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Aluminum Multicharged Ion Generation Using Spark-Assisted Laser Ion Source

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Multicharged ions (MCI) sources are of interest for their utilization in surface modification, e.g., etching and deposition, for ion implantation, and for fundamental studies of ion-surface interactions. In laser MCI sources, the MCIs are generated by focusing a laser pulse on a solid target causing its ablation and ionization. The laser-matter interaction produces dense plasma consisting of ions, electrons, clusters, and neutral particles. We report on the development of a spark-assisted laser multicharged ion (SALMCI) source to enhance the plasma ionization by depositing spark energy into the laser ablated plume. The SALMCI source is composed of a laser MCI source and a separate spark stage to deposit energy into the laser ablated plasma. A Q-switched 7.4 ns pulse width Nd:YAG laser ($\lambda = 1.06 \mu\text{m}$) is used to ablate a solid target. For an aluminum target, the spark discharge results in significant enhancement of the MCIs generated along with higher charge states than observed with the laser source alone. With amplification stage (spark discharge energy of 1.25 J) and laser pulse energy (72 mJ/pulse), the total charge measured increases by a factor of ~ 9 and charge state up to Al^{6+} was observed compared to Al^{+3} generated with only the laser pulse. Using a laser pulse energy of 45 mJ, charge amplification by a factor of ~ 13 was observed for spark discharge energy of 1.00 J. This approach also minimizes target damage by the laser pulse since the laser is mainly used to introduce the vapor into the spark while the energy delivered by the spark is used to heat the plasma increasing MCI production.