PACS: 68.43.−h

Changes in the area and composition of the surface of cavitation bubbles in liquid aluminum under acoustic influence

R. Yu. Karmokova, A. M. Karmokov, O. A. Molokanov, R. M. Kalmykov and Z. Kh. Guchayeva

Kh. M. Berbekov Kabardino-Balkarian State University
173 Chernyshevsky st., Nalchik, 360004, Russia

Received 25.10.2023; accepted 16.11.2023

Total surface area of liquid aluminium is calculated from average radius of cavitation bubbles at different cavitation index values. At the same time, it was found that the total surface area increases with a decrease in the radius of cavitation bubbles, and at certain parameters it can reach 0.4 m^2. The total number of atoms on the surface of cavitation bubbles from the radius of 1 cm^3 of liquid aluminum was estimated. The number of impurity atoms was also calculated for each impurity separately and their total amount on the surface of cavitation bubbles depending on their radius for liquid aluminum of grade A4N6 (aluminum content 99.996 %) with a volume of 1 cm^3. For example, with a cavitation index of 0.3 and a radius of cavitation bubbles of 10 μm, the number of atoms on the surface is $\sim 10^{20}$ at/cm^2, and the total number of impurity atoms reaches $\sim 10^{16}$ at/cm^2. Thermodynamic calculation of interfacial layer composition was carried out and it was revealed that surface-active impurities for aluminium are silicon, magnesium and zinc. Time dependencies of average diffusion coefficient for hydrogen and magnesium in liquid aluminium at different frequencies of acoustic impact on melt and indices of cavitation are presented. The average diffusion coefficient is shown to increase with increasing cavitation index.

Keywords: acoustic influence, cavitation bubbles, impurity atoms, segregation, cavitation index, aluminium, melt, surface layer, interfacial layer, diffusion coefficient, magnesium, hydrogen.

REFERENCES

1. Kundas S. P., Lanin V. L., Tyavlovskij M. D. et al., Ultrasonic processes in the production of electronic products, vol. 1, Minsk, Bestprint, 2002.
2. Karmokova R. Yu., Molokanov O. A., Karmokov M. M., Karmokov A. M. and Zhekamukhov Z. A. Proceedings of the XII International Scientific and Technical Conference "Micro- and Nanotechnologies in Electronics". Nalchik, 2021, pp. 242–248.
3. Khmelev V. N., Golykh R. N., Khmelev S. S. et al., News of higher educational institutions of the Chernozem region **4** (22), 58 (2010) [in Russian].
4. Golykh R. N., Shakura V. A. and Ilchenko E. V. Materials of the IX All-Russian scientific and practical conference of students, graduate students and young scientists with international participation. Technologies and equipment for the chemical, biotechnological and food industries. Biysk, 2016, pp. 19–22.
5. Physics and technology of powerful ultrasound. Powerful ultrasonic fields, ed. prof. L. D. Rosenberg. Moscow, Nauka, 1968.
6. Karmokova R. Yu., Rekhviashvili S. Sh. and Karmokov A. M., Fizika i khimiya obrabotki materialov. Physics and Chemistry of Materials Treatment. **5**, 20 (2012) [in Russian].
7. Bzhikhatlov K. Ch. Surface segregation and its influence on some properties of nanolayers on the surface of solid solutions of copper with manganese, germanium and aluminum. Diss. Candidate of Physics and Mathematics Sciences, Nalchik, KBSU, 2017.
8. Nizhenko V. I. and Floka L. I., Surface tension of liquid metals and alloys (one- and two-component systems). Directory. Moscow, Metallurgy, 1981.
9. Khmelev V. N., Golykh R. N., Bobrova G. A., Shalunov A. V., Shakura V. A. and Pedder V. V. 20 Inter-

national conference – seminar of young specialists in micro- and nanotechnologies and electronic devices EDM' 2019. Novosibirsk, 2019, pp. 231–234.

10. Arkhangelsky M. E., Uspekhi fizicheskikh nauk **2** (2), 181 (1967) [in Russian].

11. Boguslavsky Yu. A., Akusticheskiy zhurnal **13** (1), 23 (1967) [in Russian].

12. Levkovsky Yu. L., Akusticheskiy zhurnal **14** (4) 561 (1968) [in Russian].

13. Ilkovich D., J. Chem. Phys. **35**, 129 (1938).

14. Khmelev V. N., Golykh R. N., Bobrova G. A., Shalunov A. V. and Khmelev M. V. Materials of the XII All-Russian scientific and technical conference of students, graduate students and young scientists with international participation “Measurements, automation and modeling in industry and scientific research 2017”. Biysk, 2017, pp. 178–183.

15. Wang C. Y. and Beckermann C., Metallurgical transaction. **24** (12), 2787 (1993).

16. Lyashenko Yu. A., Uspekhi fizicheskikh metodov **4**, 81 (2003) [in Russian].

17. Golykh R. N. Increasing the efficiency of ultrasonic cavitation effects on chemical technological processes in heterogeneous systems with a carrier high-viscosity or non-Newtonian liquid phase, Diss. Candidate of Technical Sciences, Biysk, AltSTU, 2014.

18. Karmokova R. Yu., Karmokov A. M., Molokanov O. A. and Karmokov M. M. Materials of the XII international scientific and technical conference “Micro- and nanotechnologies in electronics”. Nalchik, 2021, pp. 358–363.

19. Babichev A. P., Babushkina N. A., Bratovsky A. M. et al. Physical quantities: Handbook, Moscow, Energoatomizdat, 1991.