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Control of Ion Beam Assisted Processing of Materials

A. Styervoyedov, V. Farenik, S. Styervoyedov, M. Silkin
Scientific Centre of Physical Technologies, Kharkiv, Ukraine[1)]
V.N.Karazin Kharkiv National University, Ukraine

Ion beam assisted deposition (IBAD) as a very complex process of multilayer functional coatings formation requires precise synchronization and control of all parts of vacuum plant. In the work the system of synchronization and control of plant for IBAD is presented. The system was elaborated for synchronization of work and parameters control of two ion sources, which can work both in pulse and continuous regime, several electron beam evaporators with different evaporable materials, ionizer and measuring devices. Elaborated system allows to completely automate a very complex technological IBAD process and opens additional benefits in synthesis of complex multi-layer coatings.

Keywords: Ion Beam Assisted Deposition, ion source, control system, synchronization system.

1. Introduction

Processing of a surface of materials and wares by ion beams is a progressive way of influence on their physicotechnical, electro-physical, physicochemical and mechanical properties. Creation of vacuum coatings on the surface (PVD) in a combination with ion irradiation - ion mixing or implantation assisted deposition, allows to get coatings, that have high adhesion, low porosity, defined thickness and precisely predicted properties. Technologies of simultaneous or alternate evaporation of two or more metals on substrates using any of methods and their irradiation by various sorts of ions (nitrogen, oxygen, argon, carbon, a pine forest) with energy in a range from tens eV up to some tens keV [1,2,3] are especially perspective.

These technologies allow to form multilayered coatings and to receive the composite materials having unique properties. In particular, it is possible, varying density of streams of evaporated metals, energy and a current of ions, changing their sort, to form ceramic-metal coatings with various structures, properties, concentration and dimensional characteristics.

It is possible to completely realize advantages of multi-component implantation assisted evaporation of coatings and synthesis of thin-film systems and also to achieve repeatability of results only in case of strictly controlling of technological process and automation of technological equipment. Automation is especially necessary for synthesis of nano-dimensional structures and layers at which duration of separate working cycles of multistage technological process can make the tenth shares of second. It is clear, that the person-operator can hardly make these operations in a manual mode.

[1)] 1, Novgorodskaya Str., Kharkov, 61145, Ukraine

The purpose of the given work was system engineering of synchronization and the technological control of experimental installation for implantation assisted evaporation of coatings and synthesis of materials.

2. Experimental Plant

The scheme of the experimental vacuum-technological plant, for which the synchronization and control system was elaborated, is shown on fig.1 on the background of control panel, realized on the base LabView software [4]. The plant is designed for deposition of hardening, protecting, wear resistant coatings including multilayer ones, onto the surface of metal and non-metal materials and products. The principle of plant operation is based on using the hybrid technology of physical vapor deposition under condition of bombarding simultaneously with small and medium-energy gas ions.

The plant is equipped with the system of oil-free pumping, two ion sources, several electron-beam evaporators, the device for specimens changing, the target temperature stabilization system, sensors of monitoring and control of flows of evaporable materials

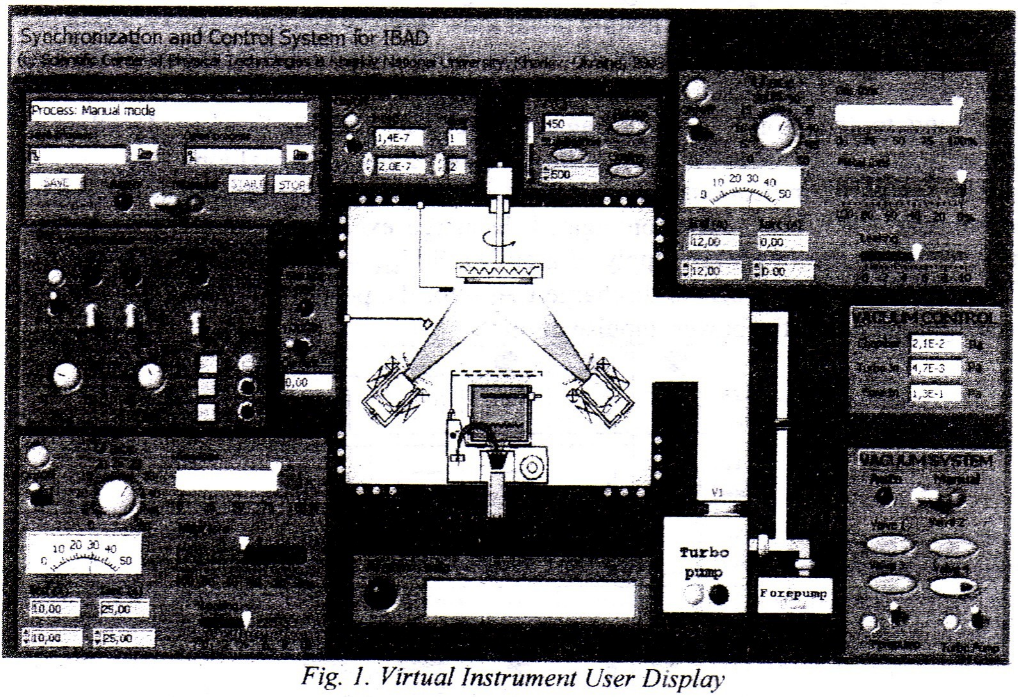

Fig. 1. Virtual Instrument User Display

The plant control system was elaborated both for the solution of maintenance task for vacuum cycle and temperature condition, and for assignment of temporary sequence of ion sources operation and electron evaporators on rigid or adaptive algorithm.

3. Ion source control and synchronization

The experimental plant contains two ion sources for gas and metal ion beam forming, of own elaboration. The principle of operation of each source is based on sequential ignition between plain cold cathodes and hollow anode of self – maintained discharge, contragated by small hole, and then excitation of vacuum arc on the surface of electrode with consumable cathode fixing. For the selection gas ions only there is no supply voltage of arc. Charged particle extraction from plasma and beam forming are realized due to multiaperture electrode system composed of emissive, accelerating and gate-type electrodes.

Pulse periodic regime of contragated and arc discharge burning allows to get a big range of pulse and average currents of charged particles beams, execute flexible controlling of average currents of ion beams, and also to change fine a sort of processing ions, thus realizing various kinds of influence. Changing pulses frequency that follow with constant duration it is easy to carry out adjustment of average current and to provide the thermal mode both of the source, and the material of a target to be processed. Changing the pulse duration of the arc and contragated discharge supply, internal adjustment of a sort of processed ions and partial currents is held. This is shown on fig.2.

At ignition only of contrageted discharge (variant 1) we have a beam of gas ions. At short-term ignition of contragated discharge and excitation of a vacuum arch (variant 2) the source generates mainly metal ions. Ignition and burning of contragated discharge during all duration of the vacuum arch current (variant 5), the short feeding pulse of contrageted discharge (variant 3), a delay of excitation of a vacuum arch concerning to the moment of contragated discharge ignition (variant 4) allow to receive beams with a wide variation of the relation of gas and metal ions.

The following indications are used in the figure: U_{sinc} – synchronization impulse accordingly: CIPS U_{sinc} – for contragated discharge excitation; APS U_{sinc} – for the controlling impulse of power supply of arc; CDPS U_{sinc} – for the controlling impulse of power supply of contragated discharge; U_{CD} – for the power impulse of contragated discharge; U_{AC} – for the power impulse of arc.

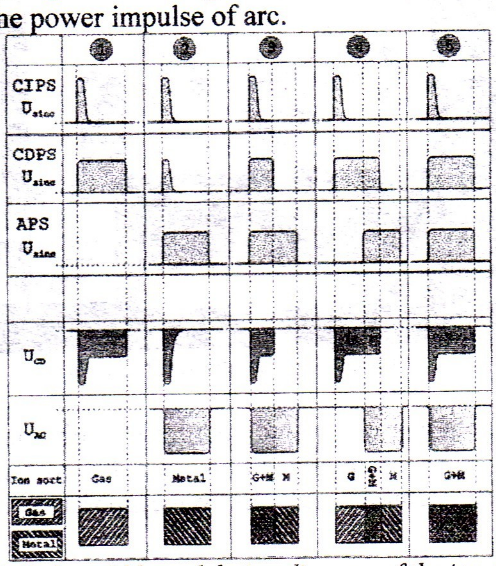

Fig. 2. Pulse-width modulation diagram of the ion source contragated and arc discharges

Realization of such pulse-width regulation of irradiation modes with necessary repeatability of results is assigned to the system of synchronization, management and control on the basis of operating controller.

3. The principle scheme of controller.

The principle scheme of controller, that is the main part of the synchronization and control system, is presented on the fig.3. Controlling unit is created on the microprocessor AT89C51 base. It has 3 parallel 8-bit ports, serial port, 2 programmable timers and 4k of EPROM.

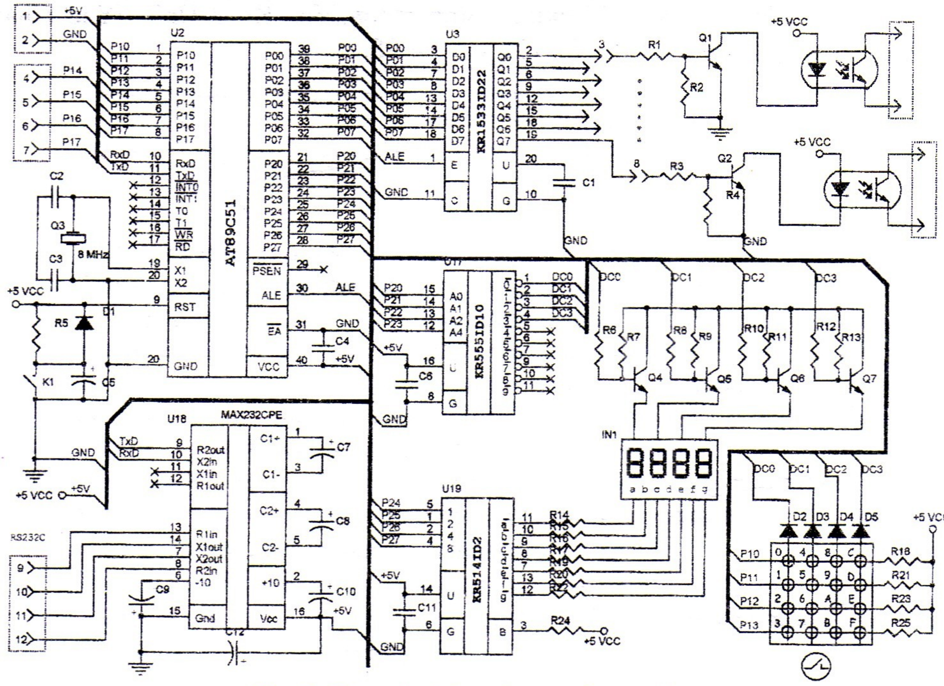

Fig. 3. The principle scheme of controller.

The 8-digit registers, transistor and tiristor keys are put into scheme for plant work cycles control, relay stabilization of its modes and pulse power supply unit control on fibre-optic lines of arc and contragated discharge of plasma-emissive sources and electron evaporators. For the data exchange with the control computer TTL- levels of the processor are transformed into levels of the standard RS-232C by microcircuit MAX 232.

4. Conclusion

The synchronization and control system of vacuum plant for ion beam assisted deposition of coatings and materials synthesis, elaborated on the base of AT89C51 and AduC812 microcontrollers, allows to automate the complex EB-IBAD process and to achieve the result resettability due to exact synchronization of the ion sources work, electron- beam evaporators and technological systems. Simple substitution of the working program for the microcontrollers allows to adopt the system easily for different tasks and also for other plants of similar class.

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