Sound Absorption in the Low Audible Frequency Range of Microfibrous Parylene-C Thin Films

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Microfibrous thin films (μFTFs) of Parylene C are deposited to a thicknesses of about 100 μm by physicochemical vapor deposition with the intention of determining the sound absorption of these films in the lower audible frequency range. The objective is to determine the sound absorption by the μFTFs by using dynamic loading experiments. The μFTFs were subjected to cyclic elastic loads in the frequency range of 5 to 200 Hz over a temperature range of 25 to 50 °C to determine their dynamic moduli and thus extract the Parylene-C μFTFs sound absorption properties. The absorption coefficient of microfibrous Parylene-C is found to be weakly dependent on temperature, however it increases with increasing frequency. Peaks in the spectra of the absorption coefficient were attributed to resonant coupling between incident sound waves and vibrating microfibers.

1. INTRODUCTION

Microfibrous thin films (μFTFs) are important materials in optical, chemical, and biochemical applications.[1] μFTFs are fabricated by either physical or chemical vapor deposition methods with oblique-angle deposition techniques.[1,2] Different material types, including metals, ceramics, and polymers were successfully sculptured by using these techniques.[1] The typical structural μFTF morphologies produced are shown in the scanning electron microscope (SEM) images in Fig. 1.

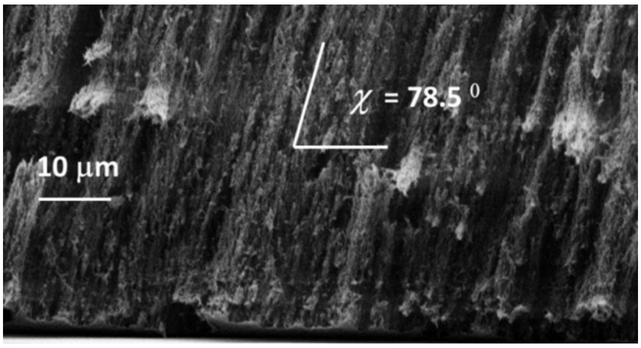

Figure 1. A typical FESEM micrograph of a Parylene-C μFTF.

Parylene-C, a polymer material, has often been used as moisture-impermeable coating in medical devices and electronics.[3] For these medical and electronic applications, Parylene-C was prepared in bulk form, i.e., as a dense homogeneous film, by using chemical vapor deposition.[4] However, the μFTF-growth of Parylene-C introduced periodicity. Therefore, it aided in the the investigation of acoustic and electromagnetic wave propagation characteristics and availed the possibility of acoustics optical applications. These applications required the investigation of the mechanical and dielectric properties of Parylene-C μFTFs.

In this article, μFTFs of Parylene-C were fabricated using a physicochemical vapor deposition process and examined using dynamic mechanical loading, acoustic insertion loss, and transmission spectroscopy.[5,6] The storage, loss, moduli, and absorption coefficient for the Parylene-C μFTFs were obtained as a function of temperature and frequency. There are several studies on the effects of nano/microstructures on sound absorption. However, this is the first such study on microfibrous thin films.[7–9]

2. THE EXPERIMENTAL PROCEDURE

The microfibers of Parylene C used in this work were fabricated using a physicochemical vapor deposition process([5,6]) and used a custom made PDS2010 Labcoater. Four grams of a Parylene-C dimer were first vaporized at 175 °C and then pyrolyzed at 690 °C into a monomer vapor. A collimated flux of the monomer vapor was directed from a nozzle at 45 ° towards a planar 2 cm × 2 cm Si substrate in a low-pressure chamber maintained at 175 °C and 28 mTorr. Finally, the thin film was removed from the silicon substrate using a razor.

After being removed, the morphologies of the grown samples were first examined using a field-emission scanning electron microcopy (FESEM) with a Model LEO 1530, Carl Zeiss microscope. After the morphology examination, each sample was held between the two appropriately spaced grips of a tension clamp and subjected to cyclic loading in a dynamic mechanical analyzer (DMA). The DMA used was the Model Q800 equipment, which was made by TA Instruments and used a "Multi-Frequency Strain" module. The tension-clamp was calibrated with a thin steel sheet of known compliance and dimensions. The measured experimental temperature range was between 25 °C and 150 °C in steps of 5 °C. At each temperature, a cyclic strain of amplitude 0.046 % (elastic regime) was set for frequencies between 5 and 200 Hz in increments of 5 Hz.

3. RESULTS AND DISCUSSION

From FESEM, the thicknesses of the samples were found to be in the range of 100 to 110 microns and the microfiber diameters were determined to be about 5 μm inclined at about 80 °