Effect of the Integration of Piezoceramic Composites into Structural Components on their Poling Condition and Polarizability

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ABSTRACT

In lightweight construction, integrated piezoelectric sensors and actuators find application for structural health-monitoring, vibration control, reduction of noise emission and condition monitoring. In order to create such smart components, we embedded piezofiber composites into thermoplastic structures. Thermal and mechanical loads during the integration process can lead to partial depolarization and thus degradation of the piezoelectric properties. In the present work, we investigate the effect of the integration on the poling condition and polarizability of piezofiber composites.

1-3 piezofiber composites (PFC) consisting of a monolayer of PZT fibers embedded in epoxy resin were used as starting material [1]. In the first integration step, they were positioned between two transparent thermoplastic carrier films and consolidated by hot-pressing, forming the so-called TPM (thermoplastic-compatible piezoceramic module). In the second integration step, these TPMs were integrated into a fibre reinforced plastic (FRP) structure [2]. The investigated samples were divided into three groups:

- reference samples, which were poled but not integrated,
- pre-poled samples, which were poled and integrated,
- re-poled samples, which were additionally poled after each processing step.

The natural aging without the influence of fabrication processes and re-poling was deduced from the capacitance of the reference samples. The poling condition was evaluated by the Laser Intensity Modulation Method (LIMM) and the thermal pulse method. The pyroelectric current was analyzed by heating with an intensity-modulated laser beam or laser pulses [3]. Hysteresis measurements were performed to determine the effect of the integration on the polarizability.

The pyroelectric current spectra of the same sample were compared for the three states PFC, TPM and FRP. Pre-poled samples showed a degradation of the remanent polarization after integration. The range of degradation varied widely between 1% and 23% for one integration step. The polarization of the re-poled samples was increased or only slightly decreased. Consequently, the results obtained by LIMM were confirmed by the thermal pulse response.

The attainable remanent polarization was derived from the hysteresis curves of the PFC and of the re-poled samples after each integration step. It was decreased after integration. The remanent polarization of the integrated composites reached 95% of the initial value.

In conclusion, the integration of a PFC into a structural component leads to a decrease of the remanent polarization and of the polarizability. However, the observed depolarization is within the variation of the polarization state of the PFC and thus, negligible. Hence, re-poling after the integration appears not to be necessary, although possible.

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