# Effects of using 2D-material buffer layer on the wire bonding graphene based devices

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Abstract

As the size of transistors and electronic devices decrease, the packaging of these components becomes a challenge and nano-wire bonding is one of the main challenges that with packaging of such devices. A challenge that is faced with wire bonding is the stress delivered to the bond pad during the bonding process. This stress can cause mechanical damage or deformation to the pad [1] and entire structure. The impact of this stress can be measured by monitoring the displacement of the structures within the device.

In this work, the effects of wire bonding of various sizes and materials using different bonding methods were investigated numerically using technique of finite element analysis (FEA) and optimum parameters were acquired to achieve the minimum mechanical stress. The effects of the stress to the bond pad and subsequent layers were analyzed by incorporating a graphene monolayer on top of the silicon substrate. Figure 1 shows a schematic numerical layout which a wire being bonded to the top of 150 nm thick gold pad. The subsequent layers under the metal pad are graphene, $MoS_2$ as buffer layer and a silicon substrate.

The effects of adding the graphene and $MoS_2$ layer were studied and displacement surface plot of different structures are shown in figure 2. From this figure, a 2-dimensional profile, it can be seen that the magnitude of displacement in the structure is decreased by adding the graphene layer. Further reduction was also observed on adding the $MoS_2$ layer, which can be attributed to increases of mechanical strength and flexibility [2].

The size of the wire was also varied from 8 microns to 20 microns. It was determined that the largest size, 20 microns, caused the smallest amount of displacement and stress in the structure. This is most likely attributed to the same amount of force and stress being distributed over a larger surface area. Aluminum and copper wires are materials that are commonly used in wire bonding [3]. Using FEA, it was determined that copper resulted in a lower displacement and stress distribution when compared to an aluminum one.

Figure 3 shows the displacement in the z-direction as the graphene and the $MoS_2$ layers were added into the structure. As can be seen from this figure, displacement was decreased through the layers as the graphene and $MoS_2$ layers were incorporated. Figure (3b) shows the effects of using graphene on the displacement reduction in the structure, while in Figure (3c), the effects of using $MoS_2$ buffer layer, on the displacement absorption were reported as appearance of a peak in the displacement profile at z=20 nm.

**References**

[1] Qin, I et al., Microelectronics Reliability, **1** (2011) 60-66.
[2] Pu et al., Nano Letters, **12** (2012) 4013-4017
[3] Murali et al., J Materials Science, **42** (2007) 615-623

## Figures

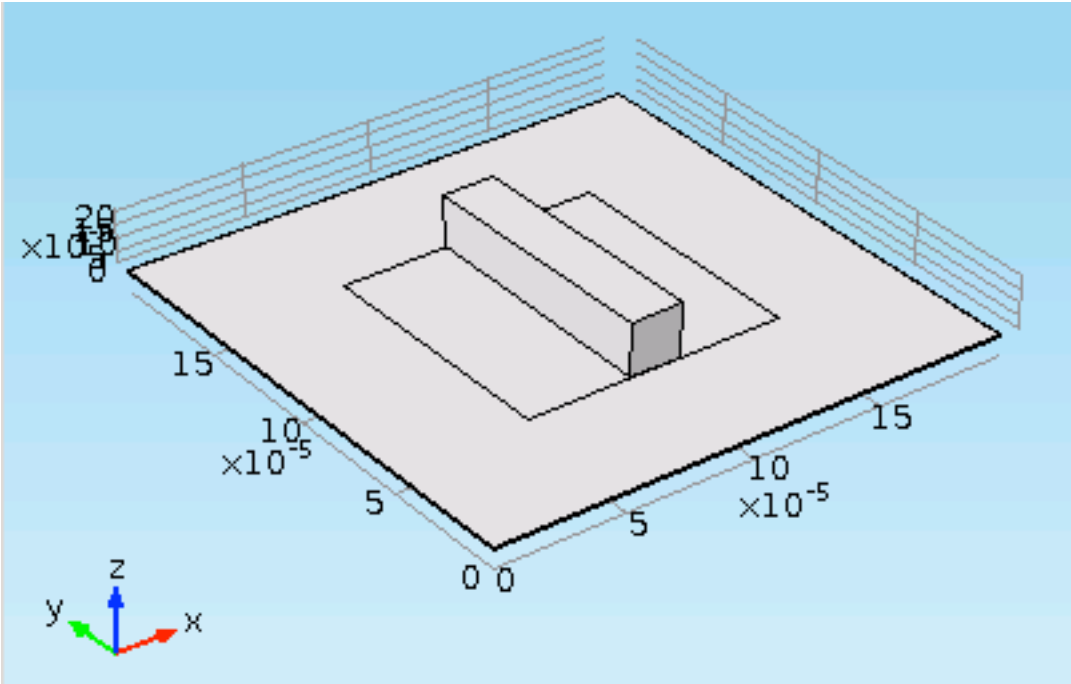


**Figure 1:** The schematic structure of graphene multilayer (1.5 nm thickness) on a silicon substrate, with a layer of 20 nm $MoS_2$ between the two as a buffer layer, with a gold contact pad (150 nm thickness) on top of the graphene to perform the bonding with a 20 micron copper wire.

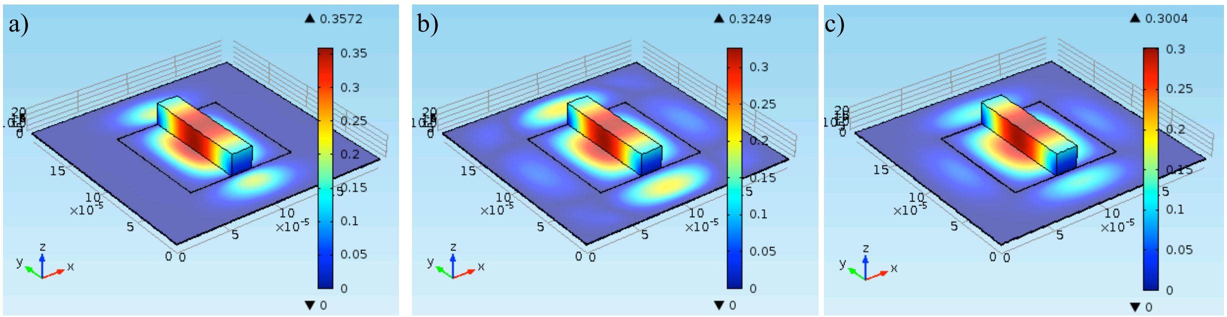


Figure 2 **:** Displacement distribution (µm) in (a) the substrate with gold pad, (b) graphene layer added between substrate and gold pad and (c) using $MoS_2$ buffer layer between substrate and graphene.

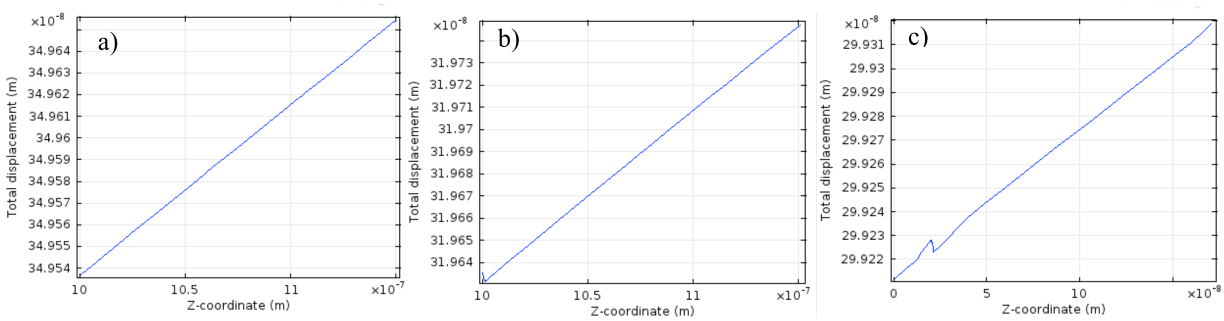


Figure 3: The displacement versus height of structure to show the amount of displacement occurring in each layer from the top of the substrate to the top of the gold film. (a) Substrate with gold pad, (b) added substrate-graphene layer–gold and (c) using $MoS_2$ buffer layer between substrate and graphene.