ELECTROPHYSICAL EQUIPMENT FOR PRODUCTION OF REACTIVE MULTILAYER NANOFILMS (RMNFS) FOR IGNITION OF PYROTECHNIC COMPOSITIONS USED IN SWITCHING DEVICES

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In the last decade self-propagating high-temperature synthesis (SHS) reactions in the reactive multilayer nanofilms (RMNFs) have attracted much interest which is due to their potential for practical application in a variety of fields such as mechanical joining of dissimilar or sensitive materials as well as energy storage for exothermic reaction synthesis in pyrotechnically-driven engineering systems for high-speed switching of fault currents [1–2].

The availability of equipment that meets the modern requirements for accuracy, resolution, and repeatability of technological processes as well as the possibility of flexible integration of individual installations into the general automated technological production chain is an absolute guarantee of implementation of this technology [3]. Mockup samples of technological installations for vacuum magnetron sputtering have been created, allowing the implementation of this technology in accordance with the requirements. A concept for increasing the uniformity of the resulting films characteristics in terms of thickness, structure, and electrical resistance has been developed; the equipment capacity has been increased.

The use of this technology in the production of pyrotechnic igniters with SHS multilayer film using thermite-type compositions such as CuO/Ti, CuO/Al, Ni/Al etc. allows obtaining a gain in the released energy compared to energy spent on the detonation of resistive bridge by tens of time while maintaining the required speed.

Switching devices with pyrotechnic igniters are used to protect electrical circuits from the short-circuit currents in particular in the power supply systems of ship electrical motors and equipment of the power supply system of the International Thermonuclear Experimental Reactor (ITER). This is due to the compactability of the design, safety, and high efficiency [4–6].

References

1. **Patent 2019000023 Russian Federation.** Method for joining piezoceramics with various materials [Text] / Kvashenkina O. E., Gabdullin P. G. ; applicant and patent holder O. E. Kvashenkina ; declared 15/05/2020. (in Russian).

2. **Kvashenkina, O. E.** Estimation of maximum transverse size of multilayer bimetallic films for self-propagating high-temperature synthesis using Ni/Al-structure [Text] / O. E. Kvashenkina, E. D. Eidelman, V. S. Osipov et al. // Technical physics. – 2020. – Vol. 90 – Iss. 7. (in Russian).

3. **Shashin, D. E.** Application of magnetron sputtering to form multilayer AlNi-structures [Text] / D. E. Shashin, N. I. Sushentsov, A. D. Dyachkov et al. // Proceedings of the conference “Vacuum engineering and technology– 2023”, Saint Petersburg. – P. 180–184. (in Russian).

4. Patent for invention (RUS). Explosive circuit breaker [Text] / Avanesov S. D., Manzuk M. V., Volkov S. M., Bestuzhev K. O., Semenova M. I., Alekseev D. I. ; applicant Join Stock Company “D. V. Efremov Institute of Electrophysical Apparatus” (NIIEFA). – No. 2020133574/07 (061327) ; declared 12/10/2020. (in Russian).

5. **Krivosheev, S. I.** Peculiarities of application of magnetic-pulse method for forming controlled pressure pulses to test metal samples [Text] / S. I. Krivosheev, S. G. Magazinov, D. I. Alekseev // Proceedings of the 15th International Conference on Megagauss Magnetic Field Generation and Related Topics. – 2016. – P. 39–42.

6. **Manzuk, M. V.** Protective systems of denotation automatic equipment in tokamaks [Text] / M. V. Manzuk, D. I. Alekseev, A. M. Kudryavtseva et al. // Scientific and practical journal of the Central Research Institute of Chemical Machines (FSUE “TSNIIHM”): Advanced technologies for security systems. – 2023. – No. 2. (in Russian).