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Structural Response of Flexible KAPTON Beam When Coated with Piezoelectric (PVDF-TrFE) Polymer

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Abstract

Piezoelectric materials are often used for vibration mode sensors. Application with flexible substrate materials can enable their placement on a variety of structures. Flexible materials such as KAPTON as a substrate can be coated with a piezoelectric polymer to enable sensor systems and application to many electro-mechanical devices. Here the mechanical response of a flexible beam of KAPTON that is coated with piezoelectric polymer (PVDF-TrFE) is studied using external excitation method. Two PVDF-TrFE solutions (A and B) of the same 1.25%w/v concentrations but having different solvents Methyl Isobutyl Ketone (MIBK) and Dimethyl Sulfoxide (DMSO) are spin coated on KAPTON substrates. In solution A both solvents are used to make the solution, while in solution B only MIBK is used. The structures are mounted on a ground base shaker and the vibrations are measured using a Polytec (OFV-505) sensor. The sensor consists of a He-Ne laser with 633 nm wavelength and is focused at a 51.5 cm distance from the beam, which measures the vibrational response. The frequency response analysis shows that the device coated with solution A is stiffer and more damped, while the device coated with solution B is more flexible and gives strong vibratory response with minimal impact on the natural frequencies of KAPTON beam. Multiple peak response frequencies are observed from 10 Hz to 720 Hz when the structure is excited from 0 Hz to 1500 Hz, indicating that the system can give response over wide range of frequencies. It is also observed that the polymer coating reduces the non-linearity in frequency response compared with bare KAPTON. The modal analysis using Euler-Bernoulli's equation in MATLAB simulations also matches with the experimental natural frequencies. Stress in polymer layer is also calculated, confirming that the structure coated with solution A is stiffer than structure with solution B.

Based on the experimental results, this may open two directions that with one type of solution open applications based on mass and stress detection due to damping and stiffness while using second solution can give high piezoelectric charge production, because of sharp peaks and more flexibility.

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