Commissioner for Foreign Affairs Josep Borrell also praises the issue condemning the Qur'an burning demonstrations as a blatant provocation and believes that religious hatred and intolerance are unacceptable to the EU. Borrell emphasizes the EU's commitment to promoting freedom of speech by recognizing ethical considerations (Liparteliani, 2023).

The tragic incidents of the attack on the offices of the French satirical magazine "Charlie Hebdo" in 2015 sparked a global debate over the delicate balance between freedom of expression and social responsibility. The editorial board's decision to publish the caricatures of Muhammad became the subject of judgment. Although the editorial board argued that their actions were in line with European standards of freedom of speech, the fact led to potential existential threats (Liparteliani, 2023).

The publication of caricatures of Muhammad on the pages of "Charlie Hebdo" caused the indignation of the world Muslim community. A section of society claimed that these caricatures insulted a significant part of the population for whom Muhammad is a saint. The conflict between the magazine's right to freedom of expression and perceived disrespect for religious beliefs highlighted the challenge to various cultural and religious sensitivities within democratic values (Liparteliani, 2023).

Conclusion

When discussing the delicate balance between freedom of expression and social responsibility, it is crucial that European nations take care of both freedom of speech and religious rights. Joint efforts can balance processes much more; Promote harmonious coexistence between different religious

communities. Achieving a delicate balance between freedom of expression and religious sensitivities requires a nuanced approach. Governments, civil society, and religious institutions play an important role in promoting an environment where both rights

coexist harmoniously. The study of historical angles allows journalists to understand how religious narratives, political events, and socio-economic factors have been combined to create the current landscape of religious conflicts.

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© Abazadze G.
Contact: abazadze58@gmail.com

Section 3. Pedagogy

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SOME QUESTIONS OF THE DEVELOPMENT OF THE PROBLEM OF FORESIGHT IN THE TEACHING OF WESTERN THINKERS

*Tulenova Karima Zhandarovna*¹

¹ Department of Social Sciences at Tashkent State Pedagogical University. Nizami

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Abstract

The article presents the results of the analysis of scientific concepts on the problem of foresight in the teachings of Western thinkers. It is shown that the issues of scientific foresight and its research have been of concern to people since ancient times, since the first attempts, which can be found in the Ancient East, as the practice of calculating astronomical and natural phenomena, etc. It is proved that the development of issues of scientific foresight and forecasting was due to both objective and subjective reasons, namely the formation of the need for scientifically based ideas about the future of objects of various nature, on the one hand, and the solution of problems related to the development of social processes. In these historical conditions, the idea that foreseeing the future is possible only through the comprehensive and in-depth use of scientific achievements is widely spread, it helps a person to learn the laws of nature hidden from our sight. Knowledge of the laws of nature, “can discover and produce something that has never happened before, which neither the course of natural phenomena, nor artificial experiments, nor the very case, which would never have presented itself to human thinking, would never have brought to fruition. It is shown that the role of science, according to Western scientists, if it relies on the inductive method, can make many new discoveries, anticipate the course of development of future events, learn the laws of nature hidden from our view, as well as express thoughts about the development of social processes.

Keywords: *science, private sciences, foresight, society, method, scientific knowledge, induction, deduction, discoveries, nature, experience, causal phenomena, religion, social progress, politics, knowledge, cognition, law, regularity*

Introduction

Thinkers from Western European countries also made a significant contribution to the development of the problem of foresight.

As is known, at the early stages of the development of human society, scientific knowledge of people was very limited, therefore, the philosophers of antiquity and the Middle

Ages, predicting the onset of future events, relied mainly on practical experience and empirical knowledge.

The great merit in substantiating this idea belongs to the founder of English materialism of the XVII century F. Bacon (1561–1626). As a proponent of experimenting natural science, F. Bacon pinned many hopes on science. He wrote: “One should generally hope that there are still many very useful things hidden in the depths of nature that have no kinship or correspondence with what has already been invented and are entirely located beyond the imagination. It has not yet been discovered, but no doubt in the course and cycle of many centuries it will appear as the previous one appeared. However, in the way we are talking about now, all this can be imagined and anticipated quickly, immediately, immediately.” The path in question here means the inductive method developed by F. Bacon.

F. Bacon deeply believed that with the help of science, we can significantly expand our knowledge of the laws of nature and put them at the service of man. This is evidenced by his work “New Atlantis”. In it, F. Bacon tells that a group of travelers after a shipwreck accidentally found themselves in a little-known city, conditionally named by him “New Atlantis”. The residents of the city provided the travelers with a warm welcome, necessary medical care and nursed them for several days. After the travelers recovered their health and became stronger, the father of Solomon’s house introduced them to the life, customs and orders of the city. From a conversation with him, travelers will learn that all branches of knowledge are developed there, thanks to which people live well, beautifully and amicably. “The goal of our society,” says F. Bacon, through the mouth of the father of the house of Solomon, is the knowledge of the causes and hidden forces of all things and the expansion of man’s power over nature, until everything becomes possible for him.”

“We have mechanics at home,” says the interlocutor, “where machines and devices for all types of movement are manufactured. This way we get faster movement than, for example, the flight of a musket ball or anything else you know, and we also learn to get movement with greater ease and with less energy expenditure... We produce artillery

pieces and all kinds of military vehicles, new varieties of gunpowder, Greek fire burning in water and unquenchable, as well as fireworks of all kinds for entertainment and other purposes. We also imitate the flight of birds and know several principles of flight. We have vessels and boats for swimming underwater and those that withstand storms; there are swimming belts and other devices that help to stay on the water. There are various complex mechanisms, clocks and others, as well as devices based on perpetual motion. We imitate the movements of living creatures, making models of people, animals, birds, fish and snakes for this purpose. In addition, we know other types of movement that are amazing in their uniformity and accuracy.

Thus, in the work “New Atlantis” F. Bacon makes a brilliant guess about the wonderful future of science, about the inexhaustible possibilities of human genius to penetrate the secrets of nature with its help, about a new social system where every person is provided with full prosperity, a healthy, happy and joyful life.

The power of science, F. noted. Bacon, it consists in the fact that it helps a person to learn the laws of nature hidden from our sight. Those who know the laws of nature “can discover and produce something that has never happened before, which neither the course of natural phenomena, nor artificial experiments, nor the very case, which would never have presented itself to human thinking, would never have brought to fruition. Therefore, the discovery of forms (meaning laws – K.T.) is followed by true contemplation and free action.”

F. Bacon warns that scientific predictions cannot be equated with prophecies that cannot be scientifically explained. “However,” says F. Bacon, – advising to despise them, I only want to say that they do not deserve faith; but their appearance and spread should not be neglected; for they cause a lot of harm, and there are many laws by which they are severely punished. And there are three reasons for their spread. Firstly, people tend to notice only those predictions that come true; the same happens with their dreams. Secondly, vague traditions or guesses are sometimes clothed in the form of prophecies, because a person tends to foresee the future and, consequently, turn conclusions into predictions...

This provision is one of the important conditions for the separation of prediction and foresight, where the latter, in turn, is based on strictly established laws and theories. Using the rules of reasoning, science discovers a number of such truths that are not the result of a direct reflection of reality. Thus, Bacon recognizes experience as the first stage of knowledge, and reason as the second stage.

Research methods

In the study, we used such methods as a comparative, historical and cultural, systematic approach, comparative analysis, generalization of scientific knowledge, etc.

Discussion

Another English philosopher of the XVII century, T. Hobbes (1588–1679), developing the doctrine of scientific foresight, wrote: “Foreseeing the future is nothing more than the expectation of things like those that we have already encountered in our practice.” This expectation of the onset of appropriate results presupposes, as its basis, knowledge of the causal relationships of things, “what inevitably causes and determines each action consists in the sum of all currently existing things that contribute to the production of this action; if one of these things is currently missing, then the action cannot be performed.” And further, T. Hobbes concludes: “Foresight is knowledge, and knowledge depends on the existence of known things.” The degree of accuracy of foresight, according to T. Hobbes, depends entirely on the experience of the one who predicts.

“Sometimes,” writes T. Hobbes, “a person wants to know the consequences of an action, and then he imagines a similar action in the past and its results, assuming that the same action leads to the same consequences. For example, someone who foresees what will follow a crime remembers what consequences of such a crime he has observed before, while his train of thought is as follows: crime, government officials, prison, courts, the gallows. This kind of thought is called foresight, prudence or foresight, and sometimes wisdom, although such a guess, due to the difficulty of observing all the circumstances, can be very deceptive.

But one thing is certain: the richer a person’s experience, the more prudent he is and less likely to be deceived in his expectations. Only the present has existence in nature, the past has existence only in memory, and the future has no existence. The future is only a fiction of the mind, applying the consequences of past actions to the actions of the present, which is done with the greatest, but not absolute certainty, by the one who has the most experience.” A further step in the development of the doctrine of scientific foresight was made by the French enlighteners of the XV century, Paul Henri Holbach (1723–1789), Jean Antoine Condorcet (1743–1794) and other thinkers.

Holbach’s views on the issue of scientific foresight are highly controversial. On the one hand, he, being a supporter of the fatalistic understanding of necessity, believed that man, as a part of nature, should unconditionally obey the laws of nature and stop looking to the future. “Come back, unfaithful child, return to nature,” Holbach wrote, “it will comfort you; it will banish from your heart the fears that depress you, the worries that torment you, the raptures that excite you and the hatred that separates you from the people you should love. Returning to nature, to humanity, to yourself, scatter flowers along the path of your life; stop looking into the future” (underlined by us – K.T.).

Conclusion

As can be seen from the above, the views of Western European thinkers of the XVII–XVIII centuries on the problems of foresight represent a significant step forward compared to previous philosophers, both in depth and breadth of the issues raised. In particular, they tried to bring a solid scientific base under their doctrine of the future; they emphasized in every possible way the role of science in the development of society, tried to spread the doctrine of scientific foresight to the analysis of phenomena of social life. Thus, summarizing the above, with the intensive development of private sciences, the foresight of the future in the teachings of the English philosophers F. Bacon, T. Hobbes is possible only through the comprehensive and in-depth use of the achievements of the sciences. The French thinkers P. Holbach and J. Condorcet attempt

to apply the doctrine of scientific foresight to the analysis of social phenomena. This problem is most fully considered by the German philosopher I. Kant and Hegel.

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© Tulenova K.Z.
Contact: gulyamovazarina@mail.ru

Section 4. Physics

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STUDY AND CALCULATION OF SULFUR- MANGANESE- SILICON CELL IN SILICON LATTICE

*Utamuradova Sharifa Bekmuradovna*¹, *Mavlyanov Abdulaziz
Shavkatovich*¹, *Matchonov Khusniddin Jamoladdinovich*¹

¹ Semiconductor Physics and Microelectronics

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Abstract

A model of hypothetical Si_2MnS structure similar to the cubic structure of $\text{F43m-}\beta\text{-MnS}$ has been proposed and quantum-mechanically calculated. $E_g \approx 0.22$ eV energy gap of the Si_2MnS structure obtained in the course of quantum chemical numerical calculation of position of electrons and the level $E_i \approx 0.226$ eV revealed during the study of the photoconductivity of the $\text{Si} < \text{Mn}, \text{S} >$ sample, have been analyzed and compared. According to the authors, further thorough theoretical studies, detailed quantum chemical calculations and experiments in the field of engineering a novel class of hybrid compounds with a cubic lattice of diamond type with the participation of elements of groups IV/III-V and IV/II-VI, could help forecast new structures. **Keywords:** *model, quantum-mechanical calculation, non-isovalent compound, single crystal silicon, manganese, sulfur, photoconductivity, forbidden band, ionic and covalent bonds*

Over recently, the intentional formation of chemical complexes from a small number of defects with an ordered arrangement of impurity atoms and the atoms of the basic material in the lattice with a partially ionic and partially covalent nature of bonds between them helps improve the functional parameters of semiconductor structures and thus vary their properties.

In particular, one of the promising areas is widening functional properties of single crystalline silicon with non-isovalent compounds in the crystal lattice with phases of

the $\text{Si}_2\text{A}_{\text{II}}\text{B}_{\text{VI}}$ type, which represent a “hybrid” of the cubic lattice of silicon Si and sphalerite ZnS (cubic modification).

Theoretical studies, quantum chemical calculations and the experiments focused on engineering novel class of hybrid chemical complexes with a cubic diamond-structured lattice that consist of elements of groups IV/III–V and IV/II–VI, are conducted by researchers of leading universities and research centers around the world. In particular, in (Liyang Jiang, Toshihiro Aoki, David J. Smith, Andrew V. G. Chizmeshya,

§ Jose Menendez, and John Kouvetakis, 2014; Joongoo Kang, Ji-Sang Park, Pauls Stradins, and Su-Huai Wei. 2017), the possibilities of nonequilibrium growth of complexes of Si-IV/III–V and Si-IV/II–VI -type compounds for receiving optically sensitive materials based on Si have been described. In (Liyang Jiang, Toshihiro Aoki, David J. Smith, Andrew V. G. Chizmeshya, § Jose Menendez, and John Kouvetakis, 2014; Joongoo Kang, Ji-Sang Park, Pauls Stradins, and Su-Huai Wei. 2017), the authors suggest that the “hybrid” phases of Si_2AlP (or Si_2ZnS) with lattice constants close to the lattice constant of the base matrix might be ideal materials with controlled local chemical order around Si atoms. In the above-mentioned studies, using the first-principles calculation methods, the authors discuss the influence of chemical order on the electronic and optical properties of non-isovalent solid solutions.

In this regard, this paper deals with modelling and quantum-mechanical calculation of a hypothetical structure Si_2MnS (Fig. 1) which is similar to the cubic structure $F43m-\beta\text{-MnS}$ (zinc blende). In doing this the authors have been motivated by a number of interesting studies done in this area.

In particular, in (Otrokov, M. M., Ernst, A., Tugushev, V. V., Ostanin, S., Buczek, P., Sandratskii, L. M., Fischer, G., Hergert, W., Mertig, I., Kuznetsov, V. M., and Chulkov, E. V., 2011) to model the SiN/Mn molecular alloy, the researchers applied $(N+1)$ -layer-thick tetragonal supercells, composed of N monolayers of Si and one Mn molecular layer. The

three different Mn configurations were considered, i.e. the substitutional site MnS (1), interstitial site MnI (2), and the configuration, labeled as IS (3), where Mn atoms occupy both interstitial and substitutional positions.

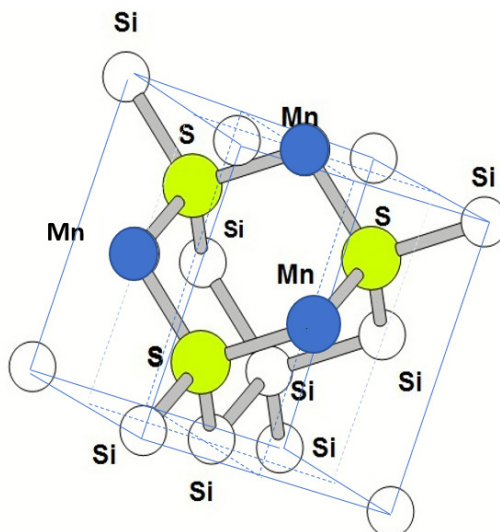
The Si thickness has varied between 7 and 31 monolayers. The unit cell vectors **a**, **b**, and **c** were directed along $[110]$, $[\bar{1}10]$, and $[001]$, respectively, with $\bar{a} = b = a_{\text{Si}}/\sqrt{2}$ and $c = a_{\text{Si}(N+1)}/4$, where $a_{\text{Si}} = 5.46 \text{ \AA}$ is the equilibrium lattice parameter of Si.

For the structural relaxation in (Otrokov, M. M., Ernst, A., Tugushev, V. V., Ostanin, S., Buczek, P., Sandratskii, L. M., Fischer, G., Hergert, W., Mertig, I., Kuznetsov, V. M., and Chulkov, E. V., 2011), the authors used the Vienna *ab initio* Simulation Package (VASP) 49–51 within the generalized gradient approximation to exchange-correlation potential.

The electron-ion interactions were described by projector-augmented wave pseudopotentials, and the electronic wavefunctions were represented by plane waves with a cutoff energy of 500 eV.

In this work, the authors investigated how magnetic properties of the concerned material affects the structural properties of such solutions. After optimization, the authors identified a shift in the positions of Mn atoms in three configurations, which changed the structural properties of the material. When studying the magnetic properties, exchange interactions were also taken into account. Spin-polarized densities of electron states were calculated for three configurations.

Figure 1. Cubic $F43m-\beta$ - MnS (zinc blende)-type hypothetical structure of Si_2MnS



In this regard, as noted above, we have chosen the cubic $F43m - \beta - MnS$ (zinc blende)-type hypothetical structure of Si_2MnS (Fig. 1) for further modeling and quantum-mechanical calculations.

An isolated Mn atom in Si matrix mainly occupies a tetrahedral interstitial position in the Si lattice acting as a donor and thus becoming a positively charged ion, while if the Mn atom occupies a substitutional position it acts as an acceptor thus becoming a negatively charged ion. The situation in the Si: Mn dilute alloys is, however, more complex. These materials attracted more interest after the observation of a ferromagnetic (FM) state with high Curie temperature of about 400 K (Otrokov, M.M., Ernst, A., Tugushev, V.V., Ostanin, S., Buczek, P., Sandratskii, L.M., Fischer, G., Hergert, W., Mertig, I., Kuznetsov, V.M., and Chulkov, E.V., 2011).

Detailed x-ray and magnetic studies of Si: Mn dilute alloys with low and moderate (from 0.5 to 17.5 at. %) Mn content indicated that, possibly due to extremely difficult doping control process, these systems tend to be in very inhomogeneous state, and the Mn ions enter not only substitutional or interstitial positions of the Si lattice but also could form molecular clusters and precipitates (Otrokov, M.M., Ernst, A., Tugushev, V.V., Ostanin, S., Buczek, P., Sandratskii, L.M., Fischer, G., Hergert, W., Mertig, I., Kuznetsov, V.M., and Chulkov, E.V., 2011).

Sulfur, in turn, as an element of group VI of the periodic table, occupying a substitution position, participates in the formation of sp^3 -hybrid bonds with four nearby silicon atoms. In this case, the remaining two excess electrons introduce two donor levels into the forbidden band of silicon.

Thus, and owing to:

- the presence in of the cubic structure of $F43m - \beta - MnS$ (zinc blende) similar to the cubic structure of diamond-type silicon;
- the existing experimental facts confirming cases of substitution of Mn and S atoms for Si crystal structure sites;
- the availability of the computing processing power and quantum-mechanical apparatus;
- the fact of ever improving methods for controlling doping processes whereby

appears a real chance to exactly specify the position of an impurity atom with a highly predictable probability (especially since effective methods for controlling the alloying process have been developed recently by using the so-called δ -alloying method (Harris, J.J., 1993; Nazmul, A.M., Amemiya, T., Shuto, Y., Sugahara, S., and Tanaka, M., 2005), when the position of the impurity is confined on the length scale corresponding to the lattice constant, and is thus placed into the base matrix of Si) all the above-mentioned pre-conditions make it possible to theoretically model, calculate such structures, perform experimental doping of silicon with manganese and sulfur impurities, compare experimental data with quantum mechanical calculation results, and afterwards forecast similar structures in the future.

The calculations were performed using and thanks to free software Abinit, designed for calculations applying the density functional method, the Firefly Quantum Chemistry License Package and the freely distributed visualizer programs ViewMol3D and Molekel.

Using the available quantum-chemical and molecular-dynamic methods, a diamond lattice cell of Si with four surrounding atoms located at the vertices of a regular tetrahedron inside a cube, as well as a diamond-type crystal lattice structure, were constructed. The corresponding lattice parameters $a = 5.43095 \text{ \AA}$, $d(A-B) = 2.35167 \text{ \AA}$, and $d(A-A) = 33.84026 \text{ \AA}$ were set for Si.

The numerical calculation revealed noticeable changes in the charge state and the electrostatic potential of the Si matrix with Si_2MnS cells compared to the base Si lattice. Mn atoms in substitutional positions acquire a negative charge, whereas S atoms in substitutional positions acquire a positive charge, resulting in an ionic component of the interatomic bond, which confirms the theory of a “*partially ionic and partially covalent*” components of the bond in binary compounds in the basic matrix of Si. The electronic spectrum of the Si_2MnS structure with absorption peaks corresponding to transition energies of 2.65 eV, 2.39 eV, 2.28 eV, 2 eV, 1.8

eV and 1.01 eV were also revealed by calculations. The results of numerical calculation of the position of valence electrons of the Si_2MnS structure revealed the gap value $E_g = 0.22$ eV, which is confirmed by the presence of the highest occupied orbital HOMO with a value of 0.1431 eV and the lowest unoccupied orbital LOMO with a value of 0.0811 eV, respectively.

In parallel, doping of Si with sulfur and manganese by using diffusion doping technique in vacuumed (10–4 bar) and sealed quartz ampoules at a temperature of 1260 °C and 1200 °C, respectively, was carried out for a duration that would be sufficient for ensuring uniform doping. The initial samples were Si doped with boron, with an initial specific resistance in the range of $\rho = 1 \Omega \text{ cm}$. After doping with Mn and S, the initial silicon remained of *p*-type, but the resistivity increased to $\rho = 2.4 \times 10^4 \Omega \text{ cm}$.

In order to study the photoconductivity (PC) curve of the silicon sample doped with Mn and S, the PC measurements have been done at IKS (infrared diapason)-21 – type spectrometer equipped with a cryostat, which allows to study photoconductivity in a wide temperature range ($T = 77 \div 350 \text{ K}$). To study the impurity photoconductivity only, a double filter of polished monocrystalline silicon wafer was used, which was installed before the cryostat window after the infrared light emitter of IKS-21.

Photoconductivity in silicon samples doped with Mn and S in the dark launches at $h\nu \approx 0.226 \text{ eV}$. In the range of $h\nu = 0.226–0.42 \text{ eV}$, with an increase in the photon energy, the photoconductivity increases continuously and then the saturation region of the photocurrent gradually begins to manifest itself. At $h\nu = 0.42 \text{ eV}$, a sharp decrease in photoconductivity occurs, and a further increase in the

photon energy leads to a noticeable decrease in photoconductivity value with a relatively deep minimum at $h\nu \approx 0.45–0.46 \text{ eV}$.

In view of the above mentioned it could be stated that the quantum-chemically calculated gap value, i.e. $E_g = |-LOMO-HOMO| \approx 0.22 \text{ eV}$ of the Si_2MnS structure, with a certain degree of consent, is confirmed by the appearance of the level $E_i \approx 0.226 \text{ eV}$ revealed in the course of study of photoconductivity of the Si<Mn, S> sample (Mavlyanov, A. Sh., Aminov, N. Sh., Sultanova, Yu. A., Khujaniyazova, A., 2019), which is most probably associated with the excited transition of an electron from an impurity level to the conduction band.

Conclusion

According to the authors, any further in-depth theoretical studies, the detailed quantum-chemical calculations and more thoroughly performed experiments in the field of engineering a new class of hybrid compounds with a cubic lattice of the diamond type where the elements of groups IV/III–V and IV/II–VI are embedded in Si matrix, will make it possible to forecast novel crystal structures in the future.

Meanwhile, experimental study of the structural and electrophysical properties of such materials on single-crystal silicon doped with impurity atoms hypothetically forming Si-IV/III–V and Si-IV/II–VI-type compounds would contribute to the expansion of the parameters of single-crystal silicon and could shed light on the possibility of engineering silicon materials with close coordinates of absolute minima in momentum space. In this case, it is necessary to take into account the fact that the electronic properties of such structures will differ depending on the ordered and random arrangement of impurity atoms in the silicon lattice.

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© Utamuradova Sh. B., Mavlyanov A. Sh., Matchonov Kh. J.

Contact: sh-utamuradova@yandex.ru; microelectronics74@mail.ru; husniddin94_04@bk.ru

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INTERACTION OF LIGHT WITH A SILICON CRYSTAL LATTICE MODIFIED WITH GADOLINIUM ATOMS

*Utamuradova Sharifa Bekmuradovna*¹, *Daliev Shakhrukh Khojakbarovich*¹,
*Khamdamov Jonibek Jumayevich*¹, *Matchonov Khusniddin*
*Jamoladdinovich*¹, *Utemuratova Khushnida Yusupbekovna*²

¹ Research Institute of Semiconductor Physics and Microelectronics

² Karakalpak State University

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Abstract

The paper presents the results of a study of the effect of gadolinium on the structure of silicon samples, performed using scanning electron microscopy (SEM) and Raman spectroscopy. The distribution of carbon and silicon on the surface of gadolinium-doped substrates was studied using energy-dispersive analysis (EDS). An uneven distribution of carbon atoms was found, with noticeable clusters in certain areas of the surface. The analysis showed a high carbon content, indicating its significant presence in the samples. Small oxygen concentrations indicate the presence of oxide compounds. Doping with gadolinium led to the formation of defects on the surface and an uneven distribution of carbon. Analysis of the Raman spectra showed the presence of several vibrational modes, including scattering on acoustic and optical phonons, as well as modes associated with gadolinium and gadolinium oxide. In addition, the spectra revealed new signals that increase with increasing resistivity of the samples.

Keywords: *silicon, gadolinium, Rare Earth Element, Energy-dispersive spectroscopy, Raman Spectra, Diffusion, Heat Treatment, Defects*

Silicon is the main material of the modern semiconductor and optoelectronic industries (Utamuradova, Sh.B., Matchonov, Kh.J., Khamdamov, J.J., & Utemuratova, Kh.Y., 2023) due to its unique electrical and optical properties. At the same time, there is a need to further modify its characteristics to expand the areas of application. One of the ways to modify the characteristics of silicon is to in-

troduce rare earth elements such as gadolinium (Gd), which can significantly affect the magnetic and optical properties of silicon. Studies have shown that gadolinium atoms introduced into the silicon crystal lattice are able to change its interaction with light and magnetic characteristics, which makes such materials promising for use in optoelectronics, sensor devices and spintronics.

Modification of silicon with gadolinium atoms causes structural changes that significantly affect its optical and magnetic properties. In particular, the introduction of gadolinium into silicon leads to changes in the crystal lattice, which causes deformation and a change in the optical activity of silicon. According to studies, the presence of gadolinium atoms in the silicon lattice can change the photochemical activity of the material, improving its ability to interact with radiation. This is due to the fact that gadolinium retains its magnetic moments even when diffused into the silicon lattice, due to localized d -electrons, which is especially important for applications in spintronics (Jucui Yang, Yutong Feng, Xiaohong Xie, Huiwa Wu, and Yuming Liu., 2016; Sercheli M. S., Retto-ri C., 2002, June).

One of the key effects is the reduction in the density of “hanging” bonds of silicon when gadolinium is introduced. Studies have shown that trivalent Gd^{3+} ions help reduce the number of defects in the crystal structure, which improves the electronic properties of the material and reduces the number of defects on the surface. It was also found that gadolinium, interacting with silicon, improves the magnetic characteristics of the material, making it suitable for use in magnetic sensors and devices using spin effects.

Raman spectroscopy is widely used to study crystalline materials, including semiconductors, including silicon (Utamuradova, S.B., Daliev, S.K., Khaitbaev, A.K., Khamdamov, J.J., Matchonov, Kh.J., & Utemuratova, X.Y., 2024). In Raman spectroscopy, light interacts with phonons (quanta of sound vibrations of the crystal lattice). As a result of this interaction, Raman scattering of light occurs, which creates characteristic spectral lines.

Phonons interact with photons of light, causing changes in their energy and frequency. These changes are reflected in the Raman spectrum. Each crystal structure has its own phonon modes, which appear in the Raman spectrum. In the case of silicon, phonon modes associated with the diamond structure of silicon can be detected. In the Raman spectrum, the position of the lines, their intensity, and the width of the lines are usually measured. Raman spectroscopy is a powerful tool for studying crystalline materials at the molecular level, and its appli-

cation in the study of semiconductors and nanomaterials allows obtaining important information about their structure and properties (Jones, R. R., Hooper D. C., Zhang L., Wolverson D., & Valev V. K., 2019).

Doping silicon with rare earth elements such as gadolinium (Gd) can significantly change its properties and, therefore, cause changes in the Raman spectra. Doping also affects the formation of defects and deformations in the crystal lattice. Changes in the Raman spectra can provide information about such structural changes. Studying the effect of gadolinium doping of silicon on Raman scattering can provide information about the possibility of technological applications of such materials in the fields of electronics, optics and nanotechnology.

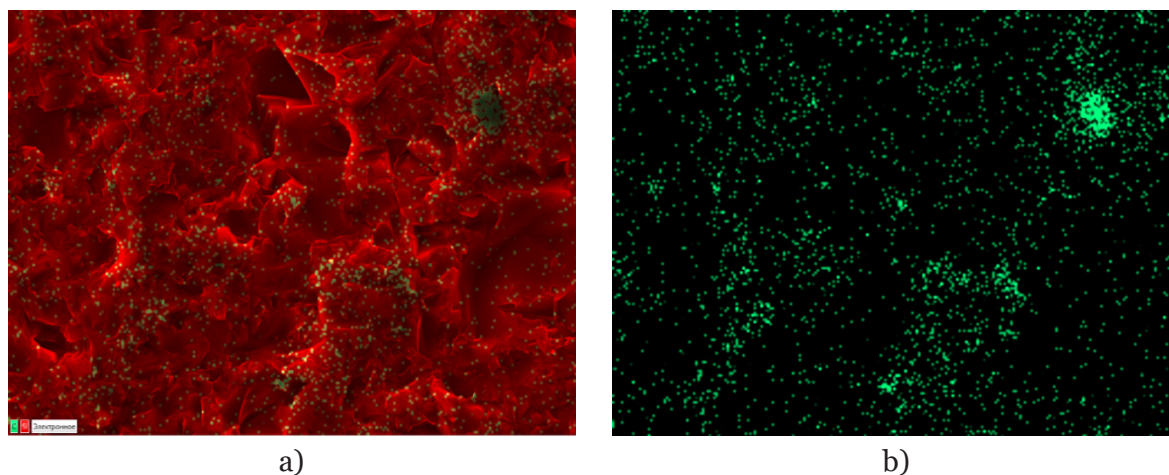
In this paper, we present the results of studying the one- and two-phonon Raman spectra of single-crystal silicon doped with Gd atoms.

For the study, n -Si and p -Si samples with an initial specific resistance from 0.3 to $40 \Omega \times \text{cm}$ were selected. Before doping, the samples were subjected to thorough acid-peroxide washing, while the oxide layers were removed from the surface of the samples using an HF solution. After thorough cleaning of the sample surface, high-purity gadolinium impurity films (99.999%) were applied to the clean Si surfaces using vacuum sputtering. Vacuum conditions in the volume of the working chamber of the order of 10^{-7} – 10^{-8} torr were provided by an oil-free vacuum pumping system.

Before diffusion annealing, the samples were placed in evacuated quartz ampoules. The samples were doped with Gd impurity by the diffusion method at a temperature of $1200 \text{ }^\circ\text{C}$ for 20 hours, followed by rapid cooling. To study the interaction of impurity atoms in silicon, not only uniform doping of the material is necessary, but also maximum concentration. In this regard, we took into account the optimal conditions for doping silicon with these impurity atoms.

The study of the surface of silicon doped with gadolinium during the growth process using energy-dispersive spectroscopy (EDS) and scanning electron microscopy (SEM) made it possible to identify the structural and elemental features of the material.

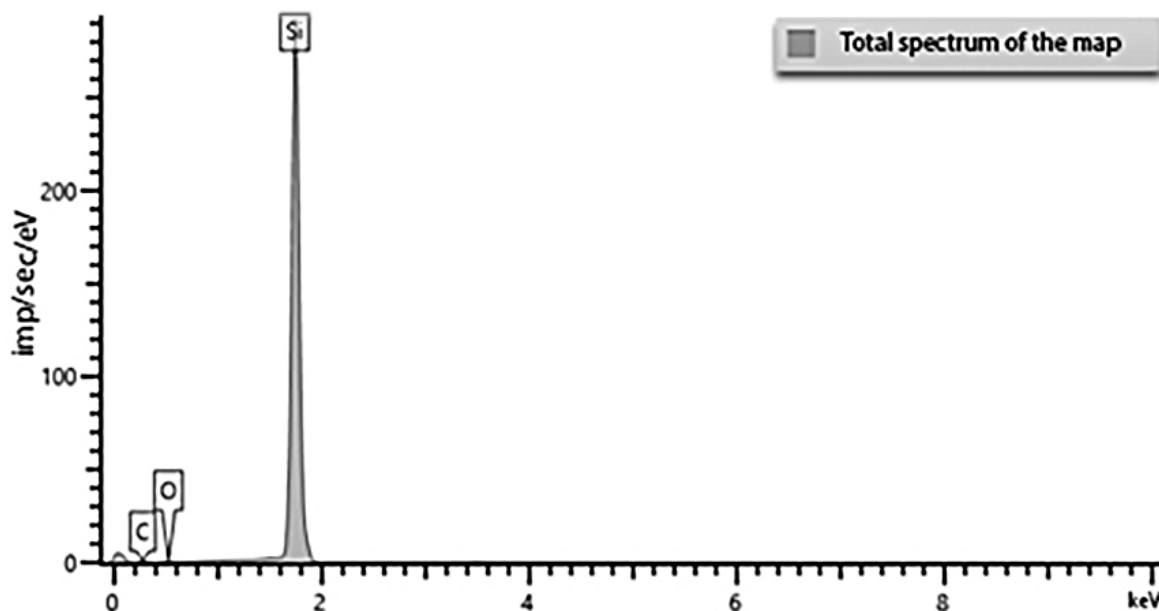
Figure 1. SEM images of the surface of silicon doped with gadolinium during the growth process



The SEM image (Fig. 1 a) showed that the carbon (green) and silicon (red) atoms were distributed unevenly over the sample surface, with noticeable areas of carbon accumulation. This is confirmed by the carbon distribution map (Fig. 1 b), which shows significant accumulations of this element in certain areas of the surface.

The EDS spectrum revealed a dominant peak of silicon (Si) with minor peaks of oxygen (O) and carbon (C) (Fig. 2). The bulk of the material is silicon, as expected for silicon substrates doped with gadolinium during growth. The presence of oxygen and carbon indicates possible contamination or oxidation of the surface.

Figure 2. EDS spectra of silicon samples doped with gadolinium during growth



According to the quantitative analysis (Table 1), the weight fraction of silicon is 86.79% and carbon is 11.90%, which confirms the significant presence of carbon on the surface. The atomic concentration of carbon (23.81%) indicates its high proportion in the sample composition. Oxygen (1.96%)

may indicate the presence of oxides, probably formed on the surface during the growth process or subsequent storage.

Gadolinium doping during growth may have affected the silicon surface structure, creating defects that contributed to the uneven distribution of carbon. The presence of

oxygen and carbon may be due to processes occurring during gadolinium doping, as

well as possible contamination that occurred during sample handling or storage.

Table 1. Summary Spectrum of the Map

Element	Line Type	Conditional Concentration	Wt%	At. %
C(Carbon)	K-series	0.61	11.90	23.81
O(Oxygen)	K-series	0.56	1.31	1.96
Si(Silicon)	K-series	92.59	86.79	74.23
Total:			100.00	100.00

Raman spectra were studied using a Bruker SENTERRA II Raman spectrometer. This fully automated instrument combines excellent sensitivity with a high resolution of 4.0 cm^{-1} . Senterra calibration was performed automatically and was linked to NIST standards, acetaminophen and silicon, resulting in a wavelength measurement accuracy of 0.2 cm^{-1} . The experiments were performed using a laser with a wavelength of $I_0 = 532 \text{ nm}$, a maximum power of $P_{\text{max}} = 25 \text{ mW}$, an acquisition time of 100 s and addition of two spectra. This instrument allows obtaining spectra in the range from 50 to 4265 cm^{-1} . Raman spectra were specially processed to be able to compare intensity ratios between samples. Before normalizing the spectra to the peak at 510 cm^{-1} , which corresponded to the most intense peak in the spectral region $4265\text{--}50 \text{ cm}^{-1}$, we subtracted the baseline for each spectrum.

It is known that the lattice constants of Gd and Si differ, therefore, if a substrate of one material (Si) is grown on top of another (Gd), built-in elastic stresses appear in the Gd, Si layers, as well as in multilayer Gd-Si structures (Ramabadran, U., & Roughani, B., 2018). In this case, the elastic stresses are so significant that they significantly affect the band structure of charge carriers and phonon spectra. The magnitude of the lattice mismatch largely determines the quality of the structures, since stresses generate the formation of structural defects and in some cases greatly limit the possibilities of creating perfect heterocompositions. In the case where the layer material is a solid solution, the lattice mismatch becomes smaller than in the case of a structure of pure Si and Gd composition, the deformations of the material change the crystal structure, and thus mani-

fest themselves in changes in the vibrational, phonon spectra.

We have studied the Raman spectrum of the $\text{Gd}_x\text{Si}_{1-x}$ solid solution ($x = 0.25$) grown on a Si substrate with the (100) orientation. The thickness of the solid solution layer is $5 \mu\text{m}$. This means that such a layer is relaxed. It follows that the lattice constant of the $\text{Gd}_x\text{Si}_{1-x}$ layer will lie in the interval between the lattice constants of Gd and Si.

Raman spectra of epitaxial films of Gd-Si solid solutions with different Gd and Si contents, grown on Gd substrates in the case of a low percentage of Si, and on Si in the case of a low percentage of Gd. The shift of the peaks of local Gd-Gd and Si-Si vibrations associated with the change in the values of deformations is clearly visible.

In the KPC spectra, three ranges of Raman shift frequencies can be distinguished, determined by the masses of the constituent elements and the elasticity coefficients of the present bonds: these are vibrations of the atoms of the Gd-Gd bonds (about 238 cm^{-1}), Gd-Si bonds (783 cm^{-1}), and Si-Si (510 cm^{-1}). The built-in stresses caused by the significant difference in the lattice constants of Gd and Si have a significant effect on the position of the lines in the spectra.

It is known that (Vas'kovskiy, V.O., Svalov, A.V., Gorbunov, A.V., Schegoleva, N.N., & Zadvorkin, S.M., 2014) when growing a layer with a different lattice constant on a substrate, the layer being grown initially grows with the lattice constant of the substrate (i.e. deformed), but starting from a certain layer thickness, the formation of dislocations is energetically favorable, after which the layer continues to grow with its lattice constant. Such layers are called relaxed or unstressed.

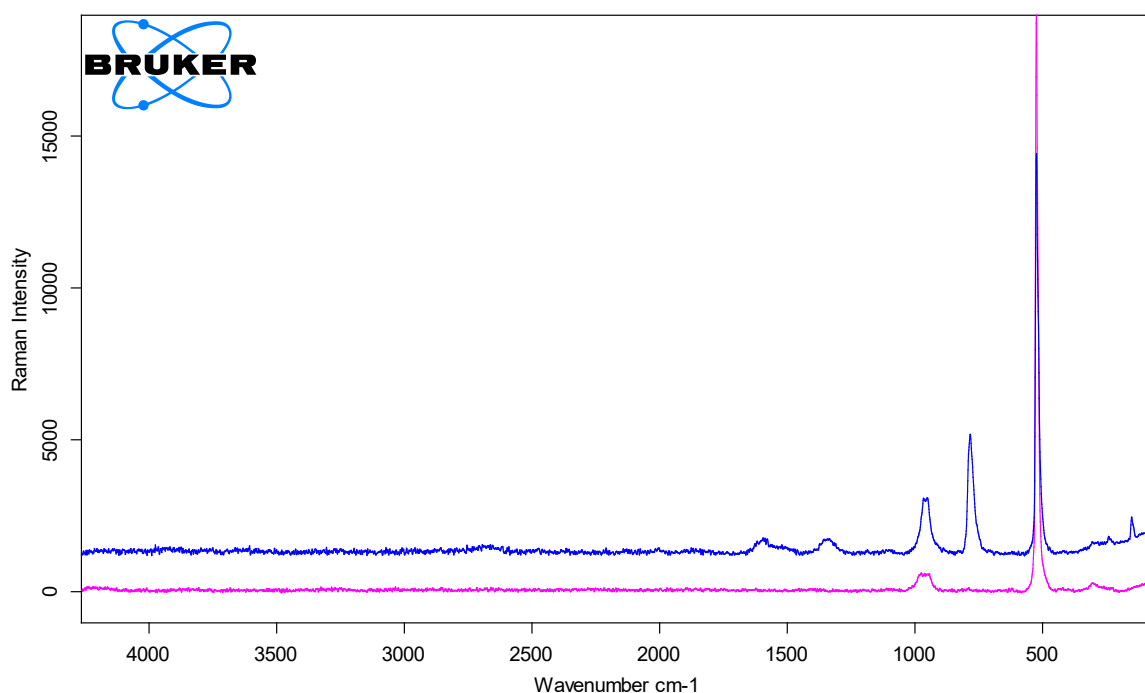
When analyzing the spectra, the intense band of asymmetric stretching vibrations $\nu_{as}(\text{Si-O})$ at 1067 cm^{-1} was chosen as an internal standard. The baseline was drawn through the absorption minima at wave numbers of 4000 and 755 cm^{-1} . The analyzed samples were compared based on the relative optical density of the characteristic bands in the reduced form to the optical density of the internal standard band.

Thus, the detected changes in the Raman spectra of gadolinium-doped silicon samples

suggest that a bond is formed between gadolinium atoms and silicon atoms in the sample under study.

The Raman spectra of the n-type silicon sample doped with Gd impurity atoms are shown in (Fig. 3). The Raman spectrum of the Si <Gd> samples shows a high peak in the region of $521\text{--}522 \text{ cm}^{-1}$. The intensity of the first-order scattering caused by optical phonons (TO - transverse optical vibrations, LO - longitudinal optical vibrations) at the central point Γ of the Brillouin zone (BZ).

Figure 3. Raman spectrum of n-type silicon doped with Gd impurities: 1 – Raman spectrum of $\text{Si}_{\text{original}}$ samples, 2 – Raman spectrum of $\text{Gd}_x\text{Si}_{1-x}$ samples, $\rho_{\text{original}} = 40 \Omega \times \text{cm}$



C:\spectry\EXTRACT_p=40 Gd-Si 1200 20 s.0_000002.2	Sample	Senterra II	4/13/2023
C:\spectry\EXTRACT_p=40 Gd-Si 1200 20 s.0_000015.0	Sample	Senterra II	4/13/2023

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In contrast to the 521 cm^{-1} mode, the Raman spectrum exhibits a peak with several vibrational modes. Using the Gaussian distribution of this peak, it was found that the Raman at 123 and 186 cm^{-1} belongs to the vibrational modes of Gd (Kasirajan, K., Bruno Chandrasekar, L., Maheswari, S., Karunakaran, M., & Shunmuga Sundaram, P., 2021), and the 148 cm^{-1} mode is related to the first-order scattering on acoustic phonons (TA), which characterizes the SiO_2 bond. The weak peak at 456 cm^{-1} is the result of scattering on optical phonons (LO). The latter

peak indicates the presence of silicon in the amorphous state (Tony, D.K., James, C.P., John, W.M., Volodymyr, T.A., Yaroslav, V.B., Bohdan, V.P., Ihor, M.T., Ning Lu, Lu Wang, Wai-Ning Mei and Peter, A.D., 2014).

The second-order spectrum is much weaker than the first-order LTO (Γ) peak with characteristics in the range of $100\text{--}1100 \text{ cm}^{-1}$. The second-order spectrum of transverse 2TA acoustic phonons is clearly observed near 303 cm^{-1} . Some authors suggest that this peak corresponds to the LA modes (Daliev, K.S., Utamuradova, Sh.B.,

Khaitbaev, A., Khamdamov, J.J., Norkulov, Sh.B., and Bekmuratov, M.B., (2024), but there is no exact confirmation of this fact. Probably, we observe a superposition of transverse and longitudinal acoustic modes. There is also a broad peak between 900–1000 cm^{-1} , which is due to the scattering of several transverse optical phonons $\sim 2\text{TO}$ phonons (Daliev, K.S., Utamuradova, Sh.B., Khaitbaev, A., Khamdamov, J.J., Norkulov, Sh.B., and Bekmuratov, M.B., 2024).

The peak broadening can be caused by the high defect density and local composition fluctuations (Daliev, K.S., Utamuradova, Sh.B., Khaitbaev, A., Khamdamov, J.J., Norkulov, Sh.B., and Bekmuratov, M.B., 2024). From the comparison of our results with the literature data, it was found that the modes at 954, 1340 and 1610 cm^{-1} are associated with combination vibrations of the GdO structure. Whereas, the peaks at 1462 and 1600 cm^{-1} are related to third-order Si scattering vibra-

tions caused by optical phonons (TO) (Tony, D.K., James, C.P., John, W.M., Volodymyr, T.A., Yaroslav, V.B., Bohdan, V.P., Ihor, M.T., Ning Lu, Lu Wang, Wai-Ning Mei and Peter, A.D., 2014; Daliev, K.S., Utamuradova, Sh.B., Khaitbaev, A., Khamdamov, J.J., Norkulov, Sh.B., and Bekmuratov, M.B., 2024; Hong, W.-E., & Ro, J.-S., 2013) and vibrations of interstitial oxygen (O_2), respectively (Daliev, K.S., Utamuradova, Sh.B., Khaitbaev, A., Khamdamov, J.J., Norkulov, Sh.B., and Bekmuratov, M.B., 2024; Hong, W.-E., & Ro, J.-S., 2013).

Thus, with an increase in the specific resistance of the studied samples from $\rho_{\text{inh}} = 0.3 \Omega \times \text{cm}$ to $\rho_{\text{inh}} = 40 \Omega \times \text{cm}$, new signals appear in the region of: 68, 123, 148, 238, 303, 456, 784, 954 1340 and 1610 cm^{-1} and then their intensities increase. The most significant band observed at 784 cm^{-1} , in our case, corresponds to the stretching vibrations of the Gd – Si bond.

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© Utamuradova Sh. B., Daliev Sh. Kh., Khamdamov J. J., Matchonov Kh. J., Utemuratova Kh. Y.
Contact: sh-utamuradova@yandex.ru; husniddin94_04@bk.ru

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