Electrochemical Performance of Silicon Enhanced Lac Knife Natural Flake Graphite

From Quebec, Canada in Lithium-Ion Batteries – Dr. Joseph E Doninger

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Focus Graphite, Inc is a Junior Mining Company established in 2010 with its headquarters in Ontario Canada and is developing two of the most promising flake graphite deposits in North America: The Lac Knife deposit with an estimated 2 million metric tons of recoverable graphite and is now in the final development stage with the submittal of an updated Preliminary Feasibility Study to the Quebec Authorities in March and the Lac Tetepisca deposit with an estimated 6.3 million tons of recoverable graphite which is in the early stage of development and just completed its first major development drilling program to delineate the extent of the ore body.

Extensive flotation pilot plant tests were run on the drill core Lac Knife ore samples which resulted in the recovery of 34%, +80 mesh course flake concentrate grading at 98.3% Cg and an average 98.1% Cg grade on all sizes larger than 200 mesh. The coarse flake was then thermally purified to reach a purity level of 99.98% Cg and used to produce the sized, highly conductive purified grades of flake and expanded graphites and the spheroidized and carbon coated grades of spherical graphite (SPG) for use in Lithium-Ion batteries.

Three grades of carbon coated spherical graphite (SPG) were developed for the anodes of Lithium-Ion batteries ranging from the standard (D50 = 23.9um) grade to the fine (D50 = 17.4um) and ultra-fine (D50 = 11.9um) grades of SPG. Initial long term cycling tests showed that the coin cells made with the high purity fine grade of Lac Knife flake graphite exhibited almost zero loss in capacity after the first 110 cycles when compared with two commercial grades of natural flake graphite tested which had capacity losses of 4% and 6%. The reversible capacity of 366.0 mAh/g of coin cells made with the fine grade of coated Lac Knife flake graphite was also about 6 % higher than the reversible capacity of coin cells made with two grades of commercial synthetic graphite at 342.2 and 345.4 mAh/g.

The process developed for the production of Silicon Enhanced SPG involves adding the silicon to the purified Lac Knife flake graphite in an oxygen free atmosphere prior to spheroidization and before coating the SPG with carbon. Although the initial tests on Silicon Enhanced carbon coated SPG were conducted on coin cells made with additions of silicon from 4.5% to 18.0% Si, customer specifications for the surface area (< 4m2/g) and tap density (> 9g/cc) of the anode mix along with the expansion characteristics of silicon are currently limiting addition levels to 9 % Si or less.

Galvanostatic charge/discharge curves for coin cells made with 4.5% silicon addition show that coating the SPG with carbon improves cycling stability and increases the reversible capacity from 392 to 462 mAh/g which is 24 % higher than the theoretical capacity of graphite alone at 372 mAh/g. Tests conducted on the 9% Si Enriched SPG showed that adding the silicon to the anode mix before spheroidization increases the capacity from 530 to 605 mAh/g, which is an additional 13% boost in capacity, or an overall 62 % increase when compared with the theoretical capacity of graphite alone.

A PCT patent application on the process used to produce the Carbon Coated Silicon Enhanced Spherical Graphite is currently under review by the Patent Office.