

Deterministic patterned growth of high-mobility large-crystal graphene: a path towards wafer scale integration

Camilla Coletti

Vaidotas Miseikis

Center for Nanotechnology Innovation @ NEST,
Istituto Italiano di Tecnologia, Pisa, Italy

Camilla.coletti@iit.it

Presently, the graphene community is very much concentrating on different solutions for maintaining the extraordinary mobility of graphene while scaling-up its size to open a realistic pathway towards wafer-scale integration for electronic and optoelectronic applications. Although recent works have reported CVD-grown single-crystals of graphene measuring a few centimeters [1,2], these approaches still inevitably produce randomly-distributed crystals of graphene, thus limiting their applicability to scaled production of graphene devices. Furthermore, the commonly-used transfer methods either allow scalability while introducing significant performance degradation (i.e., low mobilities), or are limited to transferring areas of several tens of micrometers.

During this talk, the critical issues in scaling-up graphene while maintaining its high quality will be discussed and possible solutions presented. In particular, a scalable CVD approach which allows for the deterministic synthesis of large single-crystal graphene arrays will be introduced. In this novel growth approach, the copper foil is patterned via optical lithography with chromium (Cr) seeds, which allow for the controlled nucleation of large single-crystal

graphene. The synthesized graphene arrays present periodicities up to 1 mm and grain size up to 350 μm . Also, it will be discussed a semi-dry transfer protocol which allows to minimize the transfer-related contamination and to precisely place the graphene arrays on the target substrates. The single-crystal graphene arrays synthesized and transferred in this way present remarkable transport properties [3]. When transferred on h-BN substrates (and non-encapsulated), the seeded crystals present an ultra-low width of the Raman 2D peak ($\Gamma_{2D} = 20\text{-}23 \text{ cm}^{-1}$), an extremely low residual carrier density (around $1.4 \times 10^{11} \text{ cm}^{-2}$) and a noteworthy room temperature mobility in excess of 21 000 cm^2/Vs . These values are comparable to the best published results for non-encapsulated CVD graphene and exfoliated flakes [2,4].

The presented technique is easily scalable and flexible (by simply varying the optical mask one can tailor the nucleation of large-crystals according to the desired device geometry) and also the grain size can be set by requirement. Moreover, the growth process is rapid, which is appealing for industrial applications.

References

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- [2] Wu et al., Nat Mater 15 (2016) 43
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