Influence of low-pressure atmosphere in the pores formed in hexagonal boron nitride under electron irradiation

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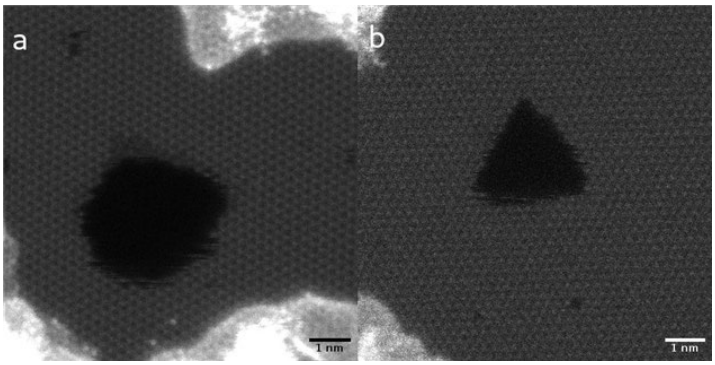
Background incl. aims
During (scanning) transmission electron microscopy ((S)TEM), the energetic electrons used for imaging can lead to damage in the sample. Electron knock-on damage caused by elastically scattered electrons is the best known of such damaging mechanisms, and has been studied extensively also for 2D materials. In contrast, less is known about the damage mechanisms in insulating materials, such as hexagonal boron nitride (hBN) . In early studies, it was shown that extended irradiation leads predominantly to the formation of triangular nanopores. These pores and their triangular shape were suggested to arise from direct interaction between the electrons and the material, and it was shown that the dominated zig-zag edges were nitrogen terminated.

Methods
The Nion UltraSTEM 100 microscope integrated into our experimental setup at the University of Vienna allows experiments at low pressure atmosphere between ultra-high-vacuum (UHV) ~ 1x10-10 mbar and 4x10-6 mbar by carefully leaking the desired gas into the column. Measurements at varying pressures have already shown that the partial pressure of different gases can have an influence in the damage observed in graphene. Specifically, it was shown that different graphene edges dominate under an oxygen atmosphere and in UHV.

Results
Here hBN was imaged at UHV and up to an oxygen pressure of around 2x10-8 mbar. The most prominent finding was that the shape of pores that appeared under electron irradiation depends on the oxygen partial pressure. As an example, medium angle annular dark field (MAADF) images are shown in figure. In UHV the pore shape is round with no preference of either boron or nitrogen termination, whereas triangular pores emerge with rising oxygen partial pressure, with edges dominated by nitrogen atoms. The rate of pore growth also increases with increase in oxygen partial pressure in microscope column, and no any pore growth was observed when the sample was exposed to air without electron irradiation.

Conclusion
The results suggest that the shape of the pores observed in the earlier studies was determined by the composition of the microscope vacuum. The pores grow only under electron irradiation and their shape depends on the vacuum conditions.

Graphic:



Keywords:

hBN, in-situ STEM, 2D Materials

Reference:

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