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Crumpled graphene-Au nanoparticle hybrid photodetector with enhanced stretchability and photoresponsivity

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Graphene has been widely explored for flexible, high-performance photodetectors due to its exceptional mechanical strength, broadband absorption, and high carrier mobility. However, the low stretch ability and limited photo absorption of graphene have restricted its applications in flexible and highly sensitive photo detector. Integration of other nanomaterials such as patterned gold nanostructures with graphene demonstrated enhancement of light absorption by increase of light absorption with the nanomaterials. Recently, controlled integration of gold nanoparticles (AuNPs) with graphene including size and number density of AuNPs was demonstrated by simple two-step processes including thin film deposition of Au and thermal wetting. Moreover, graphene was shown to be crumple-nanostructured by a uniform, large-area shrink nanomanufacturing technique. Here, we present a photodetectors based on crumpled graphene integrated with AuNPs, which shows enhanced mechanical stretchability and photoresponsivity. The crumpled graphene-AuNPs hybrid structures which was formed by delamination-buckling of the hybrid film on a highly stretchable substrate, allow high stretchability. The crumpled structures allow enhancement of photoresponsivity which results from the increase of optical absorption by areal densification of graphene. Furthermore, Au nanoparticles allow plasmonic enhancement of light absorption by which more light can be efficiently absorbed within the nanostructures. The crumpling of graphene-AuNPs hybrid film leads to number density increase of AuNPs and increases optical absorption by the plasmonic enhancement. Our photodetector based on the crumpled graphene-AuNPs hybrid nanostructures shows over an order-of-magnitude higher enhancement (~1200%) of photoresponse compared to a flat graphene photodetector and exceptional mechanical stretch ability up to 200% together with strain-tunable photoresponsivity.

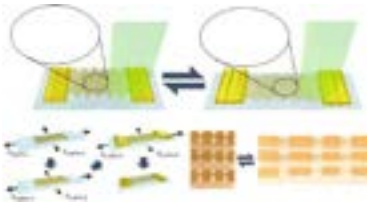

Figure1: Stretchable photodetector with crumpled graphene-AuNPs hybrid structure.
(a) Schematic illustrations, (b) Fabrication procedures, and (c) Photograph of fabricated photodetector devices array.

Biography

Pilgyu Kang is an assistant professor in the department of mechanical engineering at the George Mason University. He conducted postdoctoral research in the department of mechanical science and engineering at the University of Illinois, Urbana-Champaign (UIUC) in 2014-2017. He obtained his Ph.D. in mechanical engineering from Cornell University in 2014. He earned a master's degree in mechanical engineering in 2009 from Carnegie Mellon university. He earned a bachelor's degree in mechanical engineering with a minor in electrical engineering at Seoul National University in 2007. He has been investigating mechanics and nanomanufacturing of automically-thin materials for flexible optoelectronic devices and integrated nano-bio sensors. His work has been recognized through two journal front covers and the reception of awards including the ASME paper award in the micro/nano forum in IMECE 2016, the postdoctoral presentation award in the 5th annual MRL Biological conference Frederick Seitz materials research laboratory UIUC, and the chemistry and micro-nano systems young researcher poster award in the 17th international conference on miniaturized systems for chemistry and life sciences (μTAS 2013).

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