Reliability Tests of Grid-type Crack Detection Method Using Resistance Change

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1. Introduction

Architectural and mechanical structures are generally exposed continuously to various loads and corrosive environments. Therefore, structures are likely to cause problem such as cracks by these effects. The defective structures, such as machine and architecture, are generated additional strain energy due to defects even under the same load, so deformation is further generated by additional energy [1]. When number and scale of micro crack are increased, interaction between cracks is important. Up to now, many studies have focused on the interaction and growth of micro cracks [2]. The growth cracks have local defects from micro crack. This defects causes an acceleration of a local mechanical deformation by the micro scale. So, it is essential and important to detecting micro cracks for the structural integrity [3].

In order to prevent a defects by the continuous load, studies about real-time monitoring for securing the structural integrity are underway. Structural health monitoring (SHM) system is one of most important topic. SHM system has an integrated sensor system that can assess damage and warning for severe structural conditions. Grid-type fiber optic sensor technology is the most attractive technology currently used in large-scale applications for monitoring FRP structures [4].

Up to now, many methods have been proposed to detect micro/nano cracks, it is very difficult to detect small cracks in a composite structures. In order to detect micro cracks, sensitive sensors based on micropatterning technology are necessary.

In this paper, metal-grid samples of various cracks are fabricated by electrohydrodynamics (EHD) inkjet printing can be made micro circuit for detecting the micro crack. Physical crack location is estimated by calculating resistance change distribution at each sample, and reliability of grid-type detection method is analyzed with various crack

2. Electrohydrodynamics systems

EHD inkjet printing is a technology to make thinner circuits than commercialized printing technology by generating electric field between the nozzle and the substrate. To micro jetting, it is material to optimization between experimental surroundings, parameters and characteristics of ink such as applied voltage, distance of nozzle and substrate, flow rate, viscosity of ink, dispersibility and etc.

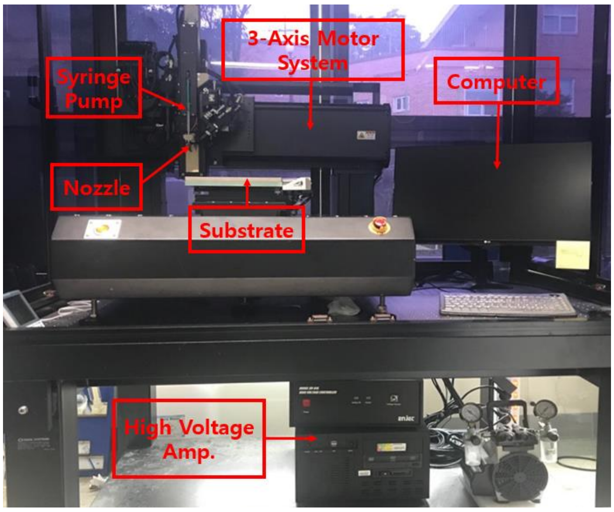

Fig.1 Components of the EHD inkjet printing machine

3. Experimental setup

Before the experiment, The Ag nano ink, typical conductive ink, is made for fabricating grid circuit. For the Ag nano ink, the solvent is first prepared by mixing DBA (diethylene glycol monobutyl ether acetate), a non-polar solvent and α-terpineol. After that, 66.56 wt% of Ag nano paste and 33.44 wt% of solvent are mixed, and the ink is dispersed for 4 hours using a stirring machine [5]. The fabricated Ag nano ink is utilized for EHD printing. The PI film patterned with Ag nano ink is sintered at 85℃ for 24 hours using a convection oven.

After that, resistance of each sample is measured using 2-point source meter. Resistance change ratio is calculated between non-cracked sample and cracked sample by measured resistance value. Crack location of each sample is displayed by resistance change distribution using MATLAB, a scientific application.

4. Results

Figure 2 shows schematic diagram at each sample and calibrated resistance change distribution by crack location. Fig. 2(a), (b) show schematic diagram at cracked sample as Y direction and resistance change distribution. Crack was located in X1 and X2, between Y9 and Y10. As shown in Fig. 2(b), resistance change ratio is increased in the upper-right. Fig. 2(c), (d) show schematic diagram at cracked sample as diagonal direction and resistance change distribution. Crack was located in X7 and X8, Y3 ~ Y6. As shown in Fig. 2(d), resistance change ratio was increased in the lower-left. Fig. 2(e), (f) show schematic diagram and resistance change distribution at multi-cracked sample. First crack was located between X3 and X4, in Y4 ~ Y6. Second crack was located in X2 ~ X4, between Y8 and Y9. As shown in Fig. 2(f), resistance change ratio was increased in the upper-middle and the upper-right.

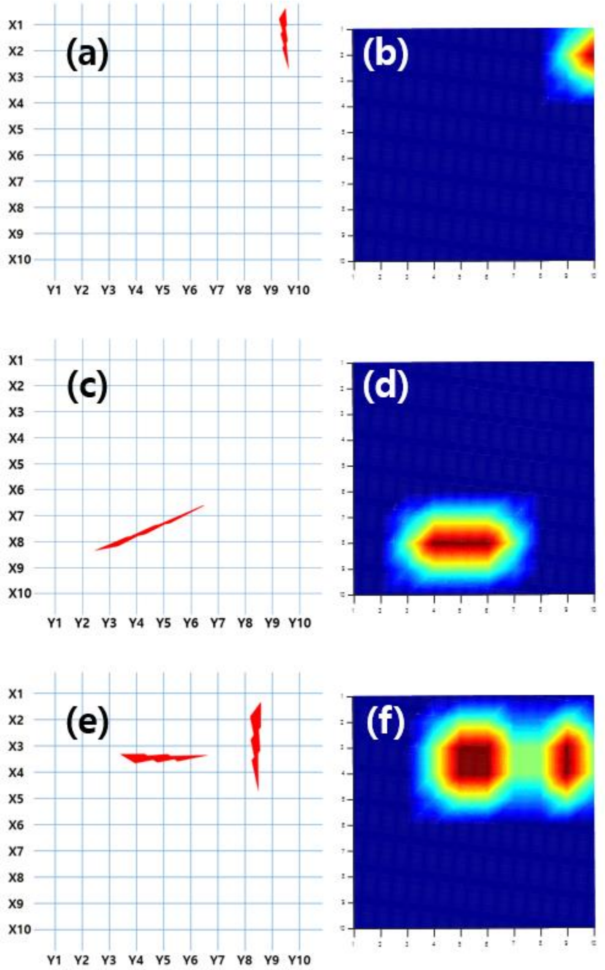

Fig.2 Schematic diagram and calibrated resistance change distribution of each cracked sample: (a), (b) single crack at Y direction, (c), (d) single crack at diagonal direction, (e),(f) multi crack

If a crack is generated so the circuit is tripped out, the path of the current is varied, thereby the resistance of the circuit was changed. With this principle, if a crack is generated, resistacnce was changed and crack location can estimated.

5. Conclusion

In this paper, reliability of grid-type detection method using resistance change ratio by various cracked sample with EHD technology is analyzed. Resistance change ratio of the cracked sample versus the non-cracked sample was calculated by measuring resistance at the each sample Approximated location of physical crack can be estimated by resistance change distribution at the each sample.

Detection accuracy can be improved by increasing number of grid. So, it will study on accuracy improvement of crack detection with more grids sample.

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