Graphene-enabled, directed nanomaterial placement from solution for large-scale device integration

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Placing of nanomaterials at predefined locations with nanoscale precision is still one of the unsolved problems that inhibit their large-scale integration in the domain of semiconductor industry. Various methods that rely on surface functionalization[1] have a drawback where undesired chemical modifications can occur that are detrimental to deposited material's performance. The application of electric-field assisted placement techniques[2] eliminates the need for chemical treatment; however, it requires the use of conductive placement electrodes that limit the performance, scaling, and integration density of electronic devices[3]. Here, we report a method for directed, electric-field assisted placement of solution-based nanomaterials by using large-scale graphene layers featuring patterned nanoscale deposition sites. The structured graphene layers are fabricated by transfer or synthesis on standard substrates, then are removed without residue once nanomaterial deposition is completed by a plasma-based process, yielding material assemblies with nanoscale resolution that cover surface areas larger than 1mm². We demonstrate the broad applicability by assembling representative zero-, one-, and two-dimensional semiconductors at predefined substrate locations and integrate them into nanoelectronic devices. This graphene-based placement technique affords nanoscale resolution at wafer scale and could enable mass manufacturing of nanoelectronics and optoelectronics involving a wide range of nanomaterials prepared via solution-based approaches.[4]

References

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Figures

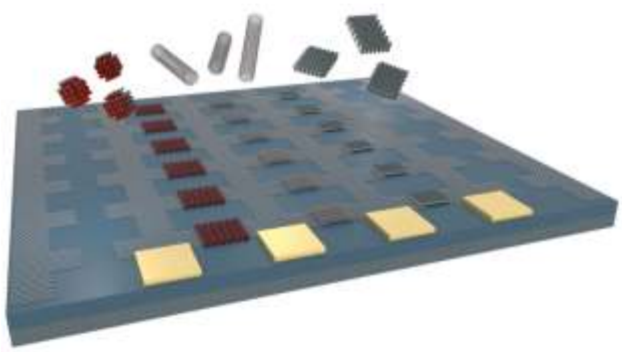

Figure 1: 3D illustration of electric field assisted, directed placement of quantum dots (0D), single-walled carbon nanotubes (1D), and layers of molybdenum disulfide (2D) at large scale using sacrificial graphene electrodes