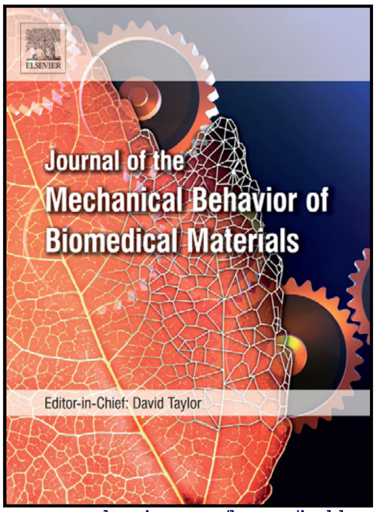
Author's Accepted Manuscript



www.elsevier.com/locate/jmbbm

Capturing tensile size-dependency in polymer nanofiber elasticity

Bo Yuan, Jun Wang, Ray P.S. Han

PII: S1751-6161(14)00344-0
DOI: http://dx.doi.org/10.1016/j.jmbbm.2014.11.003
Reference: JMBBM1308

To appear in: *Journal of the Mechanical Behavior of Biomedical Materials*

Received date: 23 September 2014
Revised date: 29 October 2014
Accepted date: 3 November 2014

Cite this article as: Bo Yuan, Jun Wang, Ray P.S. Han, Capturing tensile size-dependency in polymer nanofiber elasticity, *Journal of the Mechanical Behavior of Biomedical Materials,* http://dx.doi.org/10.1016/j.jmbbm.2014.11.003

Capturing tensile size-dependency in polymer nanofiber elasticity

Bo Yuan[a], *Jun Wang*[b,]*, *Ray P. S. Han*[c,]*

[a]*Department of Mechanical Engineering, Guangdong College of Industry & Commerce, Guangzhou 510510, China*

[b]*Department of Materials Science, Fudan University, Shanghai 200433, China*

[c]*Department of Materials Science & Engineering, Peking University, Beijing 100871, China*

*Corresponding authors
J. Wang (Tel: 86-136-8167-7556; Email: jun_wang@fudan.edu.cn)
Ray Han (Tel: 86-131-4640-1138; Email: ray-han@pku.edu.cn)
http://dx.doi.org/10.1016/

ABSTRACT

As the name implies, tensile size-dependency refers to the size-dependent response under uniaxial tension. It defers markedly from bending size-dependency in terms of onset and magnitude of the size-dependent response; the former begins earlier but rises to a smaller value than the latter. Experimentally, tensile size-dependent behavior is much harder to capture than its bending counterpart. This is also true in the computational effort; bending size-dependency models are more prevalent and well-developed. Indeed, many have questioned the existence of tensile size-dependency. However, recent experiments seem to support the existence of this phenomenon. Current strain gradient elasticity theories can accurately predict bending size-dependency but are unable to track tensile size-dependency. To rectify this deficiency a *higher-order strain gradient elasticity* model is constructed by including the second gradient of the strain into the deformation energy. Tensile experiments involving 10wt% polycaprolactone nanofibers are performed to calibrate and verify our model. The results reveal that for the selected nanofibers, their size-dependency begins when their diameters reduce to 600nm and below. Further, their characteristic length-scale parameter is found to be 1095.8 nm.

Keywords
tensile size-dependency, higher-order strain gradient elasticity, characteristic length-scale parameter, effective modulus

1. Introduction

The elastic property of a structure is traditionally defined based on the precepts of continuum mechanics, where the elastic modulus is assumed to be size independent. However, for nanostructures their elastic modulus can become size-dependent and this behavior has been confirmed through numerous experimental and computational observations (Lim et al., 2008; Zussman et al., 2006; Arinstein et al., 2007; Chen et al., 2006; Cuenot et al., 2000, 2003, 2004; Hemker et al., 2008; Lam et al., 2003; Maranganti et al., 2007; Miller et al., 2000; Song et al., 2005; Wang et al., 2007; Wu et al., 2007). As the length-scale of a macrostructure approaches the nano range, the gradient deformations, which were smooth and continuous begin to vary sharply in a non-continuous manner, and as a result,