A Tactile sensor using single-layer graphene for surface texture recognition

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Texture recognition is essential to emulate the tactile sensation of human skin [1] that is obtained from spatial encoding with complex process including detection of both pressure and vibration [2]. Emulation of this feature has been difficult to attain because spatial resolution at the level of human perception requires integrated matrix architecture with the miniaturized sensor elements. Matrix architecture, however, suffers from many practical difficulties including wiring, sneaker paths, complex driving circuit, and addressing. Moreover, materials used for the sensor element are critically limited for the integration process involving soft materials that are applicable to the artificial skin forms.

In this paper, we describe a flexible force sensor that can detect surface texture based on single sensor architecture. We developed this sensor by taking advantage of the unique electromechanical characteristics of single layer graphene (SLG), which is a continuous film with single atomic thickness, and exhibits a piezo-resistive response to local deformation. The sensitivity was enhanced by 57% by the introduction of a pressure-amplifying structure (PAS), which was a uniform array of micro-structured square pillars. Furthermore, the sensors were able to detect a vertical pressure as low as 24 Pa with a fast response of ~ 2 ms for deformation and ~ 3 ms for restoration. Introduction of an APFS structure inspired by a human finger print allowed perception of surface texture using a single sensor through FFT analysis of the resistance changes due to vibrations induced by the slip motion between the sensor and roughness of the interacting surface. Because the spatial resolution of the proposed tactile sensor can be improved by adjusting the size and periodicity of the AFPS patterns, the proposed work provides a simple method for surface texture recognition at the level of human sensation without the requirement for matrix architecture, which requires high density integration technology with force and vibration sensors.

References

[1] Maheshwari, V. and Saraf. R., Angew. Chem. Int. Ed., 47 (2008) 7808-7826

[2] Hollins, M. and Risner, S. R., Percept. Psychophys., 62 (2000) 695-705

Figures

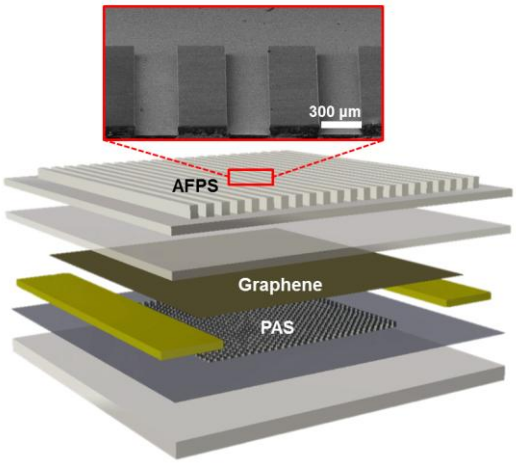

Figure 1: SLG-based tactile sensor with pressure-amplifying structure (PAS) and artificial finger-print structure (AFPS). The PAS is uniform array of microstructures fabricated on SiO_2 layer and it is used to enhance the pressure sensitivity. The AFPS is periodic line patterns with a width of 300 μm, height of 70 μm, and spacing of 300 μm and it generates an interacting vibration with slip motion.