Hall-effect charge-carrier mobility measurement system
(MCCX02-19-03)

**Background**
The charge-carrier mobility is an important parameter for benchmarking semiconducting materials and also graphene. The higher the mobility the higher the operational frequency of the transistor. The mobility can be derived from e.g. the Hall-effect measurements\(^1\). This normally requires the magnetic field and a certain alteration of electrical connections to a sample\(^2\).

**Problem description**
There is no such a system in the clean room of MC2, while there are many researchers working there and fabricating graphene and/or graphene transistors every day. It would be very valuable to have a Hall-mobility setup close at hand inside the clean room and be able to characterize graphene- and also semiconducting devices in a short time.

**Work flow**
In this project, a team of students will design and realize an electromechanical system for measurements of the charge-carrier mobility in two-dimensional (2D) conducting materials like graphene, phosphorene, molybdenum disulfide and many other materials, also including 2D electron gas in classical semiconducting devices (i.e., MOSFET’s). The Hall mobility is one of the main parameters for benchmarking the materials.

The project will roughly include three working packages (WP) regarding (1) mechanical parts, (2) electronics, and (3) programming. As an “acceptance” test, the team will grow graphene by the chemical vapor deposition (CVD) method, transfer the graphene film on an insulating substrate, attach contacts, and measure the electron mobility of graphene by using the newly built system. The growth and measurements will be repeated to possibly see a correlation between the growth parameters and the resulting mobility.

- WP1 will encompass CAD designs using Solid Works, Inventor, or similar programs and assembly of the system. It will be done in several iterations involving regular meetings with the supervisor and an engineer. The engineer will see to that the parts will not be difficult to machine.
- WP2 will include the design and ordering of the signal-conditioning pre-amplifiers, contacts-switching relays, and biasing source, all of which would be compatible with Arduino- or some other analog-to-digital cards. Control of a stepper motor will be included as well.
- WP3 will include programming of the whole system in Python, or other language, with Raspberry Pi as a computer. The final program will need to be user-friendly and have an intuitive user interface.

**Outcome**
In the case the system will have a sufficiently professional appearance, it will be permanently installed in the clean room of MC2 and will be accessible by all researchers. Also, this project might pave the way for commercialization of the system.

**Team composition & pre-knowledge requirements**
The optimal number of students is 6 (2/WP). A team composed of students with complementary backgrounds (mechanical- and electrical engineering, physics, programming) is most suited for the project.

**Supervisor**
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\(^1\) For the Hall effect in general, see Wikipedia & YouTube