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Section of Public Relations	Dongsun Cho Section Chief 062-715-2061	Nayeong Lee Senior Administrator 062-715-2062
Contact Person for this Article	Professor Hyeong-Jin Kim Graduate School of Energy Convergence 062-715-5323	
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Professors Hyeong-Jin Kim and Sungho Jeong's joint research team improves capacity and output at the same time by micro-processing the electrode of the battery with a laser

□ GIST (Gwangju Institute of Science and Technology) Graduate School of Energy Convergence Professor Hyeong-Jin Kim and School of Mechanical Engineering Professor Sungho Jeong's joint research team simultaneously improved battery capacity and output by processing electrodes in various lithium rechargeable batteries such as lithium nickel manganese cobalt oxide (NMC), lithium phosphate (LFP), and graphite by using a femtosecond laser *.

* femtosecond laser: a laser with a very short pulse width of several tens of femtoseconds allows micrometers of fine processing with little thermal effect (1 femtosecond = 10^{-15} seconds)

□ In lithium secondary batteries, structural characteristics according to electrode thickness and porosity have a great influence on battery performance. On the other hand, the thickening of the electrode, which accumulates more active materials, or high density by a strong compression process can improve the energy density, while the power density rapidly decreases due to structural limitations that are disadvantageous to ion conductivity.

- In other words, the capacity and output of the battery are inversely related, so the thickness and porosity of the electrode, which have the greatest effect on the performance, are optimized and applied within a limited range.

□ The research team made the existing electrode structure three-dimensional through laser processing of electrodes thicker (100-700μm thick) and higher density (26% porosity) than commercial electrodes in previous studies. As a result, it demonstrated the laser processing effect by increasing the energy density and power density at the same time by widening and shortening the diffusion path of lithium ions from the electrode surface to the current collector.

- This study presented laser processing design conditions considering the operating environment and performance of lithium rechargeable batteries by analyzing the correlation between various processing conditions (processing depth, spacing, etc.) and changes in battery performance for mass production application of laser processing technology. In particular, the laser processing effect was intuitively analyzed by visualizing the lithium ion distribution inside the electrode by using laser induced breakdown spectroscopy (LIBS)*.

  * laser induced breakdown spectroscopy: When a focused laser beam is irradiated on the surface of the sample and the atoms in the sample reach the excited state and return to the ground state, light of a natural wavelength is emitted depending on the element. It is a spectroscopic analysis technology that can analyze the spectral signal and analyze the composition of the material constituting the sample and the content of each component.

□ Professor Hyeong-Jin Kim said, "The core of this study is to establish major design conditions in laser processing of lithium secondary battery electrodes and to visualize the distribution of lithium ions in the electrode during charging and discharging using laser analysis technology. It is hoped that the laser micro-machining process will enable a design that goes beyond the limits of the existing electrode specifications and contributes to the remarkable performance improvement of the lithium secondary battery by simultaneously improving the energy density and power density."

□ This research was led by GIST Professor Hyeong-Jin Kim and Professor Sungho Jeong and was conducted by Dr. Junsu Park as the first author with support from the GIST Research Institute (GRI) and the Korea Institute for Advancement of

Technology (KIAT) and was published online on April 22, 2021, in the *Journal of Energy Chemistry*, a world-renowned journal in the field of applied chemistry.

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