Vid. Proc. Adv. Mater., Volume 1, Article ID 200825 **(2020)**

Impact based Deposition of Ceramics at Room Temperature: Aerosol Deposition Method (AD)

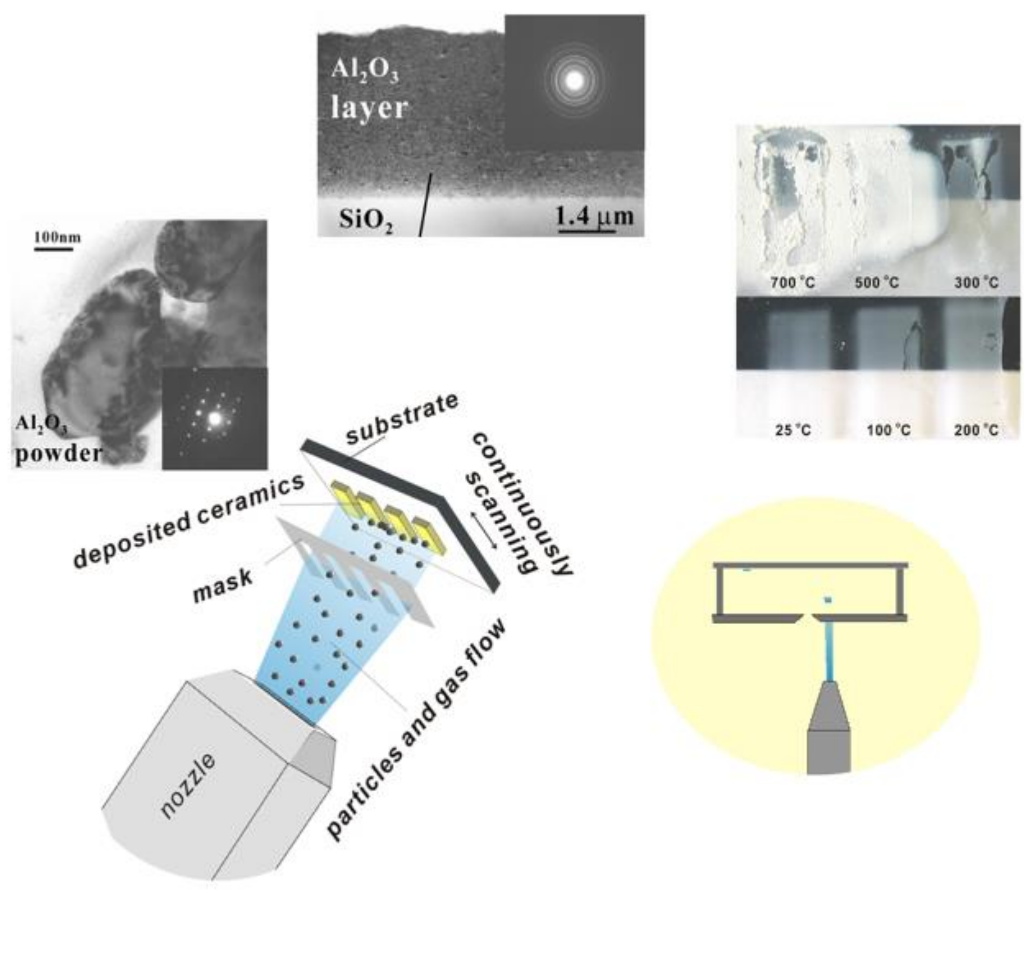
Maxim Lebedev[1]*, Jun Akedo[2]

[1]Curtin University, Perth, 6151, Australia
[2]National Institute of Advanced Industrial Science and Technology, Tsukuba, 305-8560, Japan

*Corresponding and Presenting Author. E-mail: m.lebedev@curtin.edu.au

DOI: 10.5185/vpoam.2020.0825

Graphical Abstract



Abstract

Miniaturization and enhancement of devise performance are still required in many applications such as Microelectromechanical systems, display devices, fuel cells, optical devices, RF components etc. Therefore, a fine-patterning, high deposition rate and low process temperature are the critical factors for ceramic coating for these applications. Three decades ago, the impact-based technology so-called Aerosol Deposition Method (AD) was proposed as an adjunct to the existing techniques [**1**]. Nowadays, such technology may be considered as a well-established, and many research groups and companies are using and still developing it. AD starts from the selection of the ceramics power, preparation of the aerosol by mixing with a carrier gas, acceleration such aerosol in the gas-dynamic nozzle, impact of the ceramics particles with substrates and formation of a dense ceramics layers [**2**]. Various ceramics can be deposited on different substrates by AD with a high rate; layers are thick and dense, hard and exhibiting excellent electrical, magnetic, piezoelectric properties. Surprisingly no atomic diffusion in composite ceramic layers can be observed after deposition, indication low process temperature [**3**]. Despite remarkable research activities, the key question is remains, namely "what is the mechanism of ceramics formation at this method?" The understanding of the mechanism is not only important from the fundamental point of view but will drastically improve the technology. As a starting point in mechanism understanding, it is necessary to contemplate the physics of the impact of a small particle onto a substrate. The particle size in ADM is very small (less than 1 um), and the duration of the impact process is extremely short in time (in order of 1 ns). Thus, no direct observations of the impact in experiments can be observed so far. For the appropriate simulation of this microscale, impacts effects the input parameter such as the speed of particles and particle's mechanical properties must be taken into account. Direct measurements of the velocity of particles deposited on the substrate can be done with a "self-selective" method [**4**]. This method is based on cutting the particle flow on a very small "pockets" and measurements of the time-of-flight of such pockets. The mechanical properties of deposited layers strongly depend on the particle velocity; more other the shape of the structure also depends on the velocity. There is a range of the velocities typically 100 – 500 m/s for which deposition is possible. Mechanical properties of substrates and substrate temperature also factor responsible for deposited layer properties [**5**]. More systematic investigation of the AD performance and the high-speed micromechanical impact phenomena is necessary, as the existing explanations of the mechanism are still phenological [**1,5**] and to improve the performance of AD the comprehensive theory is required.

Keywords: Aerosol deposition method, ceramics, high-speed impact, micromechanics.

References

1. J Akedo, *Journal of Thermal Spray Technology*, **2008**, *17*, 181.
2. J Akedo, M Lebedev, *Applied Physics Letter*, **2000**, *77*, 1710.
3. J Akedo, M Lebedev, *Japanese Journal of Applied Physics*, **2002**, *41*, 6980.
4. M. Lebedev, et al., *J. Vacuum Science and Technology A*, **2016**, *18*, 563.
5. M. Lebedev, J Akedo, T Ito, *Journal of Crystal Growth*, **2005**, *275*, e1301.

Biography of Presenting Author

Maxim Lebedev is a Professor at Curtin University. Maxim was awarded BS, MS and PhD degrees from Moscow Institute (State University) of Physics and Technology in Russia. He has over 30 years of research experience in physics, material science and rock physics working at leading research organizations in Russia, Japan, New Zealand, and Australia. For more than eight years Maxim was actively involved in the pioneering research on Aerosol Deposition method in National Institute of Advanced Industrial Science and Technology, Japan, in which he developed the unique way to deposit ceramics at room temperature. He joined Curtin University in 2007 and became a head of experimental rock physics program. Using innovation methods, Maxim has built from scratch a rock physics laboratory, which became the world-leading rock physics laboratory. He has published over 150 peer-reviewed papers and is the inventor of 11 international patents. His current research is focused on the properties of subsurface reservoir rocks and minerals, including elastic and unelastic properties of rocks at teleseismic, seismic and ultrasonic frequencies; digital rock physic; mechanical properties of rocks at microlevel (nanoindentation); direct observation of multiphase fluid distribution inside rocks at reservoir conditions (microCT).

Citation of Video Article

Vid. Proc. Adv. Mater., Volume 1, Article ID 200825 **(2020)**

Full Video Article www.proceedings.iaamonline.org/article/ vpoam-2020-0825