NONCONTACT AE MEASUREMENT SYSTEM USING ACOUSTIC MICROSCOPE

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The surface of a slide glass (a specimen) with a notch was set in water at the focal region of a point-focus-beam (PFB) lens to detect the AE (acoustic emission) signals radiating from cracks around the notch during a three point bending test. Output signals received by a transducer with a centre frequency around 50 MHz were amplified and A/D converted at a sampling rate of 200 MHz by a digital oscilloscope. The power spectra of the output signals were compared for the two cases with and without the weight used for the application of fracturing stress on the glass specimen. AE signals with a frequency range from a few megahertz to 100 MHz were successfully detected with this system for the glass specimen mounted on a small three point bending test bench.

Introduction: Measurements of acoustic emission (AE) are powerful methods for detecting dynamic deformation and fracture of materials with a high sensitivity. So far, many papers regarding the detection and analysis of AE signals in the frequency range below a few megahertz have been reported using ordinary AE sensors attached directly to specimens or structures.[1–3]

Recently, AE signals in the 100 MHz frequency range were measured for the first time with thin-film piezoelectric transducers during a fracture process of a glass specimen in our laboratory.[4] In this Letter, an acoustic microscopic technique with a PFB lens has been introduced to develop a new noncontact measurement system for AE signals in the VHF range.

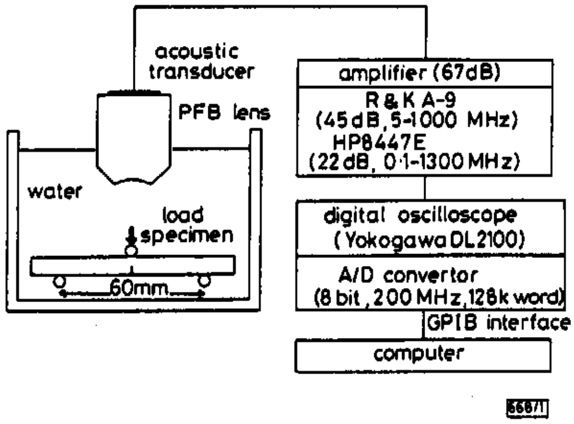

Fig. 1 *Noncontact measurement system for detection of AE signals in VHF range using acoustic microscope with PFB lens and slide glass specimen for static three-point bending test*

AE measurement system: The measurement system using an acoustic microscope is shown in Fig. 1. A glass specimen (a slide glass, 26 mm × 76 mm × 1·3 mm) with a single-edge notch introduced by a diamond cutter was prepared for a three-point bending test. The initial size of the notch was 0·4 mm wide and 0·5 mm deep.

The acoustic PFB lens employed in the acoustic microscope was composed of a concave surface (a curvature radius of 11 mm and a half aperture angle of 8·6°) on one end of a fused-quartz rod 39 mm long and a piezoelectric transducer made of thin $LiNbO_3$ plate attached to the other end of the rod.

The specimen was set in water and positioned at the focal plane of the PFB lens to detect the AE signals radiated in the neighbourhood of the notch during the three-point bending tests. A static load was applied as shown in Fig. 1. The output signal of the transducer was amplified and A/D converted with an 8 bit A/D convertor in a digital oscilloscope (Yokogawa DL2100) at a sampling rate of 5 ns. The maximum length of each signal was about 128×10^3 points ($= 640\,\mu s$) and the signal was transferred via a GPIB interface to a computer and processed using standard digital signal processing techniques. To measure the displacement of the glass specimen due to the static load, the output signals of a laser-Doppler velocity meter (Ono Sokki, LV-550) were A/D converted simultaneously using the digital oscilloscope, and integrated in time.

In the experiments, the oscilloscope was set to give a trigger when the output level of the amplifier reached 200 mV. In this way, both A/D conversion of the acoustic microscope and the laser-Doppler velocity meter started to measure the AE signals at the moment of fracture of the glass specimen by application of static load so that the output signals before and just after the moment of the fracture and the displacement of the specimen surface were measured. The moment of fracture was determined to be $400\,\mu s$ under the static load of weight 490 g in this experiment.

Experimental results: Figs. 2*a* and *c* show background noise of the system and a typical AE signal measured without and with the weight of 490 g for fracturing, respectively. Their average power spectra are shown in Fig. 2*b* and *d*, respectively. By comparing the average power spectrum in Fig. 2*d* with that of background noise in Fig. 2*b*, it is found that the detected signal with a static load has definite components in the frequency range between a few Hertz and 90 MHz.

Conclusion: A new system for noncontact measurement of AE signals has been successfully demonstrated using an acoustic microscope system for the VHF range. The AE signals detected during bending tests of thin notched glass specimens were demonstrated with this system in the frequency range 10–90 MHz. The system developed here may be used to analyse microdeformation and microfracture of materials to promote research into micromechanics. Developments of the nondestructive testing of micromachinery also can be expected with this system, so that it can be envisaged that a new scientific field of micro-AE spectroscopy will be developed soon.

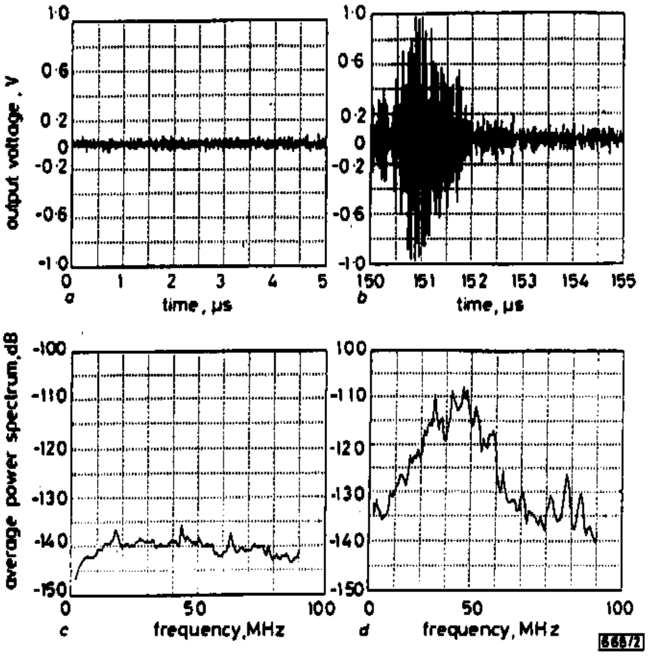

Fig. 2 *Background noise signal detected without load, averaging power spectrum for background noise signal, typical output signal detected with static 490 g load, and average power spectrum for typical output signal*

a Background noise signal
b Average power spectrum for background noise signal
c Typical output signal
d Average power spectrum for typical output signal

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