High resolution near-field photocurrent measurements reveal optoelectronic properties of graphene

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Abstract

Graphene is a promising material for optoelectronic applications as its lack of a bandgap leads to a broad band absorption that spans the visible, near-infrared, mid-infrared and THz regime.[1,2] For applications it is of great importance to know the exact optoelectronic properties of the devices used. With common far-field methods the large size of the laser spot after focusing prevents a spatial resolution below the diffraction limit. This leads to smearing of the spatial photocurrent maps, which can mask important details.

Here we introduce a photocurrent measurement technique which is not limited by the diffraction limit. Using a scattering-type scanning near-field optical microscope (s-SNOM) [3,4] with a mid-infared laser source we excite a strong near-field at the apex of a metallized atomic force microscope probe tip, which acts as a local heat source, generating a temperature gradient in the graphene. This temperature gradient together with a change in Seebeck coefficient leads to a photothermoelectric photocurrent that can be measured spatially. [5]

Here we show how near-field photocurrent measurements with extremely high spatial resolution can be used for characterizing optoelectronic devices made of graphene and graphene heterostructures.[6] We show photocurrent measurements at grain boundaries intrinsic to graphene grown by chemical vapor deposition [7] and extract their polarity. Furthermore we use this unique tool to measure photocurrent from charge puddles [8] of exfoliated graphene on silicon dioxide and show a photocurrent resolution of sub-30 nm. This proofs the extremely high spatial resolution which can be obtained, which ultimately is only limited by the radius of the tip apex. Finally we use the near-field photocurrent technique to confirm the spatial uniformity of the charge neutrality point of graphene encapsulated in hexagon boron nitride.[9]

In summary, in this talk we introduce the novel near-field photocurrent mapping technique and show its potential applications in device characterization and quality control.

References

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