Powerless µm-scale Photon Sensing Enabled by Functional Grading in Carbon Microstructures

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In this work, partial laser treatment is applied to carbon-based microfibers to tailor their thermoelectrical properties with spatial grading. Nearly half of the sample's length is laser-treated (annealed) for a certain amount of time. This treatment induces a Seebeck coefficient distribution along the microfiber's length, leading to the generation and detection of a photovoltage with no bias. Carbon microfiber (CMF), graphene microfiber (GMF), and graphene aerogel fiber (GAF) responses to µm-scale photon irradiation are investigated using a line-shaped laser spot. Moreover, comparing the characteristic times in step current heating and step photon sensing signals reveals the thermal effect of the photoresponse of these microfibers. During the photon sensing testing, the irradiating laser power is adjusted to have a photovoltage change of around 0.1-0.3 mV. A higher sensitivity for the incident photon is found for the GAF with no position sensitivity. A larger Seebeck coefficient variation is also observed for the GAF irradiated under the same amount of laser power for the laser treatment. A weaker Seebeck coefficient spatial variation is observed for the GMF compared with the GAF. However, its photovoltage shows an abrupt magnitude change from the laser-treated region to the non-treated one. Despite the low spatial variation of the Seebeck coefficient for the CMF, it features an excellent and accurate position-sensitive photoresponse with polarization change over a distance of ~100 µm. Such unique capability prompts novel applications in using partially annealed CMF for sensing the position of optical beams at the microscale.