Graphene Visualizes the Ion Distribution on Air-Cleaved Mica

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The distribution of potassium (K^+) ions on the air-cleaved mica is important in many interfacial phenomena such as crystal growth, self-assembly and charge transfer on mica. However, due to experimental limitations to non-destructively probe single ions and ionic domains, their exact lateral organization is yet unknown. We show, by the use of graphene as an ultra-thin protective coating and scanning probe microscopies, that single potassium ions form ordered structures that are covered by an ice layer. The K^+ ions prefer to minimize the number of nearest neighbor K^+ ions by forming row-like structures as well as small domains. This trend is a result of repulsive ionic forces between adjacent ions, weakened due to screening by the surrounding water molecules. Using high resolution conductive atomic force microscopy maps, the local conductance of the graphene is measured, revealing a direct correlation between the K^+ distribution and the structure of the ice layer. Our results shed light on the local distribution of ions on the air-cleaved mica, solving a long-standing enigma. They also provide a detailed understanding of charge transfer from the ionic domains towards graphene.

Figures

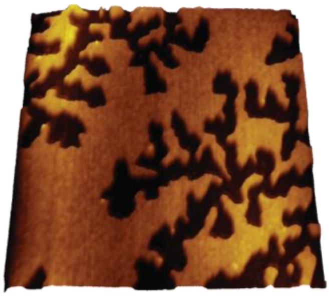

Figure 1: Scanning tunneling microscopy of the Graphene-Ice-Mica interface (190x190 nm2). Ice crystals (darker regions) are observed intercalated between graphene and mica surrounded by two water layers (brighter region).

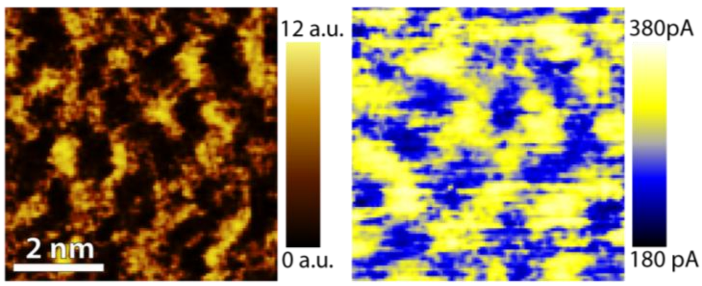

Figure 2: (Left) A small scale (6x6 nm^2) lateral force microscopy image of graphene above an ice crystal. Potassium domains (bright) are observed. (Right) The corresponding conductance map showing the regions where potassium is missing are more conductive than regions directly above potassium ions.