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Rational design of Cu-Ni alloy for growth of wafer-sized single crystalline graphene

Wafer-scale single-crystalline graphene monolayers (SCG) have garnered plenty of attention as an ideal platform for further electronic applications. However, graphene's excellence would not be fully realized before high-quality single crystalline graphene (SCG) is available. Similar to silicon ingot growth, a straightforward approach for large-area SCG is to start from a single seed and let it develop into a wafer. This simple concept has not been realized for two primary reasons – the difficulty of forming only one nucleus on a wafer-sized substrate during the entire growth period; and the low growth rate that is mainly attributed to low precursor concentration and/or high activation energy [1-2]. Overall, although we witness the rapid advance in the past few years, a complete engineering of the nucleation and growth of graphene single crystals is still challenging but is a huge step forward in the realization of next-generation technologies.

Here we demonstrate an efficient strategy for achieving large-area SCG by letting a single nucleus evolve into a monolayer at a fast rate. By locally feeding carbon precursors to a desired position of an optimized Cu-Ni alloy, we have successfully achieved a single graphene nucleus over the entire substrate. The nickel-mediated isothermal segregation mechanism and enhanced catalytic power of the Cu–Ni alloy boost the fast growth of graphene. With this novel approach, we have demonstrated the synthesis of ~1.5 inch graphene single crystal in ~2.5 hours, a 10 fold growth rate improvement compared to previous record [3]. The mobility extracted from measurements of several different samples are in the range of 10,000-20,000 $cm^2/V\cdot s$, among the best reported for CVD graphene. We believe that the novel strategy of local precursor feeding may develop into a versatile approach for the synthesis of single-crystal wafer of other two-dimensional materials. This approach certainly leads to a new area of using single crystalline 2D materials as a platform or building block for various applications and may eventually realize the potential replacing silicon in future electronic technology.

References

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Figures

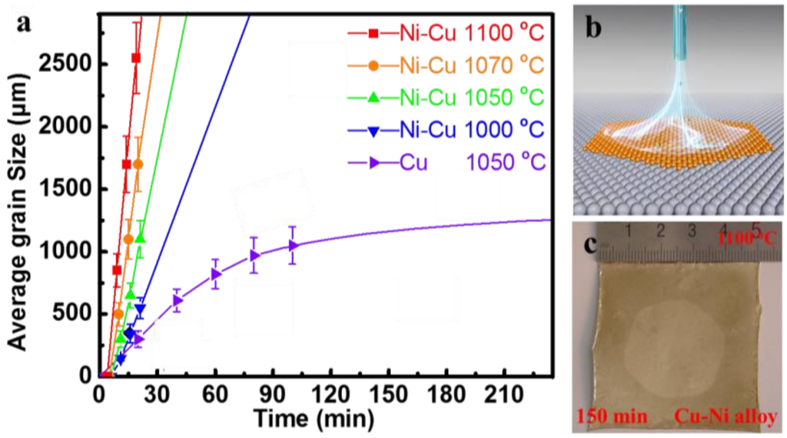

Figure 1: (a) Comparison of graphene growth rates on Cu and $Cu_{85}Ni_{15}$ alloy at different temperatures; (b) Schematic illustrations of the local feedstock feeding of methane; (c) Optical picture of ~1.5-inch SCG grown at 1,100 ^{o}C in 150 min on $Cu_{85}Ni_{15}$ substrate.