

NUMERICAL SIMULATION OF GASLESS COMBUSTION OF MULTILAYER BIMETALLIC NANOFILMS

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Abstract: A model of nonstationary gasless combustion of multilayer bimetallic nanofilms was developed using a model of planar reaction cells. The model takes into account the heterogeneity of the structure of the nanofilms and the dependence of the diffusion coefficient on temperature. Numerical simulation of the propagation of the combustion wave along bimetallic multilayer nanofilms was carried out. The dependence of the burning rate on the characteristic value of the heterogeneous structure of the sample was determined. The obtained values of the propagation velocity of the self-propagating high-temperature synthesis (SHS) wave agree with the experimental data for a wide range of SHS compositions.

Keywords: self-propagating high-temperature synthesis; reaction cells; wave velocity; mathematical modeling

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References

1. Rogachev, A. S., A. E. Grigoryan, E. V. Illarionova, I. G. Kanel', A. G. Merzhanov, A. N. Nosyrev, N. V. Sachkova, V. I. Khvesyuk, and P. A. Tsygankov. 2004. Gasless combustion of Ti–Al bimetallic multilayer nanofoils. *Combust. Explo. Shock Waves* 40(2):166–171.
2. Rogachev, A. S., and A. S. Mukas'yan. 2013. *Gorenje dlya sinteza materialov: vvedenie v strukturnuyu makrokinetiku* [Combustion for the synthesis of materials: Introduction to structural macrokinetics]. Moscow: Fizmatlit. 400 p.
3. Zel'dovich, Ya. B., G. I. Barenblatt, V. B. Librovich, and G. M. Makhviladze. 1985. *The mathematical theory of combustion and explosions*. New York, NY: Plenum. 619 p.
4. Merzhanov, A. G., and A. S. Mukas'yan. 2007. *Tverdo-plamennoe gorenje* [Solid-burning combustion]. Moscow: TORUS PRESS. 308 p.
5. Aldushin, A. P., A. G. Merzhanov, and B. I. Khaikin. 1972. O nekotorykh osobennostyakh gorenija kondensirovannykh sistem s tugoplavkimi produktami reaktsii [Some features of combustion of condensed systems with refractory reaction products]. *Dokl. Akad. Nauk SSSR* 204(5):1139–1142.
6. Aldushin, A. P., and B. I. Khaikin. 1974. Combustion of mixtures forming condensed reaction products. *Combust. Explo. Shock Waves* 10(3):273–280.
7. Khaikin, B. I. 1975. K teorii protsessa gorenija v geterogennykh kondensirovannykh sredakh [To the theory of the combustion process in heterogeneous condensed media]. *Protsessy gorenija v khimicheskoy tekhnologii i metallurgii* [Combustion processes in chemical technology and metallurgy]. Chernogolovka: United Institute of Chemical Physics AS USSR Pubs. 227–244.
8. Aldushin, A. P., T. M. Martem'yanova, A. G. Merzhanov, B. I. Khaikin, and K. G. Shkadinskii. 1975. Autovibrational propagation of the combustion front in heterogeneous condensed media. *Combust. Explo. Shock Waves* 9(5):531–542.
9. Shults, D. S., and A. Yu. Krainov. 2012. Numerical simulation of gasless combustion taking into account the heterogeneity of the structure and the temperature dependence of diffusion. *Combust. Explo. Shock Waves* 48(5):620–624.
10. Seplyarskii, B. S., N. A. Kochetov, and R. A. Kochetkov. 2016. Impact of mechanical activation on the burning rate of pressed and bulk-density samples from a Ni + Al mixture. *Combust. Explo. Shock Waves* 52(3):307–312.
11. Rogachev, A. S., and A. S. Mukasyan. 2010. Combustion of heterogeneous nanostructural systems (review). *Combust. Explo. Shock Waves* 46(3):243–266.

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