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# Concept for Detection of Viral Agents via Optically Induced Electrical Signals

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## Abstract

**Introduction:** In our research we have discovered a phenomenon known as the electro magnetic echo effect (EMEE), which generates a detectable signal when electromagnetic radiation interacts with solid matter. The signal is extremely sensitive to small changes in gas, liquid, and solid composition, allowing fast and real time control. After successful previous experiments, we propose the idea of creating a sensor system to identify viruses. The goal is to detect pathogens in air, on surfaces, and in body fluids by sensing the reaction between viruses and a solid layer of immobilized antibodies. These signals are typically too weak to be perceived, but EMEE is well suited for detecting them. **Methods:** This article presents the concept of developing such a sensor. This concept is continuation of our previous research projects, such as designing sensors for the detection of chemical and biological fluids and airborne contaminants. The present work is conceptual and does not include direct experimental data for specific viral detection yet. **Conclusion:** Our previous studies of reactions at the solid–air interface have demonstrated high sensitivity and signal stability, supporting the expectation that similar performance can be achieved in the present case. **Discussion:** EMEE sensors can be applied to various high-risk locations and connected with artificial intelligence. These sensors can be integrated into mobile and smart infrastructure, with a flexible and scalable platform to advanced bio-sensing and public health monitoring. Potential advantages of the proposed approach include high sensitivity and rapid response, although factors such as selectivity and possible environmental interferences require further investigation.

**Keywords:** Biosensor; Virus detection; Pathogens; Electromagnetic echo effect, Antibodies immobilization

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## 1. Introduction

In recent years, researchers at the Institute of Solid State Physics (ISSP) of the Bulgarian Academy of Sciences discovered and further developed the electromagnetic echo effect known as EMEE [1], which has previously been referred to as the surface photocharge effect [2,3]. It is founded on the interaction between a solid material and an electromagnetic field. Due to this interaction, there is an alternating electrical signal generated in the object, which possesses identical frequency as the electromagnetic field irradiating it [4]. That which makes the EMEE greatly important is that it can take place in all materials of any type. These include conductors, semiconductors, to insulators. As a result, the EMEE presents an effective way of making fast, precise, and reliable measurements of an extensive range of materials. The other major benefit is the affordability of EMEE-based devices. These systems are simpler to manufacture, cheaper to operate, and less expensive in the long run compared to conventional sensing technologies. These attributes make EMEE-based sensors ideal, particularly in many applications that require affordable and easy to maintain technology. Other research groups have also investigated sensor systems based on electromagnetic field–matter interactions, reporting interesting relevant results [5,6]. In particular, optical and plasmonic biosensing platforms have shown high sensitivity and real-time performance in detecting biological targets, including viruses, through surface interaction mechanisms [7-12].

The need for finding suitable sensors for detection of coronaviruses has become more pressing in recent years, during which a growing number of severe respiratory viruses such as SARS-CoV, MERS-CoV, and most recently SARS-CoV-2 (COVID-19), is observed [13]. Pathogens placed huge pressures on public health systems globally, and also the need for efficient and precise detection of viruses has never been greater. To meet this need, a research team from ISSP has devised a detailed strategy for designing and developing EMEE-based sensors to specifically detect various infections. The goal of these investigations is to take full advantage of the unique physical properties of the EMEE in an effort to present a new and effective virus detection method.

In recent years, various optical and electromagnetic biosensing methods have been investigated for the detection of viruses. The techniques that are based on detection without the need for labeling, and surface-sensitive methods have demonstrated significant potential for rapid and sensitive diagnostics. These approaches highlight the growing interest in developing alternative sensing mechanisms for virus detection in real-time.

## 2. Methods

Experiments have demonstrated that the EMEE is triggered by electromagnetic radiation not only in the visible spectrum and near bands, but even at significantly lower frequencies, ranging from as low as 1 Hz to as high as 1 GHz. Such a wide span prompts us to consider that the EMEE can, in principle, occur throughout the entire electromagnetic spectrum. However, under the present technological limitations, regions from 1 GHz to infrared, and those above the ultraviolet remain hard or impossible to implement. There has been no investigation in these high-frequency regions as yet, mainly because the necessary equipment is unavailable, or it is extremely expensive.

At lower frequencies, one can directly measure at the same frequency as the radiated electromagnetic field. In the visible and adjacent regions, one needs an additional amplitude modulation of the radiation. The technique compensates for the fact that, so far, measuring signals at higher gigahertz or terahertz frequencies with sufficient accuracy it is difficult.

The second feature of the EMEE is that it does not occur under a stationary electric field. It provides a simple method of verifying whether a signal detected is really produced by the EMEE, or by some other related phenomena, for example, photoelectric or thermoelectric effects. Other methods of verification of the origin of a signal also exist. For instance, EMEE and external photoelectric signals can be distinguished using spectral analysis. This is because the external photoelectric effect has a sharp wavelength threshold. Radiation with wavelengths above the threshold cannot cause the effect. The EMEE, however, can still be observed at such wavelengths, allowing the two effects to be cleanly separated [14].

Various theoretical models have been proposed to explain EMEE behaviour in different materials. In conductors, the effect seems to be due to a redistribution of surface charges induced by the incident electromagnetic field. The redistribution changes the electrostatic potential across the double layer present at the surface, generating a measurable voltage. Despite these advances, no single theoretical model has yet been able to describe fully how the EMEE operates in all types of solids, including metals, semiconductors, and dielectrics [3,15].

One of the most useful aspects of the EMEE is that it can yield material-specific signals. In the same way that the response of an object to gravity is defined by its mass, the response of an object to an electromagnetic field defines the nature of the EMEE signal that it produces. Each material, therefore, has an EMEE signature that is distinct and can serve as a fingerprint of its internal structure and surface features.

To observe the electromagnetic echo phenomenon under controlled conditions, we have designed a special experimental setup that is tailored for experiments in the visible range of the electromagnetic spectrum. The highlight of this setup is a light source (L) which has the capability to emit either white light spanning a wide spectrum, or a narrow beam of monochromatic radiation, such as one from a laser. On practical grounds, a laser is employed since it possesses higher precision and stability. The light beam is modulated into a train of pulses by a modulator (M), creating a periodic pattern of light. A pulsed laser or a modulated light-emitting diode (LED) can also be used in place of an external modulator to achieve the same result. A preamplifier (A) is therefore included in the system to amplify the signal before it is sent to a sensitive measuring instrument. A lock-in nanovoltmeter (N) is used for measuring and detecting the signal. The instrument can discriminate between the EMEE signal and background noise by referencing the modulation frequency supplied by the modulator. In this way, only the signal of interest is picked up and unwanted noise is effectively rejected.

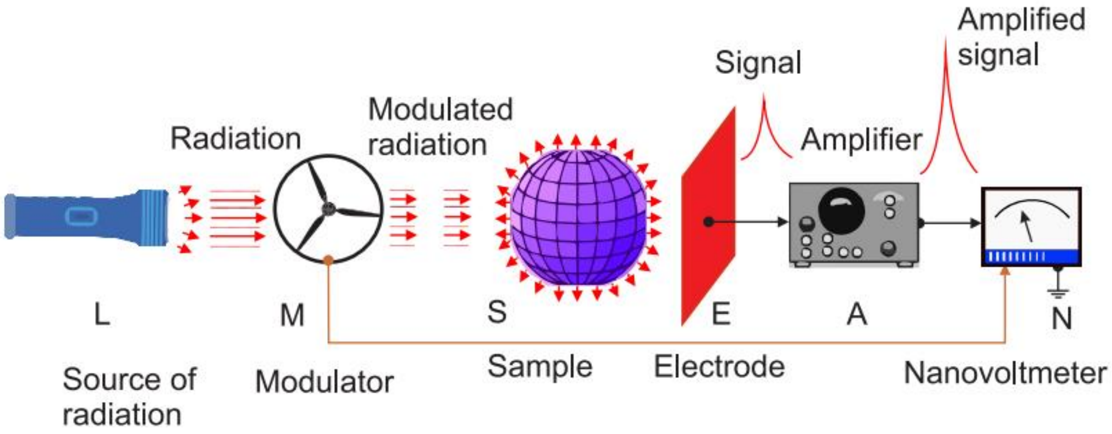

Fig. 1. Experimental setup for EMEE observation: L - light source; M - modulator; S - measuring structure; E – electrode; A - amplifier; N - lock-in nanovoltmeter.

In Fig. 2. is shown where the sample to be assayed (S) is put into a specially designed measurement apparatus that allows stable positioning and protects the signal from electromagnetic interference. This is one version of the sensor setup. Mechanical construction is critical because even very small disturbances affect the weak signals involved. The output from the sample is typically of low amplitude.

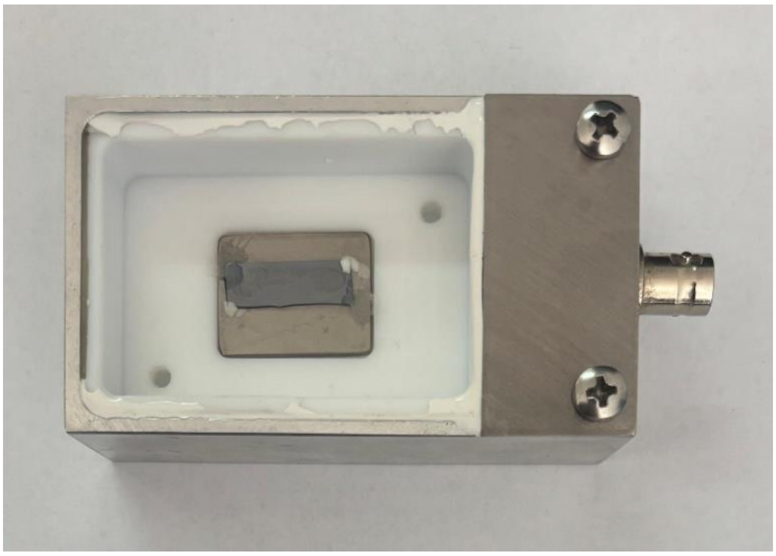

Fig. 2. Real-life view of the measuring structure and electrode, corresponding to the sample (S) and electrode (E) shown in Figure 1. The sample is positioned in a specially constructed measurement cell designed to ensure stability and reduce electromagnetic interference. This setup allows precise signal collection, which is essential due to the very low amplitude of the EMEE signal.

There exist numerous practical EMEE applications that have been experimented on with this system. They vary from non-contact examination of semiconductor material [15], tracking dynamic processes in liquids [4, 16-18], including biologically active liquids [19], to assessing surface properties such as defects, contamination, or irregularities [4]. Some other applications include measuring the octane number of gasoline [18], counterfeit coin detection, and measuring the saturation level of gas or liquid filters to determine when they need replacement. EMEE has also been applied to rapid contactless chemical composition analysis like public drinking water quality analysis [4], monitoring phase changes in liquid crystals [20], raw material identification [4], and fog density and particulate analysis [21].

Our work illustrated that EMEE gas, liquid, and vapor sensors are very promising for real-world applications. The same principle is applied in all kinds of fluids: a solid substrate is subjected to an electromagnetic field when in direct contact with the fluid to be sensed. At the interface between the fluid and the solid, which is called the interface, fluid property changes cause fluctuations in the EMEE signal. The fluctuations are particularly pronounced within the radiation-exposed area, where the signal is produced.

The interface between the fluid and the solid is very sensitive to even very small changes in the fluid's properties. We are planning to use solid-state layers of immobilized antibodies that stay on the sensor surface. This will allow the antibodies to be reused. Additionally, it will make the results more stable and repeatable. The whole process will be more efficient. Since the surface electronic properties of the solid are determined by this interface, the EMEE signal offers a powerful method of detecting such changes. If all other experimental conditions are held constant, a change in the EMEE signal may unequivocally be attributed to a change in the fluid composition.

This concept is illustrated in Fig. 3. The irradiated solid (S) forms the sensor substrate, ideally selected to produce a strong EMEE signal. The analysed fluid (F) forms an interface (I) with the solid, exactly where the radiation is targeted. A signal is detected by an electrode (E) for processing. When handling gases or vapors is involved, a dense solid substrate with high adsorption capacity should be utilized. This gives a higher level of contact between the gas and the sensor surface, thereby improving the sensitivity and reliability of the sensor.

Extremely small amounts of fluid, even single drops, are sufficient for dependable measurement if the measuring structure is appropriately selected. Such a structure is described in [18]. In this arrangement, the signal is generated at the contact point of the droplet on the sensor surface. By this technique, it is possible to conduct very effective, real-time measurements with very minute sample quantities.

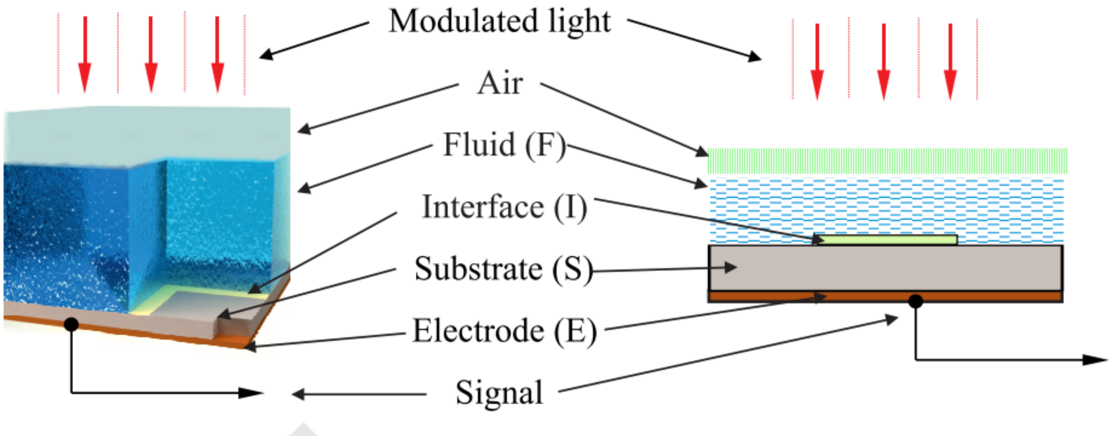

Fig. 3. Possible arrangement of a EMEE - based sensor for fluids: S - solid; I - solid liquid interface, generating the signal; F - fluid under study; E – electrode.

Experiments with a variety of liquids, gases, and vapors have explored the feasibility of this concept. Evidence suggests that EMEE signals change measurably as a function of a change in the composition or the physical properties of the sample fluid [4, 16-21]. The method has been validated under diverse environmental and experimental conditions, demonstrating its reliability and general applicability. In liquids, each substance yields a unique alternating signal under EMEE conditions. Minor changes in concentration, contamination, or pre-treatment significantly affect the signal, showing that the interaction at the solid-liquid interface is very sensitive to physical and chemical changes in the fluid [16].

Besides conventional control methods, EMEE can be used as a fast and flexible tool for complementary analysis. Universality is one of the key advantages of this method. Since EMEE signals can be created in virtually any type of fluid, the method may be utilized to analyse and characterize any substance whatsoever. The technique applies optical irradiation and electrical detection, offering a process that is effective and accurate. Also, the technical setup to implement the EMEE is relatively straightforward and does not demand significant capital investment, so it can be employed for a large variety of applications.

We believe that EMEE technology is well-suited to the development of sensors for virus detection. Our proposed research is exactly to develop such a system for the detection of coronaviruses, including COVID-19. The project seeks to address detection in three domains simultaneously: in airborne particulates, on hard surfaces, and in body fluids.

A possible approach of achieving this goal is to identify a sensor material that will react in some manner when brought into contact with the virus. The reaction does not have to be visible or quantifiable using conventional techniques, but rather, the EMEE signal would be the metric of interaction. We know from our previous experiments that the EMEE signal is sensitively responsive to minute surface-level interactions, even if these are not otherwise detectable. This gives confidence that the viral components can be detected through changes in the EMEE response at the sensor interface.

## 4. Discussion

While we are giving examples of potential detection mechanisms, our study will not necessarily be restricted to these only. Samples such as bodily fluids may be treated with specific reagents designed to trigger a measurable response when a virus is present. The primary objective is to detect pathogens, with a particular emphasis on animal viruses. Our aim is to develop a biosensor capable of reliably detecting viruses and bacteria with a high degree of specificity. To do this, we will begin with antigen-antibody interactions that are well characterized. We require antibodies specific to the spike protein of the pathogen for designing the sensor [22]. With these antibodies being used in the sensor arrangement, it becomes possible to recognize the pathogen's presence by the interactions occurring at the sensor surface. At the moment, we are doing test experiments with liquid antibodies, but we are already moving toward using solid materials, where the antibodies are fixed on the surface. These solid-state antibody layers can be used many times, unlike the liquid ones, which can be used for one experiment only. In comparison with traditional immunological methods, which rely on the presence of antibodies in the human body, the proposed biosensor will, however, aim at detecting viral or bacterial particles directly. This means that our approach will monitor the pathogen itself in respiratory secretions rather than measuring the immune response. This difference in approach allows detection at an earlier phase and is especially useful in cases where the number of antibodies might not yet be measurable. Coronavirus antibodies are commercially available today and can also be obtained from the blood plasma or serum of infected patients who have recovered. The antibodies, or indeed monoclonal antibodies, are a specific and safe means of detecting many members of the coronavirus family [13]. Monoclonal antibodies particularly provide consistent results and high specificity and are an ideal candidate for sensor development.

Another option is to monitor the agglutination reaction, in which antigen-antibody reaction leads to the generation of visible aggregates. This reaction occurs when antigens and antibodies are both present in equal concentration and are favoured by appropriate conditions, e.g., presence of electrolytes and temperature. These aggregates developed are much more easily detectable, either optically or through EMEE signal changes. Along with observable agglutination, thermodynamic processes involved in this process can also be used as markers for the presence of viruses [23]. These reactions can modulate the local environment at the sensor interface and produce characteristic EMEE responses. Investigating different reagents and reaction mechanisms will enable us to determine the best mechanisms for inducing a measurable EMEE response upon the presence of a pathogen.

Our new experimental setup will be modular and versatile. It will consist of several principal components: an optical block, sample and reagent sources, a sensor structure, and a measurement registration unit for the signal. Inside the central sensor structure, there will be contact between the irradiated solid surface and the analysed sample. This contact zone is where the signal will be produced. Additional components will be included as needed. These may be temperature control units, variable-wavelength light, or external electric fields for the adjustment of sensor sensitivity. The registration unit will be one of the most important system components. It must be capable of precisely measuring very weak alternating signals, typically in the microvolt or nanovolt range. The signals must be recorded even in the presence of electrical interference.

To overcome this challenge, we plan to use phase-sensitive detection methods, which separate the signal of interest by comparing it to a known reference. The reference will be supplied by the optical block and used to extract the EMEE signal from background noise. The optical block may also need to include provisions for scanning across a range of wavelengths, depending on the specific needs of the test environment.

A preliminary version of this study was previously published as a preprint [24], where the concept and initial experimental basis for using the electromagnetic echo effect (EMEE) in COVID-19 detection was introduced.

This work does not yet present experimental results, since it aims to serve as an initial concept. The goal at the moment is to introduce the idea and reach discussion on potential development pathways. Excluding preprints and conference reports [25-28], this is our first publication on the topic, and feedback from the scientific community will be essential for refining the methodology and identifying the most promising directions for future research, which is one of the primary aims of this paper. The experimental results obtained so far, as cited above, fully support the concept presented here.

Even though this concept shows potential for rapid and sensitive detection, several practical aspects require further investigation. These include the selectivity of the sensor in complex biological environments, possible interference from non-specific interactions, and the influence of environmental factors on signal stability. Future work will focus on addressing these aspects and providing experimental confirmation of the proposed approach, including isolation to avoid interference with the signal received while detecting viral agents.

## 5. Conclusion

Developing a sensor based on the electromagnetic echo effect for rapid detection of viruses and bacteria has significant benefits for epidemic control and public health. The method does not require costly reagents or consumables and is therefore highly suitable for large-scale adoption or in resource-poor regions. The technology has the potential to become a strong solution for rapid screening and early identification of viral and bacterial infections.

The EMEE signal in EMEE-based systems is created at the interface between a fluid and a solid surface. In our proposed application, the solid surface is irradiated while in contact with a fluid that may include viral and bacterial particles. A reagent may be added to the fluid to cause a specific reaction with the pathogen. Since the electron properties of the solid surface are influenced by the adjacent fluid layer, any reaction due to the presence of the pathogen will induce a detectable shift in the EMEE signal.

All other experimental parameters being equal, any alteration in the EMEE signal can be directly linked to the changes in the fluid brought about by the pathogen. These changes, in turn, modify the conditions at the interface and affect the sensor signal. The EMEE can therefore be utilized for developing a new generation of pathogen sensors for detection in a wide range of sample types. These include human body fluids, environmental air, and solid surfaces.

This method is highly promising, not only because of the technical potential it presents, but also for its simplicity and effectiveness. It combines optical examination of the sample with sensitive electrical signal detection. The system can deliver rapid results and, importantly, requires minimal or no expensive supplies. The compact form factor of laser modules today, even internally modulated ones, guarantees that even if laser light sources are utilized, the sensor device will remain portable and easy to deploy in the field.

The new strength of EMEE-based sensors, which is their label-free, contactless, and real-time detection, opens a great array of future possibilities in medical, environmental, and industrial applications. Our final goal is to use a solid layer of immobilized antibodies. It will be cheaper than using liquid antibodies for each test and give more reliable results. Our concept relies on reusable solid ones. Due to their low power requirements, architecture miniaturization, and low-cost materials, such sensors can be scaled for variety applications in the field. Future deployment opportunities include rapid viral and bacterial sensing in high-throughput locations such as airports, hospitals, schools, and mass transit systems. The EMEE method's sensitivity to small surface-interface reactions makes it not only relevant for clinical diagnostics, but also for continuous environmental surveillance and contamination screening on shared surfaces or public airspaces. Its miniature extension could enable wearable or handheld EMEE devices for real-time point-of-care diagnostics and individual exposure monitoring, as demonstrated in recent developments in smart biosensing technologies for COVID-19 [29].

To enhance their automation and connectivity, EMEE sensors can be integrated into Internet of Things (IoT) environments to support remote patient monitoring using wearable health devices [30]. Coupling the sensor response with artificial intelligence (AI) algorithms enables real-time pattern recognition and reduces false alarms by improving error detection and decision-making [31]. Edge computing strategies can be implemented for in situ signal processing, while cloud connectivity can be used for centralized storage, big data analytics, and visualization through epidemiological dashboards [30]. Such platforms would allow health authorities to track the spread of pathogens in space and time and impose timely interventions. Integration with mobile applications and smart infrastructure would also enable simple-to-use interfaces for medical practitioners and the public, further positioning the role of EMEE sensors in the future of smart biosensing technology [29].

Taken together, these advantages mean that the EMEE-based sensors can be a powerful new instrument for the detection and monitoring of viruses, with real-time output and relatively modest requirements for operation. Their flexibility makes them particularly well suited for use in both the clinical and public health realms.

All experimental results obtained by us so far on controlling the emergence of viruses, more specifically Chicken anaemia virus (CAV) and infectious bronchitis virus (IBV), as reported in our previous studies, support this conclusion. [25-28].

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## References

[1] Ivanov, O., Todorov, P., Gultepe, I., 2020. Investigations on the Influence of Chemical Compounds on Fog Microphysical Parameters. Atmosphere 11, Article 225.

[2] Borissov, M., Ivanov, O., Kovachev, V., Lovchinov, V., 1988. Transverse acoustoelectric effect in piezoelectric configuration - metal conductive sample. Acoustics Letters 11, 229-232.

[3] Pustovoit, V., Borissov, M., Ivanov, O., 1989. Surface photo-charge effect in conductors. Solid State Communications 72, 613-619.

[4] Ivanov, O., Kuneva, M., 2011. Quality control methods based on electromagnetic field-matter interactions. In: Ivanov, O. (Ed.), Applications and Experiences of Quality Control. IntechOpen, 509-536.

[5] Kurchanov, A. F., Kharlamov, P. G., 2024. On the Photocharge Effect. Almanac of Modern Metrology 4(40), 146–160.

[6] Kurchanov, A. F., Kharlamov, P. G., 2025. Photometric Matrix Based on the Photocharge Effect. Nanoindustry 18, S11-1(135), 350–354.

[7] Homola, J., 2008. Surface plasmon resonance sensors for detection of chemical and biological species. Chemical Reviews 108, 462–493.

[8] Anker, J. N., Hall, W. P., Lyandres, O., Shah, N. C., Zhao, J., Van Duyne, R. P., 2008. Biosensing with plasmonic nanosensors. Nature Materials 7, 442–453.

[9] Estevez, M.-C., Otte, M. A., Sepúlveda, B., Lechuga, L. M., 2014. Trends and challenges of refractometric

nanoplasmonic biosensors: A review. Chemical Society Reviews 43, 3057–3076.
[10] Damborský, P., Švitel, J., Katrlík, J., 2016. Optical biosensors. Essays in Biochemistry 60, 91–100.
[11] Qiu, G., Gai, G., Tao, Y., Schmitt, J., Kullak-Ublick, G., Wang, J., 2020. Dual-functional plasmonic photothermal biosensors for highly accurate severe acute respiratory syndrome coronavirus 2 detection. ACS Nano 14, 5268–5277.
[12] Morales-Narváez, E., Dincer, C., 2020. The impact of biosensing in a pandemic outbreak: COVID-19. Biosensors and Bioelectronics 163, 112274.
[13] ter Meulen, J., van den Brink, E. N., Poon, L. L., Marissen, W. E., Leung, C. S., Cox, F., Cheung, C. Y., Bakker, A. Q., Bogaards, J. A., van Deventer, E., Preiser, W., Doerr, H. W., Chow, V. T., de Kruif, J., Peiris, J. S., Goudsmit, J., 2006. Human monoclonal antibody combination against SARS coronavirus: synergy and coverage of escape mutants. PLoS Medicine 3, e237.
[14] Ivanov, O., Mihailov, V., Djulgerova, R., 2000. Spectral Dependencies of the Surface Photo-Charge Effect at Conducting Surfaces. Spectroscopy Letters 33, 393-398.
[15] Das, P., Mihailov, V., Ivanov, O., Gueorgiev, V., Andreev, S., Pustovoit, V. I., 1992. Contactless Characterization of Semiconductor Devices Using Surface Photocharge Effect. IEEE Electron Device Letters 13, 291-293.
[16] Ivanov, O., 2001. Level-meter for liquids based on the surface photo-charge effect. Sensors and Actuators B: Chemical 75, 210-212.
[17] Ivanov, O., Konstantinov, L., 2000. Application of the photo - induced charge effect to study liquids and gases. Surface Review and Letters 7, 211-212.
[18] Ivanov, O., Konstantinov, L., 2002. Investigations of liquids by photo-induced charge effect at solid-liquid interfaces. Sensors and Actuators B 86, 287-289.
[19] Ivanov, O., Radanski, S., 2009. Application of Surface photo charge effect for milk quality control. Journal of Food Science 74, 79-83.
[20] Ivanov, O., Petrov, M., Naradikian, H., Perez-Diaz, J. L., 2018. Phase transition detection by surface photo charge effect in liquid crystals. Phase Transitions 91, 449-460.
[21] Ivanov, O., Karatodorov, S., Pérez Díaz, J. L., 2017. Novel Electromagnetic Sensor for Contaminations in Fog Based on the Laser-induced Charge Effect. In: Proceedings of IEEE SENSORS 2017. IEEE, Glasgow, 1509-1511.
[22] Walls, A. C., Park, Y. J., Tortorici, M. A., Wall, A., McGuire, A. T., Veesler, D., 2020. Structure, Function, and Antigenicity of the SARS-CoV-2 Spike Glycoprotein. Cell 181, 281-292.
[23] Lancefield, R. C., 1928. The antigenic complex of Streptococcus haemolyticus: I. Demonstration of a type-specific substance in extracts of Streptococcus haemolyticus. Journal of Experimental Medicine 47, 91-103.
[24] Ivanov, O., Todorov, P., Stoyanov, Zh., 2020. Possibility to create a coronavirus sensor using an optically excited electrical signal. arXiv:2010.01965 [physics.app-ph].
[25] Ivanov, O., Todorov, P., Simeonov, K., Vaseashta, A., 2021. Experimental Control of a Reaction Occurring during the Interaction between Chicken Anemia Virus (CAV) and Its Corresponding Antibodies. bioRxiv 10.1101/2021.02.12.430950.
[26] Ivanov, O., Simeonov, K., Todorov, P., Stoyanov, Zh., Antonova, D., Kostadinov, K., 2021. Registration approach of viruses by using the electromagnetic echo effect. In: Proceedings of the 2021 IEEE International Conference on Manipulation, Manufacturing and Measurement on the Nanoscale (3M-NANO). IEEE, Xi'an, 296-300.
[27] Ivanov, O., Simeonov, K., Todorov, P., Antonova, D., Pulis, V., 2020. Registration of Reactions Occurring From the Emergence of a Virus by Using an Electromagnetic Charge Effect. Preprints 10.20944/preprints202012.0114.v1.
[28] Ivanov, O., Simeonov, K., Todorov, P., Vaseashta, A., Kostadinov, K., Manga, Y., 2025. Experimental control of a reaction occurring during the interaction between chicken anemia virus (CAV) and its corresponding antibodies using electromagnetic echo effect. In: Proceedings of the IEEE International Conference on Manipulation, Manufacturing and Measurement on the Nanoscale (3M-NANO). IEEE, Changchun.
[29] Xu, L., Li, D., Ramadan, S., Li, Y., Klein, N., 2020. Facile biosensors for rapid detection of COVID-19. Biosensors and Bioelectronics 170, 112673.
[30] Al Bassam, N., Hussain, S. A., Al Qaraghuli, A., Khan, J., Sumesh, E. P., Lavanya, V., 2021. IoT based wearable device to monitor the signs of quarantined remote patients of COVID-19. Informatics in Medicine Unlocked 24, 100588.
[31] Choudhury, A., Asan, O., 2020. Role of Artificial Intelligence in Patient Safety Outcomes: Systematic Literature Review. JMIR Medical Informatics 8, e18599.

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