Photoluminescence in Graphene Antidot lattices

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Since its experimental isolation, graphene has generated a lot of interest, even spawning research into other two-dimensional materials like MoS_2. While semi-conducting MoS_2-singlelayers naturally emit photoluminescence (see e.g. [1]), this is not expected for graphene due to its gapless bandstructure. However, as was reported previously [e.g. 2,3], femtosecond pulsed laser excitation creates an electron-hole plasma in graphene which emits a broadband luminescence.

Here, we present recent observations of the behavior of photoluminescence in nanostructured as well as in pristine graphene. The structure consists of a regular antidot pattern. It has been written by electron beam lithography and was etched using reactive ion etching with oxygen as reactive gas. Distance of the antidots is 100nm.

We utilize fast, high-resolution scans to map graphene flakes on Si/SiO_2-substrates. Thus, a luminescence intensity image of both the flake and its structured areas is created.

In structured areas, the absolute intensity of the photoluminescence is smaller than in pristine flakes due to parts of the graphene having been etched away. However, the observed signal in the patterned flakes is larger than expected from the mere amount of illuminated graphene. This enhancement is roughly 1/15 of the expected signal in single layer and 1/7 in bilayer graphene.

A possible explanation could be additional charge carriers at the antidot edges [4] causing this increase in luminescence.

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References

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Figures

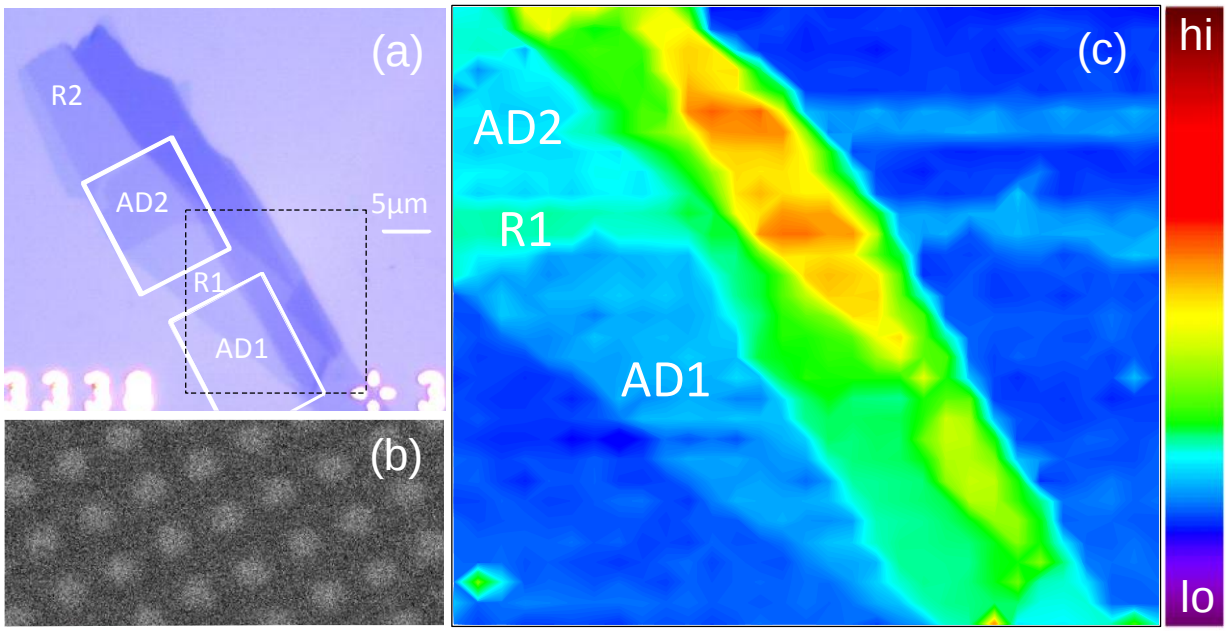

Fig. 1: (a) Microscope image of graphene flake on Si/SiO_2. Patterned areas AD1(single layer) and AD2 (lower part single layer, upper part bilayer) are denoted by white rectangles. Reference areas R1 (single layer) and R2 (bilayer) were left unstructured. (b) SEM image of a part of area AD1. The graphene appears dark gray, the lighter, regular pattern of the circular antidots where the graphene has been etched away is clearly visible. Distance of the antidots is 100nm. (c) Intensity of PL scan of the flake depicted in (a). Scanned area is marked by dashed black rectangle in (a). Clearly, the intensity is lower in the patterned areas AD1 and AD2 than in the reference region R1.

	surface ratio: (expected PL intensity)	PL intensity ratio: experimental value
AD1/R1	80%	85%
AD2/R2	68%	80%

Fig. 2: Table comparing expected values and experimental values from the scan shown in Fig. 1. The expected values are taken to be the surface ratio between graphene and antidots, that is substrate. In unpatterned areas, this ratio is 100%. Experimental values in patterned areas are compared to the experimental value of the reference areas, which are taken to be 100%. All values are mean values taken from the scan.