Double stage laser pyrolysis synthesis applied to silicon-carbon core-shell nanoparticles

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Title and affiliations (must fit in this box)

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Florent Boismain[1], John P. Alper[1], Antoine Desrues[1], Olivier Sublemontier[1], Cédric Haon[2], Nathalie Herlin-Boime[1].

1. CEA-DRF/IRAMIS/NIMBE/LEDNA, CEA Saclay, 91191, Gif sur Yvette, France
2. CEA-DRT/LITEN/DEHT, CEA Grenoble, 38054, Grenoble, France

Abstract (No longer than 250 words. Both the abstract and references must fit in this box. Style is Calibri 12, single line spacing)

Synthesis routes permitting the preparation of complex structures such as core@shell nanoparticles are of interest for the particles unique physical and chemical properties. We demonstrate here a versatile laser pyrolysis method for the one step synthesis of Si@C nanoparticles. These nanoparticles are synthesized in a double stage reactor developed with the help of flow simulation[1]. Using the laser pyrolysis method, we demonstrate production rate of 10 g/h under stable condition for over 5 hours. In the first reaction zone,the precursor gas of silicon, the silane (SiH_4), absorbs the CO_2 laser and is decomposed to form silicon nanoparticles. In the second stage the carbon precursor gas, ethylene (C_2H_4), mixed with the silicon nanoparticles through a novel radial injection, is decomposed via laser excitation and the carbon is deposited on the silicon cores while avoiding homogeneous nucleation of carbon nanoparticles. The size and the crystallinity of the silicon cores are controlled with the time of interaction and power of the laser beam while the carbon content is controlled by the ethylene flow rate. Other gases were also be added for doping or alloying of the silicon core (for example germane to achieve SiGe alloy cores or ammonia to dope the carbon shell).
These core-shell nanoparticles (Si@C) were tested as active materials for anodes of Li-Ion batteries. Compared to the commonly used graphite electrode, the capacity is significantly higher (therotecal values 3579 mAh/g vs 372 mAh/g) while the stability is improved in comparison with an electrode elaborated from pure silicon (500 cycles vs 50 cycles).

References

1. N. Herlin-Boime, John P. Alper, F.Boismain. Dispositif pour la synthèse de nanoparticules de type cœur-coquille par pyrolyse laser et procédé associé. Patent Pending n°FR1661759 (2016)