Development of graphene transistors for future high frequency and flexible electronics

Background

The frequency range of electronic components is continuously being pushed towards higher frequencies driven, in particular, by requirements of higher data transfer rate of the next generations of communication systems. The unique property of intrinsically high carrier velocity in graphene enables the possibility of much faster electronics than with traditional semiconductors. Combination of the high carrier velocity with graphene flexibility, offers many novel exciting applications. For example, flexible graphene THz devices, which are under development in our Terahertz and Millimeter Wave Laboratory, can be key elements for future niche applications, e.g. bendable THz electronics for high-speed indoor wireless communication and Internet of Things (Fig. 1,a), rf energy harvesting and wearable THz sensors for medical applications. However, realization of the competitive high frequency graphene field-effect transistors (GFETs), see Fig. 1,b, is hindered, by several intrinsic and extrinsic factors, e.g. zero-bandgap phenomenon in monolayer graphene, extrinsic scattering of charge carriers, and relatively high contact resistance of the graphene-metal junctions. Therefore, design, materials and technology of the GFETs have to be developed to address the challenges and fully exploit the unique properties of graphene in the next generation of high frequency and flexible electronics.

a)

b)

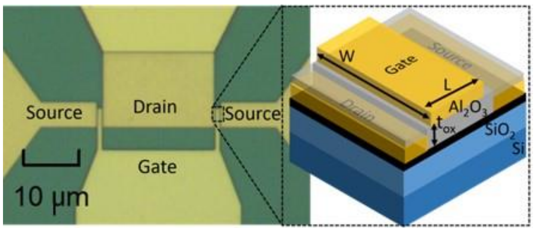

Fig. 1: a) Wearable graphene THz antennas on mannequin (X. Huang, T. Leng, M. Zhu, et al. Scientific Reports, 5:18298, 2015), b) microphoto and schematic of a fabricated GFET on Si substrate with two gate fingers (M. Bonmann, A. Vorobiev, M. A. Andersson, and J. Stake, Appl. Phys. Lett. 111, 233505, 2017).

Project description

The objective of the project is development and experimental demonstration of the GFETs with advanced performance suitable for future wide bandwidth and wearable electronics. The content of the work will be defined by the project duration (30 or 60 credit points) and may include the following specific tasks

- study of literature in the field of graphene for high frequency and flexible electronics;
- learning e-beam lithography technique and thin film processing;
- design of GFETs optimized for THz power detectors or amplifiers;
- fabrication of GFETs, with top or edge contacts, on Si or polymer substrates using chemical vapour deposition (CVD) graphene;
- fabrication of boron nitride encapsulated GFETs on Si or polymer substrates;
- dc characterization of the GFETs;
- microwave on-wafer characterization of GFETs at high fields (amplifier application);
- free-space characterization of GFETs coupled with antenna (power detectors) in the THz frequency range;
- analysis and interpretation of results.

The project will be a part of the Graphene Flagship Core 2, which is the EU's largest research initiative, tasked with taking graphene from laboratories into the market.

Contacts: Andrei Vorobiev, Terahertz and Millimeter Wave Laboratory, tel: 031 772 8931, e-mail: andrei.vorobiev@chalmers.se