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Automatic speed control system for the chemical etching of thin films

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The possibility of creating automatic control systems based on the interferometric optical method for chemical etching processes has been shown. A structural diagram of device for automatic control of the construction of an optical path from the elements of modern information fiber-optic systems has been developed. An experimental model of an automatic control system with optimal spectral "binding" of the radiation source, optical fibers, Y-splitter and photodetector has been created. The results of experimental studies of changes in the interference during chemical etching of thin films have shown that the created model provides simplicity of optical adjustment, high noise immunity and simplicity of automation of control of the entire etching process. Based on the results which were obtained during the study of the experimental model, a basic algorithm for the functioning of automatic control systems for chemical etching processes using the interferometric optical method has been developed.

Keywords: Automation of chemical etching processes, automatic control system, interference thickness control methods, etching process control algorithm.

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Introduction

Chemical "wet" etching is currently the basis of various high-precision manufacturing processes: photolithography, chemical processing, chemical milling, etc. In all such technological processes, it is necessary to continuously monitor the course of chemical dissolution reactions of individual elements of the surface of various objects in order to obtain the required surface relief of a technical drawing with specified parameters [1]. However, such control of "wet" chemical etching processes by traditional methods and devices is complicated by the needs in caring out many labor-intensive technological operations. In particular, this is the etching process itself, subsequent washing of samples, their drying, performing the necessary measurements, processing the results obtained, etc. All this makes it extremely difficult to develop modern devices for automatic continuous control of the parameters of the etching process, in particular, the etching rate, process selectivity, etching uniformity, etc.

The results of the research presented in [2] show the prospects of using interferometric methods for automating measurements of the etching rate of thin films of many materials. Such methods also allow for automatic control of the entire chemical etching process in real time. At the same time, it is possible to ensure high accuracy of measurements of etching parameters and achieve high speed of automatic devices. This poses an urgent research problem for the development of a real model of a device for automatic control of chemical etching processes of thin films based on the interference method. The results of such research are quite important for the further development of modern photolithographic technologies, in particular, in the direction of searching for new photoresist materials [3]. Automatic devices will significantly reduce the time spent on conducting scientific laboratory studies of chemical etching processes, increase their accuracy and simplify their integration into automatic production systems.

I. Analysis of literary data and problem statement

Among the automatic devices for the “wet” etching process, only equipment for electrolytic polishing methods is widely represented. A typical example is the Qetch 1000 device from QATM [4]. It is a modern laboratory device that automatically performs electrolytic etching or polishing of various conductive materials with full control of such processes. The basis of automatic control of the process in these devices is the continuous measurement of the electric current through the electrolyte and the voltage drop on the sample under study. As a result, in real time, quick control results of the etching process are obtained without structural changes in the sample itself.

As for classical chemical etching, here there are only individual developments of laboratory devices intended for highly specialized specific research. At the same time, the degree of automation of the control of the etching process is quite low. In particular, the authors of work [5] developed an automatic laboratory stand for performing “wet” etching. However, the control system of this equipment controls only the processes of feeding etchant into a closed reaction chamber and supports the necessary parameters of these etchant during etching (temperature and concentration). For this purpose, the device is equipped with a mixer, a steam-gas condenser, and thermally insulated tanks for preheating etchant and water. The control system ensures the implementation of automated multi-stage etching in one technological cycle with the replacement of etchant and washing of test samples without their removal from the reaction chamber. Testing of the device during research on deep anisotropic etching of silicon wafers in various alkaline etchants showed high quality control with ensuring uniformity of the etched surface at a level of about 1 μm. However, the developed device does not provide any control over the actual etching process.

For chemical etching of metallographic steel samples, the possibilities of automation in the work were investigated [6]. In this case, the main attention was paid to the automatic control of the etchant parameters and the processes of cleaning and drying the samples under study. The importance of ensuring the accuracy of setting the process duration by an automatic device to obtain reproducible results, which is not possible with manual control, was established. The negative effect of automatically turning on the ultrasonic generator to accelerate the etching processes was also noted - as a result, the uniformity of the etching process on the surface of the samples is significantly reduced. At the same time, ultrasonic treatment is an important stage of the algorithm for automatic cleaning of samples before etching. The authors of [6] also note that it is quite difficult to ensure full automation of continuous control of the “wet” chemical etching process.

Analysis of literature data shows that modern devices for chemical etching studies only provide automation of transitions between different technological operations and control of etchant parameters during etching. And continuous direct control over the course of the etching process and the state of the sample under study is not carried out. However, the results of research [7] indicate that the process of full automation of etching rate measurements is significantly simplified when using the physical principles of interference of coherent optical beams on a thin film to be etched. Therefore, it is relevant to conduct research on the creation of devices with an automatic system of full control of technological processes of chemical etching of thin films and automatic measurement of parameters of such processes based on the optical interference method.

II. Research goals and objectives

The aim of the research is to develop a system for automatic control and measurement of parameters of technological processes of chemical etching of thin films based on the optical interference method. Achieving the goal will allow creating simple automatic devices for express research of chemical etching processes of thin films of a wide range of materials.

To achieve the goal, the following tasks were set:

- to substantiate the block diagram of the model of the automatic control system (ACS) of chemical etching processes using the interference method;
- develop a prototype of the ACS model of digestion processes;
- create an algorithm for the functioning of the ACS model and conduct its research.

III. Research results

The development of the block diagram of the model of the automatic control of chemical etching processes was carried out on the basis of the functional optical scheme of the interference method proposed in [2]. The basis of such diagram is the use of modern optical fibers for the near infrared range as an optical path. Accordingly, a block diagram of the device for automatic control of etching processes is proposed, which is shown in Fig. 1.

The source of optical radiation is a semiconductor LED module (positions 1 and 2 in Fig. 1), which contains both the LED itself (2) and a built-in sensor of the intensity of the output radiation (1). Electrical energy is supplied to the LED from a controlled power supply module 3. Such design features of this module allow for automatic control of the radiation intensity in the optical path and control of this intensity.

The optical path of the device is built on fiber-optic channels of the near infrared range with a Y-splitter. The choice of the infrared range allows to significantly reduce the influence of external optical interference and to simplify the measurement process. During the studies, the optical input radiation is introduced into one arm of the Y -splitter. Then, through the base of the splitter, it is directed to the sample under study. Due to reflection from two surfaces of the thin film, two coherent beams are formed, which, interfering with each other, enter the base of the splitter. The intensity of the resulting interference pattern is output through the second arm of the Y-splitter.

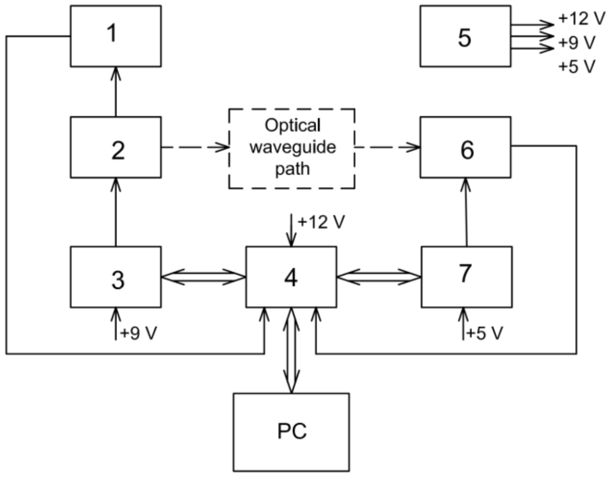

Fig. 1. Block diagram of the device model for automatic control of parameters of chemical etching of thin films: 1 – intensity sensor, 2 – LED, 3 – LED power module, 4 – microcontroller module, 5 – power supply, 6 – photodetector, 7 – photodetector power module.

Changes in the output interference intensity are recorded by the photodetector 6. The electrical signal generated by the photodetector is transferred to the control module 4. The photodetector is powered by the controlled module 7, which allows the automatic control system to change the operating parameters of this photodetector.

The basis of the control module 4 can be either a modern microcontroller (MC) module or a low-power industrial logic controller. This module in the studied model of the device was equipped with two input information communication lines that receive electrical signals from two photodetectors of the intensity of optical radiation (Fig. 1). If necessary, the number of input lines of the control module can be increased by adding information communication lines from sensors of the level of the etching solution in the tank, a sensor of the solution temperature, a sensor of the solution concentration, and other sensors.

The control module 4 also contains two bidirectional information channels that provide control of the operating modes of the LED and the photodetector of the intensity of the interference pattern (Fig. 1). In addition, the ACS has an interface communication channel with a computer based on the USB protocol. It is designed to create and compile programs in the control module and to collect and process all data received from the ACS during its operation.

A three-channel power supply is used to provide electrical energy to all components of the SAC. It provides the control module, LED, and photodetector with stable voltages of the required value.

Development of a prototype model of the ACS etching processes. The basic component of the model is a source of probing optical radiation - an LED module of the SPL 2F81-2S type from OSRAM. The maximum of its radiation spectral characteristic $P(\lambda)$ falls on a wavelength of about 808 nm (Fig. 2) [8].

SPL 2F81-2S module has high technical performance parameters: the average integrated radiation power is not less than 50 mW, the diameter of the output optical beam is about 0.25 mm, and the output power can be easily controlled by changing the operating current of the LED.

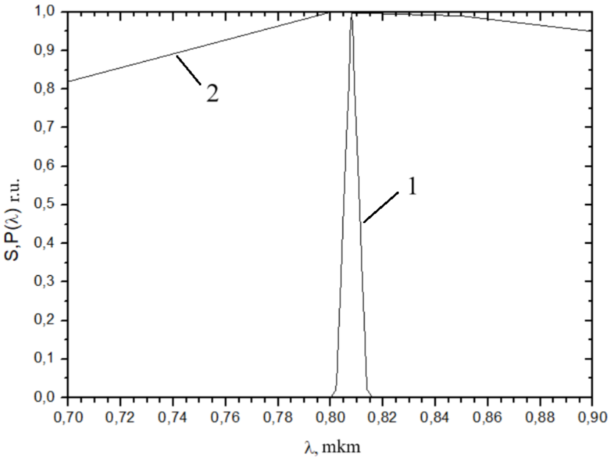

Fig. 2. Spectral characteristics of the components of the device model: 1 – SPL 2F81-2S LED module [8], 2 – photodiode OPT101 [9].

As a receiver of interference pattern radiation, a modern photodiode OPT101 from Texas Instruments was used. Its spectral sensitivity range $S(\lambda)$ is much wider compared to the emissivity of the used LED (Fig. 2). A comparison of these characteristics shows good agreement of the working spectral range of the two devices. Therefore, when choosing the OPT101 photodiode, its high sensitivity (more than 0.5 A/W) and stability of the parameters were first taken into account. The design features of such a photodiode are also very important, which provide a large viewing angle, reliable docking with an optical fiber, and mechanical stability of long-term operation of the entire optical path. Fig. 2 also shows that the OPT101 photodiode has a wide spectral range with high sensitivity. Therefore, the photodetector module can successfully function with sources of input monochromatic radiation of different wavelengths. This allows us to select the optimal radiation source for each type of thin film, which has a maximum radiation characteristic in the spectral region of high optical transmission of the samples under study.

The parameters of the optical fibers of the optical path are also important for the stable operation of the device. Our experiments with different types of fibers have shown that the optimal set of optical and structural parameters is possessed by multimode quartz fibers of the FinMark company of the PS001MM PVC type [10]. They have a core diameter $d_c = 0.1$ mm and very low radiation power losses, less than 3.0 dB/km in a wide spectral range around 810 nm. Such parameters correspond to the optimal matching with the spectral characteristics of the LED and photodiode.

The Y-splitter of the model uses a ready-made OPTOKON SFT-P device, the design of which allows easy connection of optical fibers to its inputs and outputs. According to its design, the splitter transmits optical radiation from its input arm to the sample under study through its base with minimal losses (Fig. 3). However, when passing from the base to the output arm at point A of the Y-splitter, the intensity of the interference of coherent rays is divided into two streams with a division coefficient y. As a result, the interference intensity $I y$ is transmitted to the output arm , and the intensity $I \cdot (1 - y)$ is transmitted to the input arm and lost. Therefore, to obtain the maximum value of the output information signal, it is necessary to choose a modification of the Y-splitter with a large value of the coefficient y. In particular, a device with a value of $y = 0.8$ was used in the experimental model.

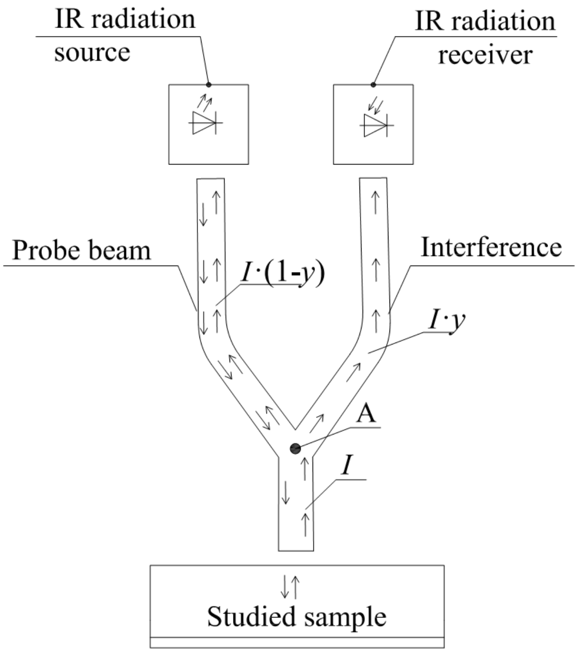

Fig. 3. Redistribution of optical flux intensity in a Y-splitter.

When analyzing the energy balance in different parts of the Y-splitter, it should also be taken into account that the average coefficient of total optical losses in modern optical splitters corresponds to values of about 0.5 dB [11]. Then, the intensity of the optical beam at the output of the splitter can be estimated as:

$$I \cdot \gamma = I \cdot \gamma \cdot 10^{-0.05} \approx 0.7$$

The calculated intensity of optical radiation is directed to the sample under study and causes the formation of an information optical signal in the form of an interference function, which is transmitted to the photodetector for its registration through the second arm of the Y-splitter. Experimental measurements have shown that the intensity of the information signal at the input of the photodetector is about 10% of the intensity of radiation from the LED entering into the waveguide path.

The optical fibers were connected to other optical components of the current model using standard OPTOKON connectors. LED BFA-PC-Z-2 is widely used in modern fiber optic networks. In order to increase the amount of light flux from the LED entering to the optical fiber, standard fiber optic lens FC were used in the connectors. This allows us to increase the efficiency of entering light power into the optical fiber by k times (the coefficient k is also called the FC efficiency coefficient). Experimental measurements showed that the used FC have a coefficient $k \approx 3.9$. This allows to entering about 60% of the optical radiation power of the LED into the optical fiber path. A similar connector was also used to mount the sample under study in a mechanical manipulator for immersing it in an etching solution.

To power the experimental model, a special electrical unit was used, which contained three independent power sources with stabilized voltage:

- + 12 V to power the LED;
- +5 V for powering the photodetector;
- +9 V for powering the AC adapter and other device components.

Development and research of the algorithm for the functioning of the ACS model. Experimental studies of the features of the etching processes were carried out on the created working model of the device. The results of these studies were clearly laid down as the basis for the development of the algorithm for the ACS device.

Before starting the process, the tank for etching is adjusted and the sample under study is placed in it. After that, the optical path is adjusted. At the same time, the ACS is started, to which all control over the etching process is transferred. In the initial session of working with the ACS, the operator, if necessary, enters a number of parameters into memory, they are necessary for the execution of the algorithm. The process of entering the initial parameters is provided by the Parameters Input subroutine (Fig. 4).

In the future, the implementation of the ACS of its functions is organized in the form of several consecutive interconnected stages. When implementing each of them, there are certain features of the functioning of the ACS. Therefore, it is advisable to divide the algorithm of this system into several separate logical blocks (in Fig. 4, they are surrounded by dotted lines).

Block B1. Is responsible for checking the readiness of the main components of the entire device for operation, which involves the sequential execution of the following individual steps by the ACS.

Step B1.1. Checking the readiness of the photodetector for conducting. For this, the MC supplies the photodetector module with the optimal voltage and checks for the presence of a background electrical signal s_p from it. If there is no background signal from the photodetector, the MC displays a corresponding message to the operator on the ACS display and goes into standby mode. If there is a background signal from the photodetector, the ACS performs the next step. This step of the algorithm is performed by the Photodetector subroutine.

Step B1.2. The LED test subroutine is executed (Fig. 4). To do this, electrical power is supplied to the LED and the microcontroller sets the minimum allowable current for its supply i_{min}. After that, the MC reads the electrical signal from the photodetector built into the LED. If there is no signal, the MC takes three consecutive steps to increase the LED supply current by Δi from the minimum to the average optimal level. At each step of increasing the current, the presence of a signal on the built-in photodetector and the correspondence of the magnitude of this signal to the supply current are checked.

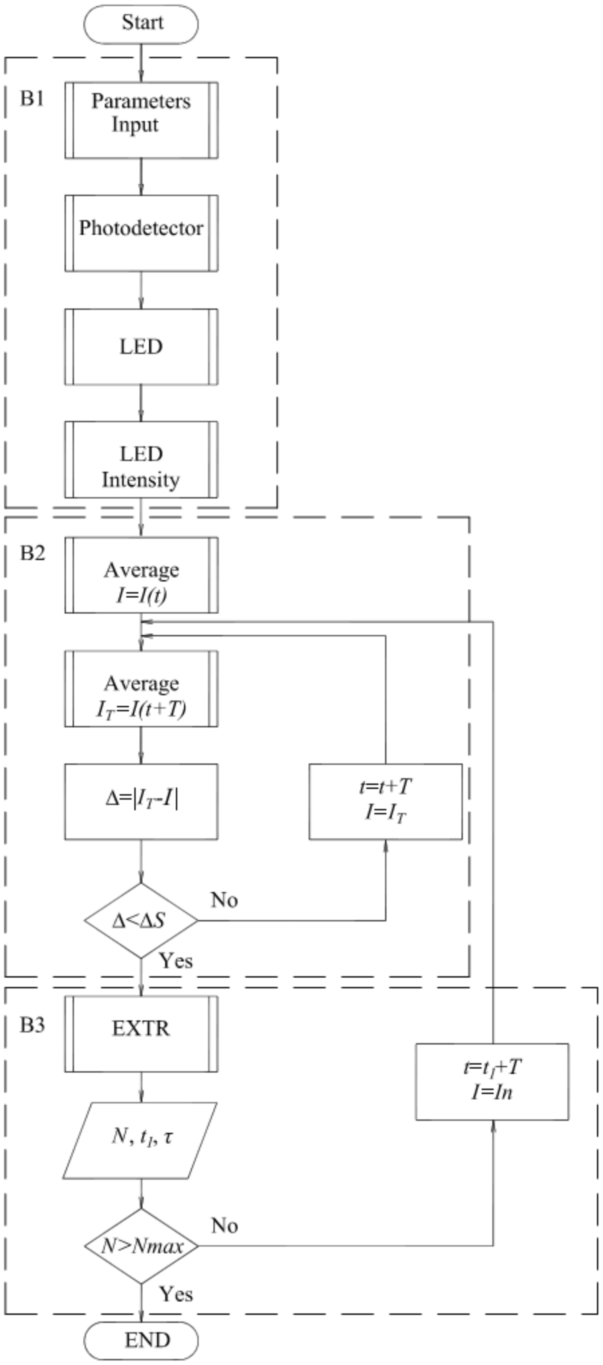

Fig. 4. Algorithm of operation of the ACS of the chemical etching process.

Based on the results of step B1.2, the MC makes one of three decisions:

- if the signal still does not appear, the MC displays a new message to the operator about errors in the operation of the LED and stops executing its program;
- if the signal on the built-in photodetector appears, but its level does not correspond to the LED power supply current, the MC displays a corresponding message on the display and goes into standby mode (in this case, the operator must make all necessary settings for the LED and the waveguide path and give the MC a signal to continue operation);
- if the signal value corresponds to the range of optimal LED power supply currents, then the MC proceeds to the next step of the MC operation.

Step B1.3. Setting the required level of LED radiation intensity. This process is controlled by the LED Intensity subroutine (Fig. 4) The MC reads the signal from the photodetector regarding the intensity of the output interference pattern. *I*. Based on the obtained results, the MC performs one of the following branches of the algorithm:

- if there is no information signal from the photodetector, the MC displays a message to the operator about errors in the operation of the optical path or photodetector and goes into standby mode, which lasts until the operator corrects the error and resumes program execution with his command;
- signal from the photodetector is present, but the intensity of the interference pattern is less than the permissible level I_{min} and insufficient for reliable measurements. Then the MC stepwise increases the LED supply current by Δi to the maximum permissible value $i_{\max}$. If such actions ensure the appearance of the required signal level of the intensity of the interference pattern, then the MK automatically proceeds to the execution of the next logical block of the algorithm. If the required signal level from the photodetector is not received, then the MK transmits a new message to the operator about the need for additional adjustment of the optical system of the device. After that, the MK again goes into standby mode until receiving the required command from the operator.
- if the level of the electrical signal from the photodetector corresponds to the required value, then the MC displays a message to the operator on the display about the readiness for measurements and goes into the next standby mode. Having received such a message, the operator completes all preparatory actions and fills the etching solution to the required level in the tank with the sample under study. After that, the operator gives the MC a command that allows the measurement process to begin. Having received this command, the MC begins to execute the next block of its program algorithm.

Block B2. At the initial moment of measurements on the photodetector, the intensity of an undetermined section of the interference is recorded. The interference method requires starting the time count from the moment the function I (t) passes its first extremum. Therefore, this block is responsible for setting this starting moment. For this, the MC periodically measures the intensity of optical radiation on the photodetector. The period T of such successive measurements must be large enough so that the thickness of the film under study decreases sufficiently during this interval. In this case, noticeable changes in the intensity of interference on the photodetector will occur. On the other hand, the period T should not reduce the "resolving" ability of the measurement process. Since the etching rates of different thin films can differ significantly, the period T should be set for the MC taking into account the circumstances noted above. For this, it is advisable to conduct preliminary trial measurements on the selected research object to assess the optimal value of the period T. Therefore, this parameter in the program will act as a certain constant, which is entered into the MC by the operator before the start of the next work session along with other constants.

To reduce the influence of the "noise" of the intensity of the interference on the measurement results, a separate procedure for "smoothing" of current measurements is introduced into the algorithm. This procedure Average (Fig. 4) is selected from the library of ready-made standard programs for MC. Since the actions of block B2 of the algorithm are carried out throughout the entire time of operation of the SAC, this block is designed as a separate subroutine, which contains the following steps.

Step B2.1. The assignment operation is performed for the current parameter $P = I(t)$. The current interference intensity I is measured with its averaging in the vicinity of a certain moment of time and the intensity value is recorded in a separate register. At the same time, this value is shown on the operator's display.

Step B2.2. The average intensity I_T is measured over the time interval T and the difference $\Delta = | I_T - I$ is calculated.

Step B2.3. Analysis of the obtained value Δ, which results in one of the following situations:

- value Δ is greater than the confidence interval Δs specified by the program. This means that the intensity of the interference is currently increasing or decreasing and then the MC proceeds to the next step of the algorithm B2.4;
- value Δ is less than the interval Δ_s. This indicates the possibility of starting the implementation of the event of the function $I(t)$ reaching its first extremum. Then the MC starts executing a separate subroutine EXTR to determine the position of this extremum. At the output of this subroutine, the value of the time instant $t_{0\text{ is formed}}$, which corresponds to the passage of the function $I(t)$ through its first extremum and the value of the interference intensity at the point of the extremum. The obtained values are written to the memory of the MC and displayed on the operator's display. Then the subroutine transfers control to block B3 of this algorithm.

Step B2.4. Performing the assignment operation $I_T = I$ and moving to the algorithm block B2.2.

Block B3 provides control of the measurement process when the intensity of the interference function passes from one of its extremes to the next.

Step B3.1. Carrying out the measurement operation of the new intensity I_T over the time interval T and calculating the new difference $\Delta = | I_T - I |$. In this case, the value I is in the register as a result of the action of the previous steps of the algorithm.

Step B3.2. Analysis of the obtained value Δ, according to the scenario described in block B2 as steps B2.3 and B2.4. The subroutine EXTR works according to the analysis results. At the output of this subroutine, the value of the time instant $t_{1\text{ is formed}}$, which corresponds to the passage of the function $I(t)$ of its next extremum. The obtained values t_1 and the intensity of the extremum are recorded in the memory of the MC and they are shown on the operator's display. After exiting the subroutine, the MC proceeds to the next step.

Step B3.3. Calculation of the time interval between the two detected extrema $\tau = t_1 - t_0$, reassignment of values $t_0 = t_1$ display of the value τ and its recording in the memory of the MC. In the same block, you can enter the calculation of the current rate of etching of a thin film. But this operation is more expedient to put on a computer which is attached to the SAC, and to which the SAC transfers all the data obtained in the measurement process.

Step B3.4. Unconditional transition to the beginning of the block B3 in order to search of the next extremum.

Block B4. Finishing the measurement process. The developed algorithm provides for cyclic automatic continuous execution of the program for searching for extrema of the intensity of the interference function. Automatic termination of the measurement process is not provided in this algorithm. Therefore, to terminate the operation of this program, an appropriate operator command must be given. Upon completion of the ACS operation, a set of parameters τ is formed in the computer, which is the basis of the experimental data base which is required for determining the etching rate of thin films.

EXTR subroutine is the finding of the position of extrema. When analyzing the extrema, it is possible that a situation will arise when the condition $\Delta < \Delta_s$ will be repeated during many cycles of measuring the intensity of interference. Therefore, this subroutine controls the number of successive repetitions of this condition. If this number exceeds the set value, the MC issues a corresponding message to the operator. Otherwise, the MC proceeds to the next block of the algorithm and continues to conduct discrete cycles of measuring the intensity of interference without any interruption over a period of time T.

IV. Analysis of research results

The obtained results show that the interference optical method allows us to automate the entire process of experimental research of the process of chemical etching of thin films. On its basis, it is possible to create various ACS`s. The structural diagram of one of such ACS`s is developed in this work (Fig. 1). Its positive features are due to the implementation of the entire optical path based on the functional elements of modern information systems and optical fibers (Fig. 2 and Fig.3). As a result, the simplicity of the adjustment of the optical part of the ACS, high noise immunity and simplicity of automation of the process of functioning of the entire ACS are achieved. However, if necessary, this ACS can also be built on the basis of the traditional method of practical implementation of the interference method of controlling the thickness of thin films with the laser beam distribution in the air environment.

The developed single-channel structural diagram of the SAC can be easily expanded to a dual-channel for simultaneous investigation of chemical etching processes of two different areas of a thin film. This will allow us to investigate in one experiment also the selectivity of etching on differently processed areas of a given thin film.

For experimental studies of the parameters of the developed structural diagram of the SAC, a model of a device for automatic control of the chemical etching process was created. In such a design, the main attention was paid to the optimal spectral "binding" of all optical elements of the SAC: radiation source, optical fibers, Y-splitter and photodetector (Fig. 2). When choosing devices for the model, considerable attention was also paid to the possibility of their easy adaptation to the electronic elements of the SAC.

A feature of the application of the created model is the need to create special samples for experimental measurements (Fig. 3). To do this, a thin film under study should be applied to a substrate transparent to the probing optical radiation, the material of which should also be sufficiently transparent to the probing optical beam. This avoids strong absorption of the formed coherent rays and ensures a high intensity of the interference pattern on the photodetector.

Model studies have shown that the interference optical method provides:

- good reliability and strict control of the work of the ACS;
- high accuracy of the obtained measurement results;
- possibility of unifying the measurement process for different materials;
- convenience of carrying out the measurement process and efficiency of processing their results;
- the ability to explore the entire etching process in real-time dynamics.

The results obtained during the study of the created model of the device for automatic control of the etching process of thin films were used as the basis for the development of the algorithm for the functioning of the ACS (Fig. 4). The presented algorithm is basic for the implementation of automatic control of the chemical etching process based on the interferometric optical method. In the future, it can be modified and optimized to solve various specific problems. In particular, the following works may be relevant in this direction.

1. Additional experimental studies of the characteristics of the interference intensity behavior at different stages of the etching process of thin films and under different technological conditions. For example, the nature of the behavior of the function $I\,(t)$ at the final stage of the etching process, when the film is completely dissolved. Based on such studies, it will be possible to create a finishing block of the program termination algorithm under a certain condition or by interruption. The analysis of the influence of different etchant on the behavior and parameters of the function $I\,(t)$ is also relevant.

2. Expansion of the algorithm functions for registering and recording changes in the entire interference intensity function $I\,(t)$ from the beginning of the etching process to its end. Subsequent mathematical processing of this function allows obtaining additional physical and chemical parameters of the entire etching process.

3. Introduction of a subroutine for rapid repetition of intensity measurements $I\,(t)$ at a given time with statistical processing of the obtained results. The speed of the developed SAC allows one measurement of intensity $I\,(t)$ within a few milliseconds. During this time, the film thickness will change by less than one monoatomic layer even at “giant” etching rates exceeding 10 μm / min. Such values are several orders of magnitude smaller than the absolute errors of etching rate measurements by the interference method – ± 0.5 nm /s [2].

4. The created ACS is characterized by high flexibility, especially in the conditions of educational and research organizations. As a result, equipment with this ACS will be able to serve many researchers who work with different materials and study the influence of various external factors on the etching process: temperature, pressure, chemical composition of the etchant, etc. At the same time, for different purposes, it is possible to create different versions of the control program for the ACS - to add the appropriate blocks of automatic control by certain external factors to the algorithm. In addition, with minor modifications, the created ACS can also be used for research into the processes of "dry" etching, for example, ionic or plasma.

Conclusions

A structural diagram of a system for automatic control of chemical etching processes using the interference optical method has been developed. A feature of the diagram is the implementation of an optical path based on modern components of fiber-optic information systems, which ensures the simplicity of adjustment, high noise immunity and flexibility of the algorithm for the operation of devices for controlling the etching process of thin films.

A prototype of the model of the automatic control system for chemical etching processes has been created. For practical application of this model, it is necessary to manufacture special samples for experimental measurements in the form of a substrate with a thin film. In this case, both the substrate and the thin film must have a small absorption coefficient in a certain infrared spectral range with a width of more than 0.2 microns. Experimental studies of the model of the automatic control system have shown its high reliability and accuracy of the obtained measurement results, the possibility of modifying the system for different materials and different research conditions; convenience of the measurement process and efficiency of processing their results.

Based on the results of experimental studies of the model of the automatic control system, a basic algorithm for its functioning has been developed. The most relevant directions for subsequent modification of the developed algorithm for the creation of automatic devices for the study of chemical etching processes have been proposed.

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Система автоматичного контролю швидкості хімічного травлення тонких плівок

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Показано можливість створення систем автоматичного контролю процесів хімічного травлення на основі інтерферометричного оптичного методу. Розроблено структурну схему пристроїв автоматичного керування побудовою оптичного тракту із елементів сучасних інформаційних оптоволоконних систем. Створено експериментальну модель системи автоматичного керування із оптимальним спектральним «ув'язуванням» джерела випромінювання, оптичних волокон, Y-розгалужувача та фотоприймача. Результати експериментальних досліджень змін інтерференційної картини під час хімічного травлення тонких плівок показали, що створена модель забезпечує простоту оптичного юстування, високу завадостійкість та легкість автоматизації контролю всього процесу травлення. На основі отриманих при дослідженні експериментальної моделі результатів розроблено базовий алгоритм функціонування систем автоматичного контролю процесів хімічного травлення із використанням інтерферометричного оптичного методу.

Ключові слова: Автоматизація процесів хімічного травлення, система автоматичного контролю, інтерференційні методи контролю товщини, алгоритм контролю процесу травлення.