SCANNING ACOUSTIC MICROSCOPY INVESTIGATIONS OF PYROLYTIC CARBON

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Introduction

A scanning acoustic microscope (SAM) has been employed to investigate subsurface flaws in isotropic silicon alloyed pyrolytic carbons (PyC) intended for use in the manufacture of prosthetic heart valves. These PyC are deposited by means of chemical vapor deposition in a bed of a fluidized particles [1]. Due the presence of flaws, subsequent potentially destructive proof testing of each component is required. Identification of such flaws nondestructively may lead to improved manufacturing methods.

Experimental

Figure 1 shows a schematic of the basic operating principle for the SAM used in this study. The system used in this study is a modified SONIX HS-500 scanning acoustic microscope composed of a UTEX Scientific UT340 square wave pulser/receiver which excites and receives signals from a piezoelectric transducer coupled to an acoustic lens. The broadband Panametrics transducer is composed of a 1.18 mm diameter element that has a nominal frequency of 110 MHz. The transducer is coupled to a fused silica acoustic lens that provides a 58 mm focal length with a 4.25 μs delay.

In order to maximize the signal-to-noise ratio, the signal from the pulser/receiver is passed through a 10 MHz high-pass filter and a 150 MHz low-pass filter. This filtered signal is then digitized at a rate of 1 GHz by a SONIX 81GU PC card. The digitized signals are collected by SONIX FlexSCAN-C version 4.6 software. This software also drives the motor controllers that raster scans the specimens to produce an image. The sample and acoustic lens are coupled by room temperature water in an immersion tank.

Results and Discussion

To demonstrate the feasibility of the technique and provide samples for process optimization, a series of monolithic PyC samples were laser etched on the backside with a 10 x 10 array of shallow holes simulating porosity. Figure 2 shows a SAM image resulting from scanning the front surface of such an array with the acoustic lens focused on the backside of the sample.

Figure 3 shows a SAM image of a test disk of PyC with numerous subsurface flaws. To verify the accuracy of the flaw detection in terms of depth and location, this disk was mounted in epoxy and cross-sectioned. The location of several of the flaws was confirmed with an accuracy of better than 50 μm. From the cross-sections, the flaws were determined to be porosity and soot inclusions in the PyC coating.

The theoretical resolution of this system is half the wavelength of the acoustic waves propagating in the test samples [2]. Elsewhere in these proceedings, it is shown that the longitudinal wave velocity for this PyC is 4.2–4.6 km/sec depending on silicon alloy concentration; therefore, the theoretical resolution is 19–21 μm at 110 MHz.

In order to test this resolution, a shallow 25 μm diameter hole was drilled into a PyC sample using a National Jet twist drill. Figure 4 shows a SAM image resulting from scanning the front surface of this sample demonstrating the resolvability of this hole.

Conclusion

A SAM operating at 110 MHz has been used to investigate simulated and real subsurface flaws in isotropic silicon alloyed PyC. A resolution for the described SAM system was demonstrated to be 25 μm.

References

1. Bokros, J.C. The structure of pyrolytic carbon deposited in a fluidized bed. Carbon 1965; 3(1): 17-29.
2. McIntire, P. Nondestructive testing handbook 2nd edition; vol. 7: ultrasonic testing. American Society for Nondestructive Testing. 1991:802.
3. Wiedenmeier, M., Hofmann, G., Freund, M., Beavan, A. Acoustic properties of isotropic silicon alloyed pyrolytic carbons. Extended abstracts, 24th biennial conference on carbon. College of Charleston (South Carolina, USA): American Carbon Society, 1999.

Acknowledgments

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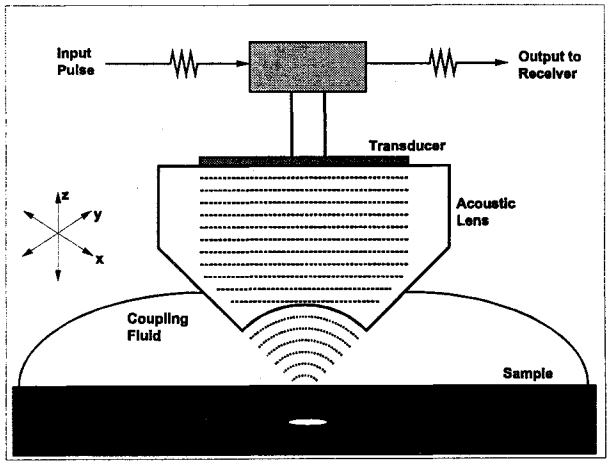

Figure 1 Schematic of a scanning acoustic microscope.

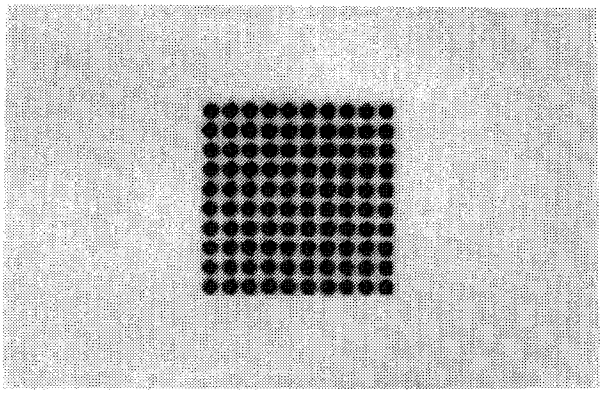

Figure 2 SAM image of a PyC sample with a laser etched 10 x 10 array of 75μm diameter 150μm on center 125μm deep holes.

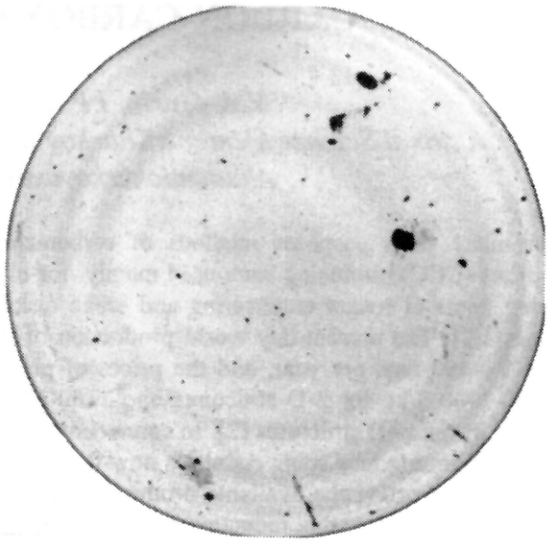

Figure 3 SAM image of 25mm in diameter PyC disk showing numerous subsurface defects.

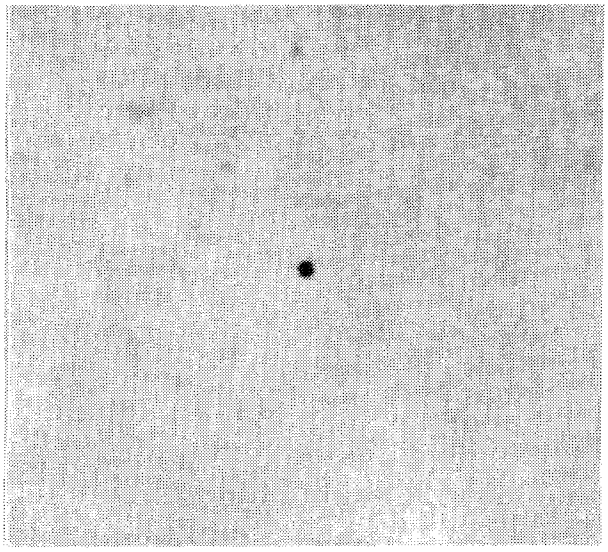

Figure 4 SAM image of a PyC sample with a 25μm diameter holed drilled into the backside.