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Multiphase AC Arc: Fundamentals and Applications

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A multiphase AC arc (MPA) as shown in **Fig. 1** is one of the new methods for thermal plasma generation. MPA has the advantages of high energy efficiency, large plasma volume, and long processing time. MPA has been studied with the aim of establishing a method for mass production of functional nanoparticles. In particular, knowledge of metal vapors as precursors of nanoparticles is needed, as they are important for the product properties.

To visualize the nanoparticle formation process, the temperature field has been successfully evaluated by measuring the emission of lithium vapor supplied as raw material. However, the fluctuations in the density field have not yet been elucidated. The line spectra of lithium atoms at 460, 610, and 671 nm have been confirmed, and it has been experimentally clarified that self-absorption occurs, especially at 671 nm [1,2]. The purpose of this study is to establish the method for measuring lithium atomic density using self-absorption.

The MPA generates thermal plasmas between electrodes by applying AC voltages of different phases to multiple electrodes. The plasma was generated by 6-phase AC under atmospheric pressure. The arc current was 87 A and the drive frequency was 180 Hz. Argon shielding gas flowed at 5 L/min per electrode.

Control of the crystal structure of lithium metal oxides is essential to improve the characteristics of lithium-ion batteries (LIBs). Spinel type layered rock salt type and olivine type materials are considered as suitable structures for the cathode material due to the high mobility of lithium ions. In particular, spinel-structured $LiMn_2O_4$ is one of the promising high-voltage cathode materials for LIB due to its high theoretical energy density, low cost and good safety, while $LiMnO_2$ is also a good candidate due to its excellent cycle life. The feedstock was fed from the center of the plasma, just below the electrodes. A mixed powder of Li_2CO_3 and MnO_2 was used as the feedstock, with a composition ratio of Li and Mn of 1:1. The feed rate was approximately 0.7 g/min.

Two high-speed cameras were installed at the same height facing each other for synchronous measurement of metal vapor in two directions. A 3-wavelength synchronous measurement of Li atoms was attempted using a system combining a high-speed camera and bandpass filters of 460±5 nm, 610±5 nm, and 671±5 nm for the line spectrum of lithium atoms.

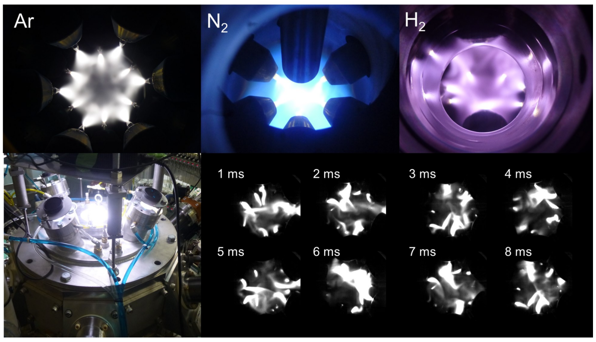

Fig. 1 Schematic image of multiphase AC arc.

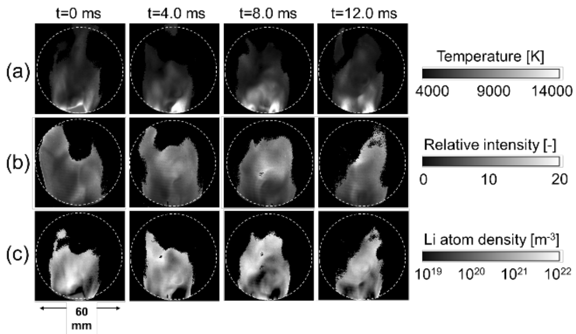

Fig. 2. Snapshots of (a) temperature and (b) relative intensity of 610 nm to 671 nm, and (c) density distribution of Li atom.

Snapshots of the temperature, relative intensity ratio, and number density distribution of lithium atoms obtained by the high-speed camera are shown in **Fig. 2**. These figures show that the density of lithium atoms is mostly in the order of 10^{20} to 10^{21} m^{-3}. The two-dimensional density distribution of lithium atoms was obtained by a high-speed camera using the luminescence and absorption phenomena of Li atoms.

Acknowledgement
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References

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