



TOYOHASHI UNIVERSITY of TECHNOLOGY

Tempaku-cho, Toyohashi, Aichi, 441-8580 Japan

PHONE: +81-532-44-6577 FAX: +81-532-44-6557

E-mail: press@office.tut.ac.jp

PRESS RELEASE

Source: Toyohashi University of Technology, Japan, Committee for Public Relations

Subject line: Monitoring the real-time deformation of carbon nanocoils under axial loading

Summary: Tensile tests were performed on nine carbon nanocoils (CNCs) using a focused-ion-beam (FIB) technique. An individual CNC was picked up using an FIB, and a CNC bridge formed between a probe and the spring-table substrate. Real-time observations of the CNC elongation and subsequent fracture under prolonged stretching enabled us to estimate the elastic limit, the spring constant, the shear modulus, and the ultimate strength of each CNC and their mean values.

Carbon nanocoils (CNCs) composed of helical shaped carbon nanofibers have potential applications including mechanical springs and nano-solenoids. There are some reports which measure the spring constant of CNCs.

However, the CNC response to prolonged stretching, which includes initial elastic elongation to large-scale deformation in the plastic regime and subsequent tensile fracture followed by post-fracture contraction and the release of the applied strain, remains undetermined. It is crucially important to secure real-time measurements of CNC deformation beyond the linear elastic regime.

Here, Taiichiro Yonemura and colleagues at Toyohashi University of Technology describe the real-time deformation data that exhibited sequential change in CNC geometry after each coil was subjected to a uniaxial load at a constant rate.

CNC tensile tests were conducted as follows: The CNCs were installed into an FIB system with a tungsten (W) probe with a 500 nm tip diameter and the W probe moved until it adhered to CNC using Pt ion beam whereas the Si ion beam cut the CNC bottom; then the CNC-adhered W probe approaches a spring table substrate surface, until the CNC was almost perpendicularly to the substrate. The tensile tests were performed on nine CNCs by gradually changing the distance between the substrate and W probe.

The real-time data of a CNC tensile test performed using a spring table in the FIB chamber was monitored. A series of three scanning ion microscopy (SIM) images offers visualization of the geometric evolution of the CNC under a tensile load. These images were captured in the free state ($t = 0$ s), the maximum elongation point ($t = 910$ s), and a post-fracture state ($t = 960$ s).

To determine the elastic boundary of the CNCs, we examined the relationship between the applied strain and residual elongation ratios of CNCs after the load release. The result indicates that the CNCs were in the elastic region for elongations up to approximately 15% strain.

Tensile tests, performed on nine different CNCs, revealed that the average CNC spring constant was 1.8 N/m. Using a theoretical equation for the design of macroscopic springs, the shear moduli of the nine CNCs were estimated to be 6 GPa on average. These results may serve as a milestone for developing CNC-based applications in the future.



TOYOHASHI UNIVERSITY of TECHNOLOGY

Tempaku-cho, Toyohashi, Aichi, 441-8580 Japan

PHONE: +81-532-44-6577 FAX: +81-532-44-6557

E-mail: press@office.tut.ac.jp

Reference:

Taiichiro Yonemura, Yoshiyuki Suda, Hiroyuki Shima, Yasushi Nakamura, Hideto Tanoue, Hirofumi Takikawa, Hitoshi Ue, Kazuki Shimizu, and Yoshito Umeda

Real-time deformation of carbon nanocoils under axial loading

Carbon, 83, 183-187 (2015).

Digital Object Identifier (DOI): <http://dx.doi.org/10.1016/j.carbon.2014.11.034>

Department of Electrical and Electronic information Engineering, Toyohashi University of Technology.

Department website: <http://www.tut.ac.jp/english/introduction/department02.html>

Further information

Toyohashi University of Technology

1-1 Hibarigaoka, Tempaku

Toyohashi, Aichi Prefecture, 441-8580, JAPAN

Inquiries: Committee for Public Relations

E-mail: press@office.tut.ac.jp

About Toyohashi University of Technology:

Founded in 1976 as a National University of Japan, Toyohashi University of Technology is a vibrant modern institute with research activities reflecting the modern era of advanced electronics, engineering, and life sciences.

Website: <http://www.tut.ac.jp/english/>

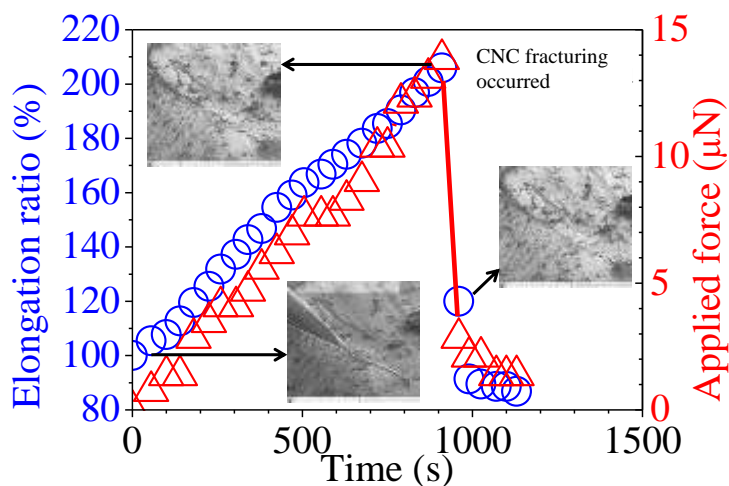


Figure 1: Real-time observation of CNC tensile tests and SIM images of variations in the coil geometry over time.

Keywords: Chemistry/ Physics/ Material Science, Nanotechnology/ Micromachines