Sensing Sound from Materials with Nanofibers

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Abstract. The acoustic sensing capability of a non-woven textile made of electrospun piezoelectric nanofibers is investigated in this paper with the focus on structural damage detection. The non-woven textile is made of a complex aggregation of piezoelectric nanofibers that form a porous material. The electro-mechanical response of the textile once exposed to a sound source, is monitored through metallic electrodes that, in a sandwich configuration, let the non-woven textile be directly exposed to sound. The functionality of this unique acoustic sensor was then validated to monitor impulsive ruptures coming from a polymer-based sample under mechanical stretching. Not only the preliminary results confirmed the capability of this textile to monitor acoustic waves, but also showed its great potential for direct damage detection.

Introduction

Monitoring damage from a structure by analyzing sound and ultra-sound waves is a known concept. Several are the works in the literature showing the capability of piezoelectric sensor/actuator arrays mounted or embedded in structures for structural health monitoring [1]. In some works the possibility of using acoustic waves for structural monitoring was also demonstrated [2]. Despite the great success and developments that were achieved in the last couple of decades, there are still several challenges to be solved. In the case of the PZT arrays, these challenges are mostly related to the complexity of the hardware/signal processing especially once a large number of devices need to be handled. Acoustic monitoring instead is not as established as the PZT technology. The few studies in the literature show the conceptual feasibility in using acoustic waves for structural monitoring with the support of external and large-in-scale microphones. Despite the interesting outcomes of these initial studies, the major limitation is obviously related to the complexity in coupling and isolating such microphones to a structure or material. For this reason, this approach has not been widely explored so far. Thus the search into novel monitoring technologies is still highly desired. A great potential can especially be found taking advantage of the novelty of multifunctional nanostructured materials.

Results and Discussion

A preliminary study on the use of piezoelectric non-woven textiles for acoustic sensing toward damage detection is performed in this paper. This material is fabricated by electrospinning a piezoelectric polymer in the form of nano/microfibers assembled together in a random configuration, giving rise to an ultra-light and mechanically flexible porous mat. The electromechanical response of such a mat, when it is exposed to an acoustic wave, is allowed by sandwiching the material between two electrodes that collect the charges produced by the fabric once it is dynamically strained. It is observed that acoustic sensing with such a material is allowed only if the fabric is directly exposed to pressure waves (by patterning the electrodes at the edges only). Covering the textile with an electrode (standard configuration) in fact prevents this functionality. The sensor was then successfully used to monitor impulsive damage in a polymeric composite, opening up interesting and broader future prospective.

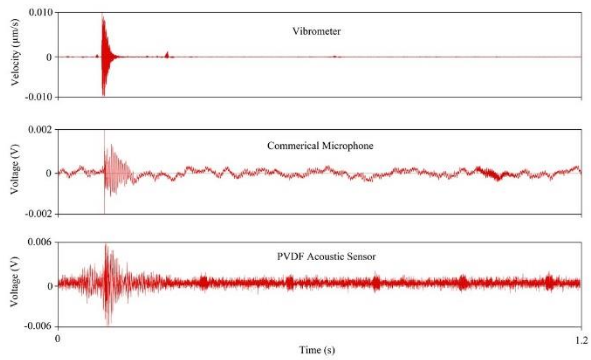

Figure 1 . Sensed impulsive signal generated by damage with multiple devices in comparison: laser vibrometer, commercial microphone and the here presented non-woven-textile sensor.

References

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