Materials Science & Engineering Doctoral Defense

From materials to devices: (I) Ultra-thin flexible implantable bio-probes with biodegradable sacrificial layers (II) Carrier spin injection and transport in diamond

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abstract

My PhD research has been focusing on the innovations of material and structure designs, and the development of fabrication processes of novel nanoelectronics devices. My first project addresses the long-existing challenge of implantable neural probes, where high rigidity and high flexibility for the probe need to be satisfied at the same time. Two types of probes that can be used out of the box have been demonstrated, including (1) a compact probe that spontaneously forms three-dimensional bend-up devices only after implantation, and (2) an ultra-flexible probe as thin as 2 μm attached to a small silicon shaft that can be accurately delivered into the tissue and then get fully released in situ without altering its shape and position as the support is fully retracted. This work provides a general strategy to prepare ultra-small and flexible implantable probes that allow high insertion accuracy and minimal surgical damages with best biocompatibility. My second project focuses on the injection and characterization of carrier spins in single crystal diamond based nanoscale devices. The conventional diamond-based quantum information process that exploits nitrogen vacancy centers faces a major barrier of large scale communication. Electron/hole spin in diamond devices, on the other hand, could also be a good candidate for quantum computing due to the very small spin-orbit coupling and great coherent transport length of spin. To date, there has been no demonstration of carrier spin transport in diamond. In this work, I try to answer this fundamental question of how to inject and characterize electron spins in Boron doped diamond. Nanoscale diamond devices have been fabricated to investigate this question, including Hall bar device for material characterization, and lateral spin valve for injecting spin-polarized current into a mesoscopic diamond bar and detecting induced pure spin current. The preliminary results show signatures of spin transport in heavily doped diamond films. Looking into the future, the knowledge we obtained in these two projects, including the strategy to integrate thin-film nanoelectronics devices on a flexible bio-probe configuration, and how to build spintronic devices with diamond structures, could be unified in the exploration of spin-based sensors in biological systems.

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