Wafer-scale fabrication of graphene field effect transistors for neuronal interfacing

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There are plenty of invasive methods for studying a neuronal network's activities [1]. Of course, the invasiveness of the processes makes them undesired. In recent years, there has been vast research in the field of non-invasive neuronal interfacing and extracellular neuronal recordings [2]. Different methods (passive – MEAs and active – FETs) and different materials (carbon, silicon, PEDOT:PSS) have been used for the purpose.

Graphene's excellent electrical, mechanical and biological properties make it a perfect candidate for such a role. Firstly, liquid-gated graphene field effect transistors (GFETs, see fig. 1) show very high transconductance, and therefore sensitivity [3]. Secondly, graphene is a very stable and biocompatible material (fig.2). Thirdly, flexibility and bendability of graphene make it the most promising material for future bio-implantable devices [3].

Therefore we established our 4-inch wafer fabrication process based on CVD-grown graphene (fig. 3a). Each fabricated wafer results in 52 biocompatible chips (fig. 3b). Each chip comprises 32 GFETs (fig. 3c). The size of graphene active area is varied in order to study the noise of the system. Each chip is measured on a multi-channel measurement system, which allows us to measure all the GFETs simultaneously. Thus, it is possible to measure not just single action potentials of the electrogenic cells, but even propagation of the potential through the network.

References

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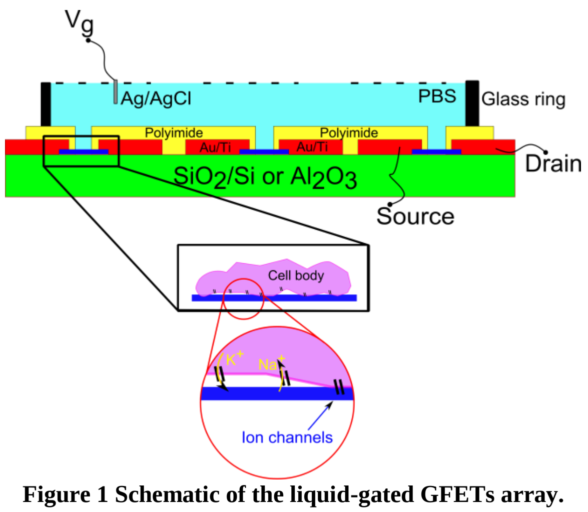

Figure 1 Schematic of the liquid-gated GFETs array. Inserts – the interface between graphene and a cell

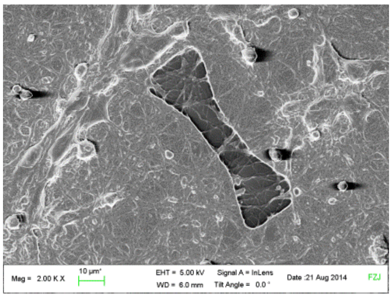

Figure 2 An SEM image of a neuronal network grown on top of a GFET

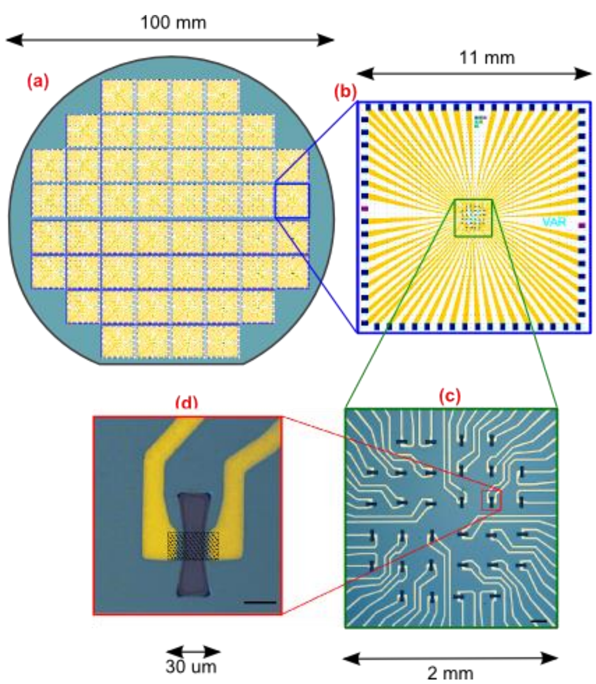

Figure 3 Design of the wafer. (a) – the whole 4-inch wafer view; (b) – zoom in on a chip; (c) – zoom in on an active area with 32 GFETs visible; (d) – zoom in on a single GFET.
Yellow –source and drain, dashed area - graphene