Automated Installation for Studying Electrochromic Characteristics of Materials in Real Time with Remote Control Functions

E.V. Sokhovich, M.M. Sychov, S.V. Myakin, V.I. Khalimon, O.V. Prostitenko

Abstract: ***The automated experimental installation representing the two-level automated system allowing to realize both manual, and automatic control of parameters of the electrochromic device, to carry out data collection from devices of measurement of working parameters and calculation of the main characteristics of the electrochromic device in real time is developed. The first level of this installation is connected directly with the studied object the equipment of data collection and transfer of management. The second level represents the multimodular program system providing a task of the mode of carrying out an experiment and also processing, storage of the obtained data and providing information in a look, convenient for perception and the analysis, including in the remote mode.***

Keywords: electrochromic device, multimodular program system, remote access, mode of real time, program of carrying out experiment.

INTRODUCTION:

The development of "smart" materials featuring with precisely adjustable properties via external control effects and capable of mutual transformation of different kinds of energy is one of the most promising areas in modern materials science and technology. This direction particularly relates to materials with adjustable optical properties, i.e. transmission (absorption, reflection, refraction, scattering) of electromagnetic radiation in a target frequency wavelength band. A wide range of presently developed electro-, photo and thermochromic materials provides reversible color (transmission in a certain optical spectrum area) changes under the effect of electric current, light or temperature. Such materials can be used for used for protection from solar radiation (in particular, "chameleon" glasses, anti-glare coatings for rear-view mirrors, etc.), energy-efficient glazing of buildings and vehicles, light filters with adjustable transparency, special displays and a number of other promising applications, including orbital trajectory regulation for currently developed ultra-small spacecrafts via the "solar wind" due to changes in light absorption [1, 2]. The most promising approach to adjustment of optical performances is based on exploring the electrochromic effect affording a rapid and precise control over light transmission. Furthermore, available inorganic electrochromic materials maintain the required stability under extended exploration conditions and sustain a long time use with the number of coloration-bleaching cycles up to 10^6 at low power consumption (nominal voltage and current not exceeding 3-5 V and 5 mA, respectively) [1].

The considered problems can be effectively addressed due to the development of electrochromic materials meeting the above requirements, improvement of the electrochromic device structure as well as development of automated techniques for their testing in the course of multiple impacts of voltage with alternating polarity and variation of the process conditions.

The main target performances of electrochromic devices (ECD) include optical contrast (ratio between the transmission coefficients in the bleached and colored states), electrochromic efficiency (colored surface related to the electric power consumption), colored state maintaining duration, stability of the above parameters at numerous (at least about 10^5) coloration-bleaching cycles and no degradation during active (frequent switching) or passive (in the bleached state) exploration within at least several months. The improvement of these performances requires the optimization of the composition and manufacture processes for all ECD functional components (supports with transparent conducting layers and electrochromic material, e.g. tungsten oxide layer deposited onto one of the supports in combination with a counter electrode placed onto another support to accumulate the charge carriers, as well as an electrolyte separating the functional layers) [3] as well as the development of integrated control-measuring systems affording a programmable change of the control parameters for ECD coloration-bleaching and synchronized dynamic measurements of optical (transmission or optical density in the target wavelength range) and electric (current and voltage) parameters of the process.

Based on the approach described in [4, 5], in order to address this problem an automated installation was

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developed comprising a two-level automated system for experimental studies affording both manual and automatic control/adjustment of ECD parameters, data collection from working parameters (voltage, current, transmission at the required wavelengths) measuring units and calculation of ECD basic performances in a real-time mode. The first level of this installation directly relates to the controlled ECD via data collection-transmission system (sensors, connectors, microprocessor). The second level provides a multi-modular programming system responsible for setting the measurement mode (cyclic voltage changes) as well as data processing, storage, transmission and convenient displaying, including a remote mode.

A general functional chart of the system is shown in Figure 1.

RESULTS & DISCUSSIONS

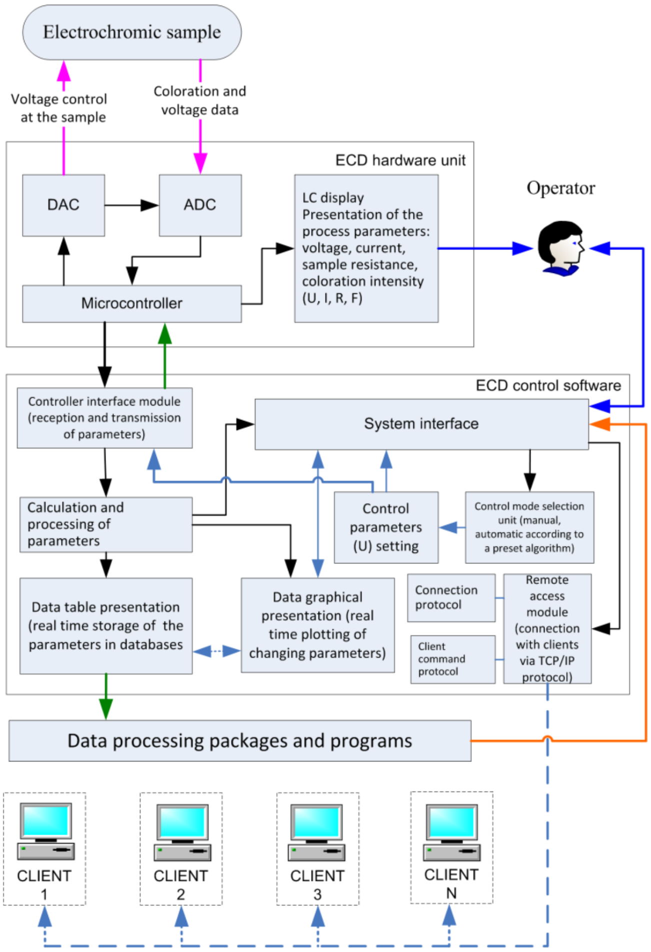

Figure 1 - General functional chart of ECD control system

The developed integrated laboratory system involves electrochromic device, control computer complex and software/algorithmic support providing data acquisition from ECD sensors, transmission to the server (head computer) located close to the installation, followed by data transmission to clients (students or researchers) via the web for processing and decision making regarding the current experiment control. Remote clients can process the data transmitted from the installation in a real time and operate with the earlier obtained data. This approach affords both performing students' laboratory works in a simulation mode and carrying out additional analysis of the data for researchers.

The system is open and affords modification, adjustment and variation of methods, algorithms and programs depending on specific features and properties of the controlled technological object. The system also provides the obtained data import to other software packages of processing.

During a laboratory practical work, this system allows students located in a computer class to monitor the work of a remote installation with real time processing and analysis of the data.

Initially, the laboratory study performance requires setting the experiment program.

The experiment program comprising a combination of control blocks is set via a screen interface (Figure 2).

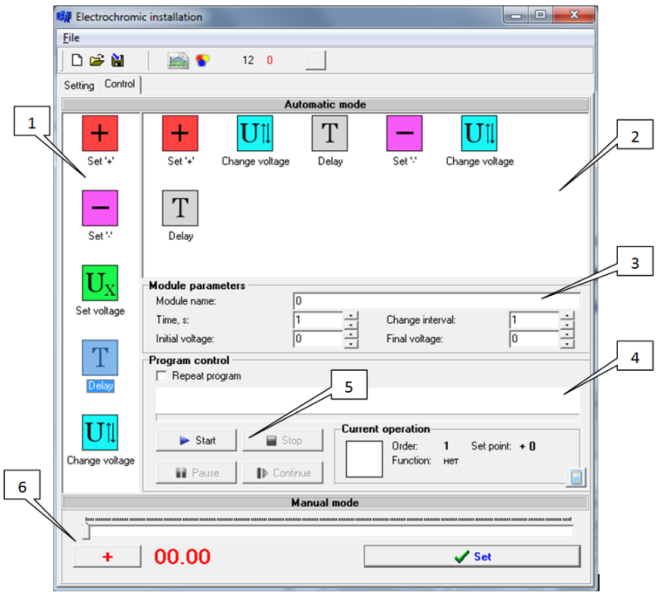

Figure 2 – Operator interface

The Figure 2 includes the following designations:

1 – database of control blocks;

2 – window for algorithm construction field for automatic control mode;

3 – tuning and displaying the control blocks parameters;

4 – field for control algorithm diagram;

5 – tools for automatic control mode;

6 – tools for manual control mode.

The installation affords a real time plotting of experimental results on display and storage of data arrays in files.

A multi-window interface allows a simultaneous monitoring of the plots and corresponding data (Figure 3) or the experiment program in couple with current relationships characterizing changes in the controlled parameters.

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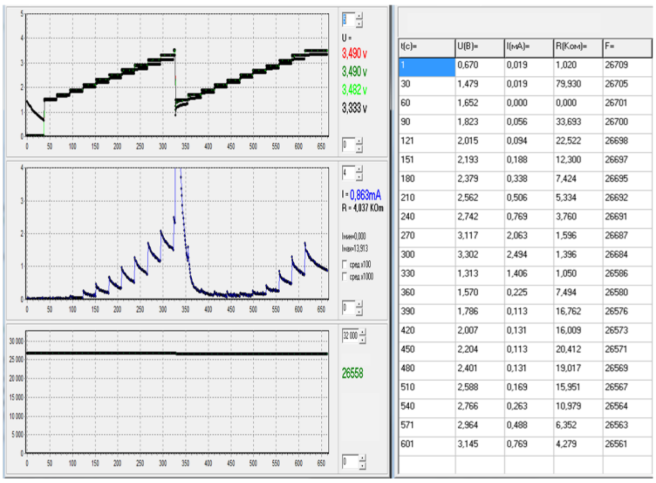

t(c)=	U(B)=	I(мA)=	R(Kом)=	F=
1	0,670	0,019	1,020	26709
30	1,479	0,019	79,930	26705
60	1,652	0,000	0,000	26701
90	1,823	0,056	33,693	26700
121	2,015	0,094	22,522	26698
151	2,193	0,188	12,300	26697
180	2,379	0,338	7,424	26695
210	2,562	0,506	5,334	26692
240	2,742	0,769	3,760	26691
270	3,117	2,063	1,596	26687
300	3,302	2,494	1,396	26684
330	1,313	1,406	1,050	26586
360	1,570	0,225	7,494	26580
390	1,786	0,113	16,762	26576
420	2,007	0,131	16,009	26573
450	2,204	0,113	20,412	26571
480	2,401	0,131	19,017	26569
510	2,588	0,169	15,951	26567
540	2,766	0,263	10,979	26564
571	2,964	0,488	6,352	26563
601	3,145	0,769	4,279	26561

Figure 3 – Visualization of basic parameters from the ECD control installation

In addition to electrochromic effect characterization, the developed automated installation can be used for research, testing and students laboratory works involving long time (particularly cyclic) measurements of optical and electric performances of various materials, including possibilities for adjustment and remote control.

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