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STM study of oxidative etching of graphite surface defects produced by low energy ions

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The thermal oxidation of the basal plane of highly ordered pyrolytic graphite leads to the formation of shallow circular and/or hexagonal pits. These pits are presumably known to be originated from natural defects. However, the identity of those defects has not been revealed. In order to investigate this issue we deliberately have made surface defects kinds of a vacancy and an interstitial by using low energy ion (50-500 eV) collision on graphite surface, and subsequently oxidized them in air to produce pits.

Surface defects are produced in our low energy ion-surface collision chamber. Cleaved graphite surface was introduced into chamber using sample transport system. Low energy ions (Ar^+, Kr^+) of ~10^{-12} ions/cm^2 are impacted on surface. Subsequently the surface was investigated by using STM to confirm defect production following oxidizing in air at temperature range from 500 to 650 °C and investigated again using STM.

50-500 eV ion impact on graphite surface produces surface defects, and following oxidation could make nearly circular pits of from 1 to 4 ML depth. Pit formation probability increases with ion energy. Their diameter distribution is singular, indicating no spontaneous nucleation occurs. Pits grow linearly with time and collide each other through tangential contact or channeling process. It finally results in cleaving whole monolayer. The pits are induced from both vacancy and interstitial of trapped atom under basal plane. The vacancy defect produces pit more effectively than the interstitial does. Paired pits are also observed, which distance is less than 22 nm. They were induced by vacancy and interstitial pair, showing ion penetration, carbon sputtering, and trajectory under basal plane. Furthermore it was possible to measure ion penetration threshold from oxidative pit formation. Most of pits are 1 ML depth and the distribution of deeper pits (2, 3, and 4 ML depth) increases with ion energy, indicating the limitation of penetration depth.