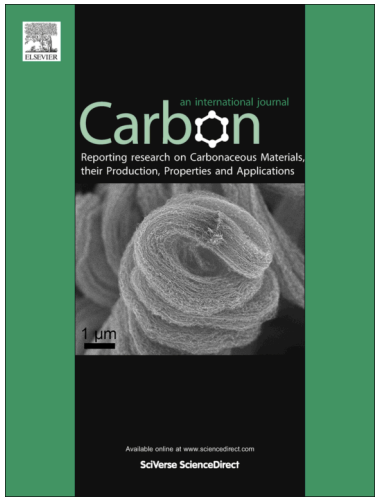

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PII: S0008-6223(14)00489-8
DOI: http://dx.doi.org/10.1016/j.carbon.2014.05.049
Reference: CARBON 9015

To appear in: *Carbon*

Received Date: 10 February 2014
Accepted Date: 19 May 2014

Please cite this article as: Şahin, K., Fasanella, N.A., Chasiotis, I., Lyons, K.M., Newcomb, B.A., Kamath, M.G., Chae, H.G., Kumar, S., High Strength Micron Size Carbon Fibers from Polyacrylonitrile - Carbon Nanotube Precursors, *Carbon* (2014), doi: http://dx.doi.org/10.1016/j.carbon.2014.05.049

High Strength Micron Size Carbon Fibers from Polyacrylonitrile - Carbon Nanotube Precursors

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Abstract

An improved, high strength, carbon fiber derived from islands-in-a-sea bi-component gel spun polyacrylonitrile (PAN)-carbon nanotube (CNT) precursor fibers containing 1 wt% mixture of single, double, and few walled CNTs was developed. Microscale experiments with properly designed MEMS tools provided the mechanical properties of individual, 1-μm diameter carbon filaments, which were isolated from bundles of 407 fibers. The statistics of the mechanical strength were described well by the cumulative Weibull probability density function that resulted in characteristic strength of 6.2 GPa and a modulus of 4.5, while the highest tensile strength and Young's modulus values were 7.3 GPa and 323 GPa, respectively. At the lower end of the spectrum, the strength values correlated well with predictions based on an effective flaw size obtained from fracture cross-sections. On the other hand, the failure cross-sections of the high strength carbon fibers contained a large number of long and oriented CNTs but no discernible flaws. The high interfacial strength between the CNTs and the surrounding carbon resulted in fracture and telescopic pull-out of the CNTs, which was corroborated by individual CNT pull-out experiments with MEMS tools inside an SEM, and in situ fiber failure observations of telescopic pull-out of CNTs inside a TEM.

1. Introduction

Carbon fibers are employed in composite structures requiring high strength, stiffness, and additional functionalities [1-7]. High performance carbon fibers are derived from mesophase pitch or polyacrylonitrile (PAN). The latter are known for their high strength due to a less

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